SECOND EDITION

BRITE EURAM

PROGRAMME

SYNOPSES OF CURRENT PROJECTS 1990 - 1991

INCLUDING PROJECTS RUNNING UNDER BRITE AND EURAM

COMMISSION OF THE EUROPEAN COMMUNITIES

BRITE/EURAM
Programme

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Preface

This publication is an update of the previous "Project Synopses" book and includes all the projects selected after the two rounds of BRITE/EURAM in 1989 and 1990. Each page contains the basic information about a research project, consisting of a summary of the objectives and achievements to date, the contact address of the main contractor and a list of the other major participants (contractors, subcontractors or sponsors), together with the duration and starting date. In addition, projects supported under the previous BRITE and EURAM programmes are included, apart from any which finished before January 1991

New features of this book are the inclusion of an index of participants and a keywords index. I hope this will make the book more generally useful and encourage contacts to be established.

Activities under BRITE/EURAM now represent a total financial investment of approximately 1.3 billion ECU, of which roughly 50% is being provided by the Community. This is a substantial effort, and must be related to complementary activities in materials and manufacturing research being carried out through national programmes and other schemes. BRITE/EURAM does not have a monopoly of research in these disciplines, but it does provide a special context for transnational, interinstitutional (companies, universities and research centres) and multidisciplinary teams to combine forces and undertake industrially relevant projects together. Current statistics show that approximately 56% of BRITE/EURAM participants come from industry ($^1/_3$ of these are SMEs), 27% are universities and 17% are research centres

Information and progress on all the 374 research projects selected under BRITE/EURAM have been updated for this edition. Many of the very new projects, with "4000" series project reference numbers, have only just started or are still under negotiation. The total number of projects outlined in this book is well over 500.

Projects summarised represent roughly one quarter of the total number submitted under various calls. They are therefore of good quality, but it is always a disappointment to me that we have been unable to fund all the good projects we have received due to limited programme budgets.

Opportunities for research under BRITE/EURAM are now over. However, with the current implementation of the Third Framework Programme, I am confident that the forthcoming Industrial and Materials Technologies Programme - "BRITE-EURAM II" will provide an even greater occasion for the BRITE/EURAM initiative to develop and expand into an increasing number of industry sectors across the Community.

A. GARCIA ARROYO
Director, Technological Research

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How to use this book

The projects described in this book fall into BRITE/EURAM's four main technical areas. These Areas are shown in the table of contents.

Areas are introduced by a special title page (see pages 1, 191, 295 and 385).

Each Area is divided into sub-areas.

Sub-areas are identified at the top of each ***left-hand page*** of the project synopses, next to the page number. *(If a sub-area starts on a right-hand page, its title appears at the top left of this page.)*

Each of the programme's sub-areas has again been divided into sub-sub-areas.

Sub-sub-areas are identified at the top of each ***right-hand page*** of the project synopses, next to the page number. *(If a sub-sub-area starts on a left-hand page, its title appears at the top right of this page, after the sub-area title.)*

If you want to find a particular type of project, go to the main table of contents and choose the Area, Sub-area, and Sub-sub-areas which interest you.

The information about each Brite/Euram project is summarized on a single page of the book. Each page gives up-to-date information on that project's title, starting date, duration, objectives, achievements to date and keywords. At the bottom of the page the name and address of the main contractor (prime partner) is given, along with the name of their contact person for the project, and the telephone, telefax, and telex numbers for that person. Also given are the names and country codes of the other major partners in the project.

Country codes are shown to the right of each partner's name, and are:

A	Austria	IRL	Ireland
B	Belgium	L	Luxembourg
CH	Switzerland	NL	the Netherlands
D	Federal Republic of Germany	NO	Norway
DK	Denmark	P	Portugal
E	Spain	S	Sweden
F	France	SF	Finland
GR	Greece	UK	United Kingdom
I	Italy		

Each project has a 4-digit proposal number. Projects funded under the Brite and Euram programmes have proposal numbers preceded by 'P-' (for example, P-1244). Projects funded under the Brite/Euram programme have proposal numbers preceded by 'BE-' (for example, BE-3328).

Proposal numbers are located at the *bottom right hand corner* of the page.

Each project also has a contract number.

Contract numbers are also located at the *bottom right hand corner* of the page.

ALL PROJECTS ARE IDENTIFIED IN THE INDEXES OF THIS BOOK BY THEIR 4-DIGIT PROPOSAL NUMBER.

INDEXES

If you want to find information about a specific project, you can do this in a number of ways by using the book's six indexes.

Index of projects by area (page xi): This lists each project title with its proposal number and *follows the page order of the book,* area by area.

Index of projects by proposal number (page xli): This lists the projects by their proposal number *in numerical order,* and gives each project's title and page number.

Index of proposal numbers (page lxix): This lists the project proposal numbers *in numerical order* and gives their corresponding contract numbers. (*Note:* if there is no contract number yet, this is indicated by a dash '—'.)

Index of contract numbers (page lxxv): This lists the project contract numbers *in numerical order* and gives their corresponding proposal numbers.

Index of keywords (page xci): This lists the programme keywords and gives the projects to which they apply.

Index of participants (page xcvii): This lists all the participants, and gives the projects in which they are involved.

Examples of how to use the indexes

To find information about the project with proposal number P-3322, look in the **Index of projects by proposal number**, where it says that project 3322 has the title *Sub angstrom structure characterization,* and is described on page 271.

To find information about the project with contract number RI1B-192, look in the **Index of contract numbers**, where it says the project's proposal number is 2341. Then look in the **Index of projects by proposal number**, where it says that project 2341 has the title *Performance and reliability evaluation of welding in elevated temperature service,* and is described on page 223.

Index of projects by area

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4.1.1 SURFACE TECHNIQUES

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Index of proposal numbers *

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0031	MA1E-0056	0508	MA1E-0045	2019	RI1B-178
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0047	MA1E-0005	0553	MA1E-0055	2026	RI1B-223
0049	MA1E-0086	0570	MA1E-0079	2027	RI1B-292
0054	MA1E-0011	0603	MA1E-0070	2029	RI1B-240
0083	MA1E-0040	0612	MA1E-0071	2031	RI1B-236
0113	MA1E-0058	0653	MA1E-0001	2032	RI1B-306
0135	MA1E-0098	0677	MA1E-0036	2033	RI1B-291
0148	MA1E-0068	0706	MA1E-0049	2038	RI1B-182
0157	MA1E-0066	0717	MA1E-0065	2044	RI1B-287
0165	MA1E-0083	0721	MA1E-0047	2049	RI1B-264
0191	MA1E-0051	0774	MA1E-0050	2051	RI1B-285
0201	MA1E-0063	0809	MA1E-0016	2052	RI1B-261
0224	MA1E-0072	0831	MA1E-0069	2058	RI1B-237
0257	MA1E-0054	0837	MA1E-0027	2064	RI1B-217
0275	MA1E-0074	1025	RI1B-150	2079	RI1B-196
0287	MA1E-0076	1027	RI1B-85	2082	RI1B-286
0300	MA1E-0052	1145	RI1B-134	2085	RI1B-235
0320	MA1E-0062	1202	RI1B-166	2086	RI1B-293
0325	MA1E-0081	1253	RI1B-90	2090	RI1B-279
0329	MA1E-0061	1300	RI1B-157	2103	RI1B-186
0339	MA1E-0029	1339	RI1B-120	2112	RI1B-245
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0357	MA1E-0014	1354	RI1B-156	2121	RI1B-101
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0475	MA1E-0037	1545	RI1B-101	2133	RI1B-201
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0494	MA1E-0064	2001	RI1B-274	2145	RI1B-188
0505	MA1E-0067	2006	RI1B-171	2146	RI1B-288

* Projects for which contract numbers were not allocated at the time of publication of this book are marked with a dash (" —").

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2150	RI1B-187	2324	RI1B-255	3039	BREU-0068
2156	RI1B-271	2331	RI1B-262	3041	BREU-0151
2158	RI1B-304	2335	RI1B-246	3042	BREU-0194
2162	RI1B-176	2341	RI1B-192	3048	BREU-0172
2165	RI1B-259	2343	RI1B-228	3051	BREU-0099
2167	RI1B-248	2344	RI1B-263	3055	BREU-0181
2168	RI1B-227	2348	RI1B-199	3062	BREU-0268
2172	RI1B-190	2349	RI1B-300	3069	BREU-0208
2177	RI1B-177	2357	RI1B-253	3072	BREU-0077
2178	RI1B-185	2361	RI1B-173	3076	BREU-0266
2182	RI1B-284	2362	RI1B-200	3077	BREU-0112
2186	RI1B-272	2369	RI1B-215	3080	BREU-0086
2195	RI1B-266	2370	RI1B-226	3082	BREU-0168
2197	RI1B-204	2382	RI1B-296	3086	BREU-0133
2199	RI1B-180	2385	RI1B-198	3090	BREU-0171
2202	RI1B-294	2387	RI1B-193	3091	BREU-0186
2208	RI1B-184	2396	RI1B-301	3092	BREU-0095
2210	RI1B-281	2397	RI1B-242	3096	BREU-0140
2213	RI1B-243	2401	RI1B-267	3102	BREU-0050
2219	RI1B-202	2406	RI1B-197	3103	BREU-0046
2226	RI1B-225	2408	RI1B-203	3104	BREU-0061
2231	RI1B-295	2409	RI1B-231	3106	BREU-0088
2232	RI1B-303	2412	RI1B-241	3110	BREU-0192
2234	RI1B-298	2413	RI1B-278	3111	BREU-0142
2237	RI1B-195	2414	RI1B-254	3115	BREU-0150
2242	RI1B-174	2417	RI1B-251	3117	BREU-0165
2245	RI1B-265	2418	RI1B-249	3119	BREU-0349
2248	RI1B-282	2424	RI1B-216	3120	BREU-0170
2251	RI1B-172	2431	RI1B-232	3122	BREU-0111
2278	RI1B-220	2437	RI1B-257	3125	BREU-0304
2280	RI1B-205	2449	RI1B-297	3127	BREU-0066
2281	RI1B-252	2476	RI1B-244	3130	BREU-0094
2289	RI1B-290	2478	RI1B-299	3135	BREU-0159
2293	RI1B-219	3005	BREU-0132	3137	BREU-0125
2294	RI1B-258	3006	BREU-0076	3138	BREU-0158
2297	RI1B-224	3009	BREU-0137	3142	BREU-0193
2309	RI1B-273	3012	BREU-0083	3147	BREU-0091
2315	RI1B-247	3014	BREU-0078	3148	BREU-0265
2317	RI1B-275	3015	BREU-0067	3150	BREU-0055
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Proposal. no.	Contract no.	Proposal. no.	Contract no.	Proposal. no.	Contract no.
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3167	BREU-0350	3326	BREU-0164	3455	BREU-0333
3176	BREU-0204	3327	BREU-0049	3456	BREU-0333
3177	BREU-0081	3328	BREU-0080	3457	BREU-0333
3182	BREU-0057	3332	BREU-0117	3459	BREU-0177
3194	BREU-0089	3336	BREU-0147	3466	BREU-0156
3197	BREU-0161	3337	BREU-0141	3467	BREU-0079
3203	BREU-0097	3338	BREU-0338	3469	BREU-0074
3207	BREU-0296	3339	BREU-0122	3472	BREU-0102
3208	BREU-0278	3341	BREU-0160	3473	BREU-0174
3209	BREU-0100	3345	BREU-0273	3474	BREU-0351
3212	BREU-0135	3348	BREU-0053	3476	BREU-0205
3217	BREU-0121	3355	BREU-0176	3480	BREU-0113
3218	BREU-0085	3357	BREU-0191	3486	BREU-0062
3223	BREU-0129	3359	BREU-0118	3489	BREU-0134
3231	BREU-0127	3360	BREU-0207	3490	BREU-0136
3236	BREU-0139	3364	BREU-0264	3494	BREU-0267
3243	BREU-0334	3366	BREU-0155	3495	BREU-0146
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3607	BREU-0269	4108	BREU-0507	4244	BREU-0513
3612	BREU-0263	4112	BREU-0448	4249	BREU-0400
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4088	BREU-0452	4215	BREU-0424	4394	BREU-0420
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4096	BREU-0518	4227	BREU-0489	4407	BREU-0421
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4514	BREU 0399
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4522	—
4527	—
4529	BREU 0411
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4539	—
4545	BREU-0510
4551	BREU-0451
4554	BREU-0501
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4564	BREU-0431
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4596	BREU-0443
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RI1B-296	2382	—	4126	—	4302
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AREA 1

Advanced materials technologies

TEXTURE AND PLASTIC ANISOTROPY IN ALUMINIUM LITHIUM ALLOYS

Starting date: February 1988 ***Duration:*** 36 months

OBJECTIVES

The aim of the project is to determine the influence of alloying elements on the texture development in 3 various Al-Li model alloys. The programme includes 3 parts:

- theoretical and experimental studies of rolling texture development-rolling experiments on technical and large grain size alloys to determine the slip systems, slip inhomogeneities and lattice reorientations of individual grains
- experimental study of texture evolution during heat treatment
- measurements of plastic anisotropy and comparison with anisotropy data calculated from textures.

The ultimate aim was to provide a method for predicting the mechanical properties of highly textured alloys as occurring in Al-Li alloys.

ACHIEVEMENTS TO DATE

Bands of the three alloys have been prepared by casting and hot extrusion and were hot or cold rolled to various thicknesses. Some of these bands were subjected to a further heat treatment. At each stage detailed texture measurements were made by X-ray pole figures and ODFs (Orientation Distribution Functions). Tensile tests on the hot rolled samples have been carried out to determine the Lankford coefficient R and the yield stress σ_Y. The results reveal a pronounced R(α) anisotropy; after hot rolling R is very low at α=0°, increases to over 1 at 45° then decreases to ±0.5 at 90°C. The R and $\sigma_Y$values could also be calculated using the texture data. To examine in greater detail the mechanisms of rolling texture development, a sample with grains of 3mm diameter was deformed in plain strain compression and the orientations of 26 indivdual grains were measured. The lattice rotations of the grains were also compared with the different theoretical predictions according to Taylor-type models (Full and Relaxed Constraints) of the grain deformations.

KEYWORDS Materials science; Metallic structural materials; Materials processing; Aeronautics; Texture; Plastic anisotropy; Al-Li alloys

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Contract no: MA1E-0064
Proposal no: P-0494

WORKABILITY OF METALS AND METAL MATRIX COMPOSITES IN PARTICULAR AL-LI ALLOYS AND ALUMINIUM-BASED METAL MATRIX COMPOSITES

Starting date: June 1991 ***Duration:*** 36 months

OBJECTIVES

The proposal is concerned with progressive plastic deformation and fracture of advanced aerospace materials in quasi-static and dynamic tension, compression and torsion. The test materials will be Al-Li and Al-based metal matrix composites. The following areas will be investigated :

(i) the micro-mechanisms of plastic deformation and fracture in both classes of material

(ii) the application of macroscopic shear banding to flow localization in these materials will be studied along with the development of the Bai-Dodd shear banding model for multidimensional stress states which will be completed

(iii) examination of the dilatational strain-energy density criterion (T-criterion) for specification of the type of fracture under various strain states and strain rates

(iv) development of forming limit diagrams as functions of imposed strain rate and strain rate for use in metal forming processes to make fabrication of the two types of material more economic to the Community. Incorporation of the forming limit loci in CAD/CAM programs will make the outcome of this work particularly valuable.

KEYWORDS

Materials processing; Forming; Formability; Composites (metal matrix); Reinforcing materials; Materials science; Materials characterization

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Contract no: BREU-0398
Proposal no: BE-4500

INVESTIGATIONS ON ALUMINIUM-LITHIUM ALLOYS FOR DAMAGE TOLERANT APPLICATION

Starting date: July 1990 ***Duration:*** 24 months

OBJECTIVES

New almuminium-lithium alloys offer aircraft manufacturers considerable weight saving potential without extensive conversion of their manufacturing facilities.

At present the main material used for civil aircraft structures is the conventional alloy 2024 T3 because of its excellent damage tolerant behaviour. Al-Li alloys becoming available do not cover the whole range of properties required by the aircraft industry in respect of damage tolerance.

A priority of the programme is to identify the weak points of the existing materials and to define procedures for improvements.

A further increase in attractiveness and cost-efficiency for future use of the material will be possible when a naturally aged alloy becomes available instead of the artificially aged alloy.

Another priority is the understanding and evaluation of specific behaviours of the now available alloys which are specific to Al-Li and mainly unknown today. Special items such as corrosion, fracture toughness, flight simulation and component tests have to be solved.

ACHIEVEMENTS TO DATE

To investigate the possibility of developing a natural ageing alloy, background information on the existing commercial alloys, and information on research alloys has been collated. Two series of new alloys are then to be cast, forged and rolled.

The aim of activities regarding fracture toughness testing is to devise a simple method for the evaluation of this important behaviour which may be used as a quality control test.

The first step was to provide a data base of tests used today (definition and parameter) and fracture toughness properties obtained from the different methods.

Theoretical studies such as elastic-plastic finite element calculations and literature survey of testing methods were undertaken in order to understand the different methods and identify possible candidate methods.

For flight simulation most of the specimens have been made and tests started.

Results obtained so far in this project need more analysis by partners and have to be completed a stage further before any correlation is possible and a common tendency is found.

KEYWORDS Aeronautics/Aerospace; Manufacturing; Engineering; Metallic structural materials; Materials science; Research/Development

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Contract no: BREU-0128
Proposal no: BE-3250

NEW ACCELERATED CORROSION TEST METHODS

Starting date: June 1990 ***Duration:*** 36 months

OBJECTIVES

New accelerated corrosion test methods for investigating aircraft corrosion will be developed to face the corrosion problems of present and future aircraft. Highly sophisticated multi-system electrochemical monitoring techniques can help to detect corrosion at a very early stage. Real-time measurements in aircraft may be possible. Better applicability of the corrosion tests presently being used for Al alloys will be achieved. The influence of micro-organisms on corrosion and the role of hydrogen for stress corrosion cracking will be investigated comprehensively.

ACHIEVEMENTS TO DATE

Long-term outdoor exposure tests in different environments have been launched. Initial results of exposure to marine atmosphere have been obtained and will be compared with conventional standard corrosion tests. The monitoring equipment for electrochemical noise and impedence measurement has been installed and tests will commence. The testing unit for corrosion monitoring in an aircraft appears to be working well now. The hydrogen permeation measurement apparatus has been completed and preliminary measurements have begun. Sampling methods for microbiologically induced corrosion have been applied. Micro-organisms have been isolated from aircraft, identified and enriched. The corrosive behaviour of the isolated microrganisms will now be studied.

KEYWORDS

Aeronautics; Metallic structural materials; Corrosion materials science; Microorganism; Development; Materials characterization

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Contract no: BREU-176
Proposal no: BE-3355

FORGING TECHNIQUE AND ALLOY COMPOSITIONAL OPTIMIZATION FOR THE PRODUCTION OF ALUMINIUM LITHIUM DIE FORGINGS

Starting date: February 1991 ***Duration:*** 36 months

OBJECTIVES

Although aluminium-lithium based alloys 8090, 2091, 2090 have reached commercial status, emphasis has been directed primarily at the manufacture of sheet, plate and extrusions wherein the relationship between composition, fabrication techniques and property levels is relatively well developed and understood. The similar situation for die forgings is not so well advanced and is the objective of the current project. The overall aim is to optimise the various steps in the hand and die forging processes and, together with development of an 8090-based variant specifically for die-forging, it is hoped to achieve enhanced properties in this product form. The project is comprised of the following specific tasks:

- optimisation of hand forging techniques–development of thermomechanical processing parameters to optimise grain shape, size and type (i.e. recrystallized, unrecrystallized, duplex, etc.)
- mechanical working effects–maximisation of degree/uniformity of S-Al_2CuMg precipitation by optimising post-solution heat treatment cold compression levels using special finishing dies. Correlation between experimentally measured strain distribution levels in hand and dye forgings with theoretically predicted values from FE analysis
- compositional effects.–Maximisation of degree/uniformity of S-Al_2CuMg precipitation by modification of lithium, copper and magnesium levels. Modification of S-Al_2CuMg precipitation and/or precipitation of further strengthening phases by minor additions of other alloying elements.

ACHIEVEMENTS TO DATE

Optimisation of hand forging techniques is currently in progress (July 1991).

KEYWORDS

Aeronautics/Aerospace; Materials processing; Research/Development; Metallic structural materials; Non ferrous; Materials Characterization/ Testing; Forming/Shaping/Casting

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Proposal no: BE-3167

OPTIMISATION OF CERAMIC FIBRE - REINFORCED ALUMINIUM ALLOYS

Starting date: February 1988 ***Duration:*** 36 months.

OBJECTIVES

The goal of the project was to acquire a comprehensive know-how on Ceramic fibre reinforced Aluminium alloys, referring to manufacturing, processing and heat treatment and to evaluate their performance in terms of mechanical and wear properties.

ACHIEVEMENTS TO DATE

Ceramic fibre and whiker preforms from several suppliers have been infiltrated by squeeze casting with a wide variety of Aluminium alloys. It has been found that infiltration causes heterogeneities in the preform and segregation of alloying elements. The composition of the alloy that actually infiltrates the preform is not exactly that of the original alloy, as a fraction of the alloying elements is retained above the preform. Heat treatments commonly used for unreinforced aluminium alloys are not optimal for composites, and we have come to the conclusion that reinforcing materials modified solution treating and age-hardening kinetics. Hence solution treating and tempering times and temperatures have been optimized for composites.

Mechanical testing and wear tests have been carried out on almost all composites. The influence of the preform composition and binder on tensile characteristics was clearly revealed. There exists an optimal composition of the alloy that yields the best tensile properties to the composite, as well as some other alloys that will give more wear-resistant materials.

KEYBOARDS

Metal matrix composites; Fibres; Aluminium alloys; Squeeze casting; Mechanical testing

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Contract no: MA1E-0051
Proposal no: P-0191

PREPREGS AND COMPOSITE MATERIALS MADE OF ALUMINIUM ALLOYS REINFORCED WITH CONTINUOUS FIBRES

Starting date: March 1989 ***Duration:*** 36 months

OBJECTIVES

The aim of the project is to investigate advanced aluminium matrix composites, obtained via the prepreg route, for applications in aerospace structures (C/Al) and heat engines (SiC/Al). The programme has four steps:

- prepreg-processing, C (HM or UHM) Al and SiC (NICALON-type/Al)
- characterisation of the prepregs
- composite processing
- characterisation of the composites.

ACHIEVEMENTS TO DATE

For prepreg production an equipment for fibre spreading and coating was developed. The equipment for fibre spreading has already successfully been demonstrated. Coating of the fibres with pure aluminium is performed in a PVD process. The equipment for continuous prepreg production has been developed.

Basic investigation to characterize the prepeg and the fibre/matrix interactions occuring during consolidation of the composite from the prepeg stage were performed. Due to the manufacturing temperature a reduction of the mechanical properties can be observed, as a result of the formation of aluminium carbide (Al_4C_3).

The results achieved give rise to the assumption, that if an optimized manufacturing process can be used, sufficiently good mechanical properties retain in the composite, without the necessity of carbon fibre coating.

The progress achieved up to now has shown that composite materials can be produced via the prepeg route.The work in the future has to concentrate on further improving the quality of the prepeg, the manufacturing processes, and to better understand fibre/matrix interactions. After these problems can successfully be solved, a material is available, which can be used for space structures.

KEYWORDS

Composites (metal matrix);Carbon/Graphite; Materials characterisation/ testing; Aeronautics/Aerospace; Fibres/Reinforcing materials

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DEVELOPMENT OF FIBRE REINFORCED ALUMINIUM METAL MATRIX COMPOSITES FOR APPLICATIONS IN AEROSPACE PRIMARY COMPONENTS USING POWDER METALLURGY TECHNIQUES

Note: Updated information was not provided in time for publication.

Starting date: November 1988 ***Duration:*** 36 months

OBJECTIVES

The aim of the research is to investigate the characteristics and the production processes of metal matrix (aluminium alloys) composites reinforced by short fibres or whiskers and by using powder metallurgy techniques. This technology is suitable for manufacturing extruded or forged composite structural components with high strength metal matrices. The programme envisages the following phases:

- production and characterization of all powders and fibres
- MMC sintering and extrusion
- forging and characterization of the finished part.

This process complements both the squeeze casting, currently being considered for full commercialization, and the diffusion bonding process which enables very high performance MMC reinforced with continuous fibres to be obtained but at high costs, therefore limiting their use to particular applications.

KEYWORDS

Aeronautics/Aerospace; Forming/Shaping/Casting; Composites (metal matrix); Materials science; Powder metallurgy

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Contract no: MA1E-0065
Proposal no: P-0717

NOVEL METAL - MATRIX COMPOSITES BASED ON HYPEREUTECTIC ALUMINIUM / SILICON ALLOYS

Starting date: May 1990 ***Duration:*** 48 months

OBJECTIVES

The aim is to develop a new family of MMCs based on Al/high Si alloys. The composites will consist of primary Si particles formed in situ in an Al/Si eutectic matrix, and will have enhanced specific stiffness, strength and wear resistance. In contrast with MMC systems such as Al/SiC, formed by mixing, there should be no brittle compounds at the matrix/particle interfaces. A fine, uniform distribution of primary Si will be obtained by spray-forming and preserved by semi-solid processing (thixoforming and thixocasting), which will result in near-net shape products.

ACHIEVEMENTS TO DATE

Hypereutectic Al/Si alloys have been spray-formed to produce MMCs with primary Si size <5μm in Al/20Si, <8μm in Al/36 Si and <20μm in Al/50Si. Near-net shape pieces of these compositions have been produced by thixoforming, with only limited coarsening of the primary silicon. Chill-cast and die-cast specimens of the same compositions did not possess the fine Si sizes found in spray-formed samples, even when refining agents and high cooling rates were used. Preliminary mechanical tests have confirmed the superiority of the spray-forming/thixoforming route.

KEYWORDS

Materials processing; Forming/Shaping/Casting; Processing (minerals & metals); Composites (metal matrix); Materials characterization/Testing); Materials science; Semi-solid metal processing

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Contract no:BREU-0129
Proposal no: BE-3223

DEVELOPMENT OF NOVEL AUTOMOTIVE PISTON/ROD COMPONENTS AND AEROSPACE GEARBOXES FROM LONG FIBRE/METAL MATRIX COMPOSITES

Note: updated material was not provided in time for publication

Starting date: 1990 ***Duration:*** 36 months

OBJECTIVES

This programme for the development of techniques for ceramic long fibre reinforcement, fibre preforms, design of automotive and aerospace components, production via new squeeze casting routes and liquid metal infiltration route and testing and evaluation of products manufactured both before and after test bed evaluation will permit the introduction of high performance MMC materials on a commercial basis. The potential for weight savings, noise reduction and enhanced performance have been realized for some time and put to technical and commercial advantage in both the USA and Japan. The major objectives of this programme are to enable European automotive and aerospace companies to develop technology which will enable them to catch up and surpass overseas competitors and gain an increased world share of the market in these areas. The programme will enable the technical benefits of MMC materials to be related to the fundamental understanding of the interaction of metal fibre interfaces, component design, processability, FEA and part performance.

KEYWORDS

Aeronautics/Aerospace; Automotive, Components & Parts; Forming/Shaping/Casting; Ceramics/Glasses; Composites (metal matrix); Fibres/Reinforcing materials

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Contract no: BREU-0138
Proposal no: BE-3279

INNOVATIVE MANUFACTURING, DESIGN AND ASSESSMENT OF ALUMINIUM MATRIX COMPOSITES FOR HIGH TEMPERATURE PERFORMANCE

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

Recent developments in processing technology have enabled the manufacture of aluminium based composite with reinforcements which are stable above 300°C, opening the possibility of major new industrial applications in automotive and aerospace applications. Fundamental materials science problems have been identified for these important candidate materials. One basic weakness is in the understanding of how mechanical performance is determined by the complex interaction between matrix reinforcements and processing routes. The essential objective of this project is to under-spin industrial progress through a materials science research consortium focused on:

- shape, size and volume fraction of reinforcements in the microstructure
- interface reactions for selected reinforcements
- the influence of thermal expansion mismatch within the composite on elevated temperature performance
- the evaluation of microstructural damage and performance parameters for life prediction under monotonic and cyclic load at a range of temperatures and under various environmental conditions

The object of the research is to optimise manufacturing processes to produce microstructures which exhibit excellent temperature performance in selected aluminium alloy systems and allow predictive engineering design of components for European industry.

ACHIEVEMENTS TO DATE:

The work is on schedule with preliminary studies of the materials selection/manufacturing routes in place. This involves all five partners plus selected industries.

KEYWORDS

Composites; Fracture mechanics; Creep; Manufacturing; Performance; Materials science; Fatigue; Corrosion

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Contract no: BREU-0075
Proposal no: BE-3398

A NEW APPROACH TO HIGH PERFORMANCE REINFORCED ALUMINIUM COMPONENTS USING FIBRES WITH PREDETERMINED ORIENTATION

Starting date: 1991 ***Duration:*** 36 months

OBJECTIVES

The aim of this project is to develop techniques for the manufacture of aluminium MMC's with orientated continuous ceramic fibres.

The potential of aluminium MMC is currently hindered by the technical limitations of short/medium fibres and the high cost of long fibre reinforcement. This project seeks to overcome these technical and cost limitations.

A continuous ceramic fibre will be developed together with novel preform manufacturing techniques and testing procedures.

Preforms will be infiltrated using both direct and indirect squeeze casting, optimization of process parameters will be achieved by experimentation with integrated computer simulations. The acquired data will be applied to the manufacture of a complex shape similar to a commercially available high performance component.

The economics of the process route will be analysed. This project will give a better fundamental understanding of continuous ceramic fibre manufacture and preform processing for squeeze cast infiltration. The merits of direct and indirect squeeze casting in this context will be evaluated.

KEYWORDS

Materials processing; Forming/Shaping/Casting; Composites (metal matrix); Metallic structural materials; Materials characterization/Testing; Materials science; Reinforcement technology

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Contract no: BREU-0421
Proposal no: BE-4407

MMC SHEETS AND SHEET STRUCTURES MADE FROM PARTICULATE REINFORCED ALUMINIUM ALLOYS

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

This project intends to develop the necessary technology basis for the production of sheets and sheet structures made from particulate reinforced Metal Matrix Composites (MCC). Particulate reinforced Aluminium is currently the only cost effective MCC which allows the production of improved stiffened structures by taking advantage of the high stiffness values. Most activities - mainly performed in the USA and Japan - have so far been concentrated on the production of forgings or extrusions. Little attention has been paid to the development of MCC sheets, even though many stiffness critical parts have a sheet type geometry. MCC sheet structures may become a substitute for Titanium, Aluminium and carbon fibre reinforced plastics and will account for significant weight savings. This will lead to improved performance of all kinds of transportation systems but especially for air- and spacecraft. General engineering applications may include automatic handling devices or machining systems with faster and closer positioning and electronic packaging with tailored thermal expansion. Within the project a European production route for MCC sheet and processes for secondary manufacturing (forming, joining, etc.) will be developed. The material properties will be established, the numerical process modelling will be enhanced and stiffened sample structures will be produced.

KEYWORDS

Aeronautics/Aerospace; Assembly/Joining; Composites (metal matrix); Non ferrous; Materials science; Particle technology

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Contract no: BREU-0395
Proposal no: BE-4030

TOUGH TITANIUM BASED CERMETS FOR TOOLS AND WEAR RESISTANT COMPONENTS

Starting date: April 1988 ***Duration:*** 45 months

OBJECTIVES

The objectives of this project are:

- to devise Titanium based cermets for metal cutting and wear resistant applications
- to develop analytical techniques with high resolution (submicrometre), particularly for light elements carbon and nitrogen
- to make and characterize new Ti(C,N) powders
- to assess the performance of new cermet compositions
- to study laboratory test methods for property characterization of cermets.

ACHIEVEMENTS TO DATE

Methods for the production of Ti(C,N) and (Ti, X) (C,N) powders have been developed, where X is a combination of Ta, W and Mo. Elecctron energy loss spectrometry has been applied to the measurement of C and N compositions in Ti(C,N) cermets with spatial resolutions better than 0.01μm. Energy dispersive analysis has been developed to measure Ti and Mo contents of cobalt/nickel binder phases. Pore free products have been made using gas atmosphere control during sintering to avoid loss of nitrogen. Preliminary experiments with quaternary (Ti, Ta, W, Mo) (C, N) powders has shown that simple two-phase structures can be produced for comparaison with the multi-phase (up to 6) structures observed in commercialcermets. The tests method for surface toughness has been characterized and the uncertainties associated with its use quantified. Performance (severe cutting) tests have been performed on commercial materials for comparaison with cermets produced by the project partners.

KEYWORDS

Materials processing; Machining; Other materials; Materials characterization /testing; Tools/Dies; Powder metallurgy; Cermets

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Contract no: MA1E-0074
Proposal no: P-0275

MICROSTRUCTURE AND TEXTURE CONTROL OF HEXAGONAL SHEET ALLOYS – ROLE OF ALLOYING ELEMENTS ON MECHANICAL PROPERTIES AND FORMABILITY

Note: Updated information was not available in time for publication

Starting date: 1990 ***Duration:*** 48 months

There is considerable evidence to show that variations in microstructure and texture result in considerable scatter in the mechanical properties and formability of currently-produced titanium alloys. These alloys are not therefore used as efficiently as they could be and this proposal is aimed at rectifying this situation by addressing the following objectives: the identification of which aspects of microstructure and texture most critically affect properties; and the proposing of ways of producing these materials so that controlled microstructure and textures which must reduce scatter in properties can be produced consistently and economically. Such information could be used in the future production of all existing and new titanium alloys. The work is viewed as the first phase of a long-term programme. This initial phase will concentrate on an in-depth characterization of the microstructures and textures of the alpha and the beta phases of titanium both individually and collectively, for a series of model alloys as a function of cold-rolling of small laboratory-produced ingots to thin sheet and their subsequent recrystallization. This microstructural characterization will be accompanied by the development of models to predict accurately the observed deformation, fracture and recrystallization behaviour. To increase the basic understanding of deformation in hexagonal metals, equivalent studies will also be carried out on magnesium and zinc. Subsequent phases of the work, for which a separate proposal will be made later, would employ hot and cold rolling and the scale-up to larger ingots through cooperation with the European Titanium industry.

KEYWORDS

Aeronautics/Aerospace; Non ferrous; Materials science

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Contract no: BREU-0117
Proposal no: BE-3332

A STUDY OF ADVANCED HIGH TEMPERATURE CREEP RESISTANT DISPERSION STRENGTHENED TITANIUM ALLOYS USING A POWDER METALLURGICAL PROCESS

Starting date: October 1988 ***Duration:*** 30 months

OBJECTIVES

The purpose of this work was to assess the feasibility of producing high temperature creep resistant titanium alloys by dispersion of rare earth oxide particles by rotating electrode process and powder consolidation. An $\alpha+\beta$ alloy was chosen for applications in the intermediate temperature range 450-550°C and α near α matrix was selected to provide α temperature capability beyond 600°C (IM1550 and IM1834-type alloys respectively).

ACHIEVEMENTS TO DATE

During ingot productions, Y_2O_3 was directly incorporated in the alloy instead of yttrium in order to maintain the initial oxygen content of the titanium matrix. Alloy electrodes were transformed to powder by REP. For each alloy, about ten electrodes were made, yielding roughly 3kg of useful powder. Powder consolidation was performed both by extrusion and HIP'ing.

Microstructural analysis of the as-consolidated products showed, significant segregation of very large Y_2O_3 particles. The origin of this segregation was attributed to the non-dissolution of pre-existing large yttria aggregates during REP. Attempts were made to understand why Y_2O_3 was not dissolved during REP and to find out means to remedy this difficulty.

Despite the occurence of the macro-segregation, TEM study revealed a fine and homogeneous Y_2O_3 dispersion in the as-consolidated products of both of the yttria containing alloys indicating that a part of the Y_2O_3 was dissolved in liquid droplets during REP.

Mechanical tests conducted on P/M processed alloys show a substantial strength increment of the Y_2O_3 containing IMI550 extruded alloy, compared to the Y_2O_3 free alloy, particularly around 500°C. Conversely, the addition of Y_2O_3 gave no significant improvement in creep strength between 400-500°C. The strength increment provided by yttria dispersion to the IMI834 type alloy was significant at room temperature. Conversely, at 650°C the strength of both Y_2O_3 containing and Y_2O_3 free alloys after extrusion was found to be very low and both alloys showed a "superplastic" behaviour. Significantly high strengths were only observed after consolidation by HIP'ing.

KEYWORDS Dispersion-strengthened titanium; Creep resistance; Aeronautics; Materials processing; Metallic structural materials; Powder metallurgy; Materials characterization

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Contract no: MA1E -0054
Proposal no: P-0275

ENVIRONMENT SENSITIVE CRACKING OF TITANIUM

Starting date: November 1988 ***Duration:*** 36 months

OBJECTIVES

The purpose of this project is to study the behaviour of titanium grades 2, 5 and 12 in hydrogen uptake environments and the role of hydrogen and hybrides in the mechanism of cracking.

ACHIEVEMENTS TO DATE

The results obtained in:

1.SSRT and fatigue tests in air and seawater with previously hydrided and unhydrided specimens with hydrogen evolution on its surface during the test in order to assess the possible loss of ductility.

2.Electrochemical studies in different testing media to study the behaviour of these alloys in hydrogen uptake conditions.

3.SEM and TEM studies to understand the role of hydrogen and hydrides in the cracking mechanism.

Show that titanium grade 12 is the most sensitive to hydriding and cracking. A considerable loss of ductibility has also been observed in titanium grade 5. Finally, titanium grade 2 has proven to be the most resistant to the hydrogen effect on the mechanical tests.

KEYWORDS

Titanium alloys; Hydrogen; Non ferrous

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Proposal no: P-0031

DEVELOPMENT OF AN ALPHA-2 BASED TITANIUM ALUMINIDE ALLOY FOR HIGH TEMPERATURE APPLICATIONS

Starting date: July 1991 ***Duration:*** 48 months

OBJECTIVES

Current high temperature titanium alloys are limited to temperatures around of 875K, where both creep strength and oxidation resistance restrict their endurance. The titanium aluminide, Ti_3Al, offers higher temperature capability but suffers from poor fracture properties due to its having an ordered structure. Possibilities exist for improving the fracture properties while maintaining the superior creep and oxidation properties by alloying but little is understood regarding the effects of alloying additions.

This project will study the effects of impurity elements, alloying additions and thermomechanical processing on the microstructure and mechanical properties of Ti_3Al alloys. The improved understanding will be used to design an optimum alloy for more extensive process and mechanical property evaluation. The main objectives are to:

(i) develop a European-sourced alloy based on Ti_3Al with optimum levels of impurity elements/alloying additions for use at high temperatures

(ii) establish the processing parameters necessary to produce 2mm thick sheet and isothermal forging for typical structural application

iii) assess the potential benefits of the optimized composition for structural components.

The project will develop a generic understanding of Ti_3Al alloys that can be applied to future materials for specific applications.

KEYWORDS

Non ferrous; Materials characterization/Testing; Titanium alloys; Alloy development; Intermetallics

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IDENTIFICATION AND EVOLUTION OF CRYSTALLINE STRUCTURES DURING PROCESSING AND TEACHING OF SHAPE MEMORY ALLOYS

Starting date: January 1988 ***Duration:*** 42 months

OBJECTIVES

The purpose of the project is to manufacture TiNi(x) and Cu Zn Al Shape memory alloys for electrical contacts. The objective of the research is to reach a systematic approach of crystalline structures that develop in SMA during thermal and/or mechanical cycles. The economic interest lies in the fact that it will be possible to define industrial processes which are optimized at the level of cost, quality and reproductibility of materials. SOURIAU manufactures electrical contact, CEZUS and NIVAROX provide wires and strips, E.N.S.C.P. is involved in X-Rays data.

ACHIEVEMENTS TO DATE

A special X-ray diffractometer has been assembled, in which the samples can be stressed up to 10N, and gaz heated or cooled from 200°C to -180°C. Strips of CU ZN Al Ti Ni(x) alloys have been investigated in both as-recieved or trained by thermal and/or mechanical cycles states. It has been shown that in every case, the Austenite and Martensite structures are much more complex than trivial b.c.c. and closed-packed polytypic structures. Widely diversified structures appear in the as-recieved and prime-cycled training states. These evolutions during training show a stabilization which began to occur after 20 training cycles and is completely achieved after 50 training cycles.

KEYWORDS

Electrical/Electronic industry; Materials processing; Engineering (electrical); Forming/ Shaping/casting; Electronics

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DEVELOPMENT OF STEELS HAVING A HIGH ALUMINIUM CONTENT RESISTANT TO WEAR AND TO ENVIRONMENTS THAT ARE SUBJECT TO HOT CORROSION – APPLICATIONS TO COATINGS

Starting date: February 1988 ***Duration:*** 42 months

OBJECTIVES

In order to solve the problems of high temperature corrosion and wear the project involves the development of an intermetallic iron-aluminium alloy (25-28% by mass of aluminium), whose metallurgical properties will have been improved by adding other elements and hot working processes. The ingot route and the powder route will be examined and atomization will be used to produce powders. Different coatings will be prepared too (PVD, semi-transferred and low pressure plasma spray). The behaviour of these alloys will be characterized in corrosion atmosphere (carburizing and sulphidizing environment). Wear tests will be conducted.

ACHIEVEMENTS TO DATE

FeAl alloys (25%Al) with the addition of boron, zirconium and cerium have been prepared by both ingot route (vacuum casting) and by powder metallurgy. They have been extruded at 1100°C or formed by compression. Coatings of Fe Al by plasma techniques and PVD have been prepared. Best adhesion and resistance to corrosion were obtained with PVD coatings.

In tensile tests, the alloys are brittle up to 400°C, above 600°C ductility increases. A good toughness (charpy V > 505/cm^2) is found for bimodal structure produced during compression.

A special reinforcement technique of the material results in a marked improvement of the creep resistance. Initial results indicate that this alloy exhibits higher resistance to sulphidizing and oxidizing corrosion, wear and creep, than stainless steel and is competetive with Nickel based superalloys with the advantages of low density and low inherent material cost.

KEYWORDS

Intermetallic; Corrosion; Wear

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ECONOMIC AND RELIABLE TURBINE BLADING BY LOW COST SINGLE CRYSTAL ALLOY, CASTING PROCESS AND NON DESTRUCTIVE TESTING

Starting date: July 1991 ***Duration:*** 36 months

OBJECTIVES

The availability of affordable and reliable single crystal components for high temperature applications, in particular in gas turbines, is an essential aspect for competitive engines. New approaches are necessary to reduce the costs of these components, which are still to high for certain applications.

This project consists of three complementary objectives which combined will significantly decrease costs of single crystal components with high performance potential.

The first objective is to improve the performance of the single crystal material by careful balancing of conventional Ni-base alloy chemistry (rather than following the conventional method of adding extremely expensive elements like Re).

The second objective is to signficantly lower production costs by utilizing conventional vacuum casting furnaces available even in smaller investment foundries and by reducing cycle times. Process parameters will be controlled by mould design rather than by heating/cooling devices.

The third objective is to lower quality assurance costs for detecting orientation and grain structure defects by simultaneously increasing the reliability of quality control test results.

KEYWORDS

Materials processing; Aeronautics/Aerospace; Engineering (process); Forming/Shaping/Casting; Quality assurance; Superalloys/Special alloys; Materials characterization/Testing

PRIME PARTNER

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DEVELOPMENT OF ADVANCED CARBON-MAGNESIUM METAL MATRIX COMPOSITES BY APPLYING THE SEMI-LIQUID PHASE INFILTRATION

Starting date: October 1988 ***Duration:*** 39 months

OBJECTIVES

Development of a processing route for carbon-reinforced magnesium matrix composites. The research programme involves:

- optimization of the composite processing by liquid hot pressing
- coating of fibres and its influence on mechanical properties
- microstructural and microanalytical studies
- measurement of mechanical properties
- manufacturing and testing of composite sheets.

ACHIEVEMENTS TO DATE

It has been demonstrated that liquid hot pressing (with moderate pressures of about 15MPa) is a viable and relatively simple process for fabricating carbon-reinforced magnesium composites. Rupture strengths of 1400MPa have been obtained in tensile tests on unidirectional composites constituted of AZ61 matrix and M40J carbon fibres (volume fraction: 40%). Young's moduli close to the rule of mixture value have been measured.

Microstructural and microanalytical investigations have revealed:

- a satisfactory infiltration provided the fibres are not too closely packed
- no significant interface reaction zone except a slight aluminium enrichment near the fibres
- the presence of a thin MgO layer at the fibre/matrix interface.

A tool has been designed and fabricated in order to manufacture 300mm x 300mm x 1.5mm sheets in industrial conditions.

KEYWORDS

Composites (metal matrix); Aeronautics/Aerospace; Materials processing

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DEVELOPMENT OF MAGNESIUM ALLOYS FOR PRESSURE DIE CASTING IN THE SEMI-SOLID STATE (THIXOCASTING AND RHEOCASTING)

Starting date: June 1988 ***Duration:*** 36 months

OBJECTIVES

These are to develop strong magnesium alloys which can be shaped in a semi-solid state,e.g. by casting under pressure to form accurate pore-free components of good surface finish which can be strengthened by heat treatment. The effect of this on their susceptibility to electrochemical corrosion and an assessment of means of protecting them will be studied. C.E.M.E.F. are developing the Gircast process to produce AZ91 (Mg-Al-Zn) ingots suitable for semi-solid injection into a die. Fulmer is evaluating a wider range of alloy compositions for semi-solid processing and studying their casting and reheating behaviour. Both C.E.M.E.F. and Fulmer are preparing feedstock for S.A.M. to establish the industrial parameters for making components in a modified die-casting machine. Trento is developing electrochemical techniques capable of distinguishing the corrosion behaviour of the alloys in different stages of manufacture.

ACHIEVEMENTS TO DATE

Using the Gircast II process, C.E.M.E.F. have established the parameters for preparing AZ91 ingots suitable for pressure die casting. BNF-Fulmer have also prepared a range of alloys with a suitable microstructure and cast ingots for shaping. S.A.M. have developed an induction heating apparatus and carried out an extensive range of pressure die casting trials on both sets of alloys.

It has been shown that pressure die casting in the semi-solid state reduces the shrinkage porosity, especially in thick sections and also improves the fatigue resistance of such alloys.

Electrochemical techniques have been developed by Trento and specimens from the various alloys at different stages in their processing have been tested. The results have shown that no substantial differences in performance can be expected from the various alloy additions made to improve the handlability of such alloys in the semi-solid state.

KEYWORDS

Rheocasting; Thixoforming; Mining/Extraction; Materials processing; Automotive, components & parts; Pressure die casting; Semi-solid processing

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Contract no: MAIE-0055
Proposal no: P-0553

SQUEEZE CASTING OF LIGHT ALLOYS AND METAL MATRIX COMPOSITES – MECHANICAL PROPERTY EVALUATION

Starting date: February 1988 ***Duration:*** 36 months

OBJECTIVES

1. To determine the optimum squeeze casting conditions for a number of high strength Al and Mg-base alloys in order to optimize microstructure and maximize metal quality and mechanical properties.

2. To improve mechanical properties even further by producing MMCs using high strength alloys as the matrix phase for selected particulate, fibre and hybrid reinforcements.

ACHIEVEMENTS TO DATE

Combinations of squeeze casting parameters such as mould temperatures, melt pouring temperature and applied pressure have been investigated for Al casting alloys A357 and 201, for Mg casting alloy AZ91 and for wrought Al alloys 2014 and 7050. Tensile, fracture toughness and fatigue properties for squeeze cast and heat treated materials have been measured and from relationships established between casting parameters, the resulting cast structures and the mechanical properties, an optimum set of casting conditions for each alloy has been established to achieve high integrity castings with a good combination of mechanical properties. With the exception of Al alloy 2014, squeeze casting of these materials possessed good mechanical properties with significant potential for applications. MMCs with Al alloy A357 matrix and silicon carbide particulate reinforcement and with Mg alloy. AZ91 matrix and alumina fibre or hybrid reinforcement have been produced by squeeze casting. The squeeze cast MMCs exhibited increased moduli and tensile properties compared to other unreinforced matrices. Fatigue strength of composite materials with A357 and with AZ91 matrices have been measured at room temperature and at 150°C. Interactions between pure alumina and 2014 alloy matrices and titanium alloy, silver steel and stainless steel reinforcements after heat treatment sequences have been established on a quantitative basis. The project has been completed and all objectives have been achieved.

KEYWORDS Squeeze casting; Materials processing; Composites (metal matrix); Non ferrous; Materials characterization; Fatigue

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FABRICATION OF ENGINEERING COMPONENTS FROM AL ALLOY RS POWDERS. A COMPARATIVE STUDY OF THE RELATIVE IMPORTANCE OF POWDER MORPHOLOGY, COMPOSITION AND THERMODYNAMICAL PROCESSING

Starting date: February 1988 ***Duration:*** 42 months

OBJECTIVES

High temperature Al alloy components are needed for turbines, compressors, motors and chargers in aerospace, automotive and mechanical engineering sectors. These high strength structural alloys offer weight and energy savings.

The present proposal is concerned with the production of aluminium-lithium alloy components utilising rapidly solidified powders. The clear objective is to produce near net shape components in these alloys. The influence of powder surface on the mechanical properties as well as quality of PM-series has to be characterized.

ACHIEVEMENTS TO DATE

High strength AlLi-alloys and hot temperature resistant AlFeNi-alloys were produced using the rapid solidification technology.

The alloy content, but not the heat treatment, significantly influences the powder surface conditions.

AlLi-alloys as well as AlFeNi-alloys show promising mechanical properties, for example UTS>600 MPa (RT) and UTS>250 MPa (300°C), respectively.

The up scaling of the pilot processing technology to production level would seem to be possible.

KEYWORDS

Materials processing; Powders; Materials Science; Material characterization.

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Proposal No: P-0287

IMPROVED ALUMINIUM ALLOY MATRIX COMPOSITES THROUGH MICROSTRUCTURAL CONTROL OF THE PROCESSING AND FABRICATION ROUTES

Starting date: January 1989 ***Duration:*** 36 months

OBJECTIVES

The aim of the project is to produce an Al metal matrix composite with:

- improved fracture toughness
- better elevated temperature properties.

The main programme is based on Al-6061+SiC and Al-6061+SiC+Al_2O_3 produced with a range of 15-50 volume percent ceramic to study the following aspects:

- variations in manufacturing parameters, fabrication routes and heat treatment procedures
- variations in particle size, in particle shape and in the ratio of the two ceramic compounds added.

ACHIEVEMENTS TO DATE

MMCs based on Al-6061 have satisfactorily manufactured and fabricated with 15 or 20% SiC, with 10% SiC+5% Al_2O_3, with 5% SiC+10% Al_2O_3 and with 15% Al_4O_3 (Saffil) using a hot pressing powder metallurgy route, and with 60% SiC, 10% SiC + 10% Al_2O_3 (Saffil) and 10% SiC + 20% Al_2O_3 using a liquid infiltration method, modified through the use of novel preforms.

Metallographic procedures have been developed to reduce the artefacts due to unsatisfactory preparation. Room and Elevated Temperature testing of some MMCs has been reported.

It has been established that accelerated ageing occurs in 6061+20% SiC but not with 6061+20% Al_2O_3(Saffil).

KEYWORDS

Metal matrix composites; Manufacturing; Materials Characterization/Testing; Toughness; Elevated Temperature Properties

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Proposal no: P-0774

PROCESSING AND MICROSTRUCTURAL MODELLING FOR DEVELOPMENT OF ADVANCED MATERIALS BY RAPID SOLIDIFICATION TECHNOLOGY

Starting date: February 1990 ***Duration:*** 36 months

OBJECTIVES

The prime objective is to develop realistic and fundamentally sound quantitative models of the relationships between process variables and solidification structure for conditions of rapid solidification.

ACHIEVEMENTS TO DATE

Achievements to date (mid-May 1991) include:

- first ever results for spacing of primary silicon as a function of solidification variables in hypereutectic Al-Si alloys
- development of a numerical model of single cell growth that shows that steady state solutions exist for dendrites only if some anistropy stabilises the tip
- measured critical velocities for formation of αAl dendrites in laser suface traversed hypereutectic Al-Si in good agreement with predictions of competitive growth modelling
- measurements of atomizing gas velocity vs position in a spray chamber in excellent agreement with published data
- development of a numerical model of spray droplet cooling and solidification in good agreement with experimental results for Cu-6wt%Sn
- predictions of time and position dependence of temperature and state within a growing spray deposit.

KEYWORDS

Materials processing; Processing (minerals & metals); Composites (metal matrix); Metallic structural materials; Laser technology/Power beams; Materials science; Mathematical modelling

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CAST LIGHT ALLOY MATRIX COMPOSITES – ASSESSMENT OF A RHEOCASTING ROUTE

Starting date: April 1988 ***Duration:*** 37 months

OBJECTIVES

The objective of the project was to assess the potential of a compocasting route for making Al matrix composites and acquire a scientific knowledge of the rheology of the metallic slurry.

ACHIEVEMENTS TO DATE

Rheological study: at Delft University, a Couette viscosimeter was used to study the rheology of semi liquid metal and composites, as well as a micro compocasting pilot. The viscosity of fully liquid composites is about 50 to 300 times higher, depending on SiC content, than that of the fully liquid matrix, but relatively low when compared to the partially solidified matrix. In both cases shear thinning properties were measured. As sudden changes of shear rates were imposed, a time dependency was observed, called thixotropy. Interaction between ceramic particles and solid phase coalescence in the semi-solid Al alloy reduces the thixotropic tendency of the composite, by comparison with the semi solid alloy alone.

Materials elaboration and characterization: Pechiney Research centre has developed a system for particle introduction into (semi) liquid metal based on a hollow rotor principle. Partial optimization and upscaling of the system from 3kg up to a 50 scale have been carried out. 70mm diameter and 2 to 3 metre long billets of AS7G or 6061 Al alloy reinforced with 15% of 10 to 50μm SiC or Alumina particulates were made, direct chill cast and extruded. The mechanical properties were at INTA, showing encouraging levels:

Material extruded, T6	**YS(O.2%)**	**TS(MPa)**	**e%**	**E(GPa)**
6061	275	300	10	70
6061+15% Alumina 50μm	315	320	2	92
AlSi7Mg0.3	250	310	12	70
AlSiMg0.3+15% 10μm SiC_p	312	374	6	97

KEYWORDS Materials processing ; Composites (metal matrix); Materials science

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Proposal no: P-0516

ASSESSMENT OF SEMI-SOLID STATE FORMING OF ALUMINIUM METAL MATRIX COMPOSITES

Starting date: July 1990 ***Duration:*** 33 months

OBJECTIVES

Taking advantage of thixotropic properties, semi-solid state processing of metal matrix composites offers many advantages over conventional shaping processes, such as reduction of operating temperatures, porosity, shrinkage, energy consumption, tool wear, damaging of the reinforcing phases and segregation of the reinforcing phases as well as easier machining. The main objective of the current research is the assesssment of semi-solid state processing as a new near-net shape forming technique for MMCs. The rheological behaviour of semi-solid MMCs in the semi-solid state. Microstructural and mechanical characterization will, finally, assess the potential of semi-solid forming of MMCs.

ACHIEVEMENTS TO DATE

Partially solidified AlSi7Mg0.3 matrix alloys and composites are pseudoplastic and thixotropic, which is the result of the specific structure of semi-solid slurry and the interactions of the primary particles. In addtiion to earlier experiments, viscosity changes were monitored as a function of waiting time during which no stirring was applied. As a function of waiting time, the viscosity increases. It is found that the viscosity increase, which is attributed to agglomeration and bonding of particles during the period of rest, is a long-time effect, whereas return to the steady state value of the viscosity after recommencement of stirring, which is attributed to disruption of particle bonds, is a much shorter time effect. It was further found that presence of SiC inhibited bond formatoin and thus lowered the thixotropic nature of the slurry. Furthermore, the composite was partially remelted by heating in the semi-solid region. Globularization of the structure takes place more rapidly in the composites than in the matrix alloy, which is very beneficial for the forming capabilities of the material. Compression tests in the semi-solid state using a standard compression machine confirm the advantage of having a composite material since the stresses needed to deform the composites are smaller than those required for the matrix alloys.

KEYWORDS

Composites (metal matrix); Non ferrous

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MICROSTRUCTURAL MODELLING OF INDUSTRIAL THERMOMECHANICAL PROCESSING OF ALUMINIUM ALLOYS

Starting date: July 1991 ***Duration:*** 38 months

OBJECTIVES

The overall objectives of this project are to develop micromechanical models for the kinetics and the microstructural changes that take place during and after each deformation step in industrial hot processing of aluminium alloys. The effect of the microstructural changes in between deformation passes will be expressed in terms of change in the constitutive equations for flow stress as a function of strain, strain rate and temperature so that they can be incorporated directly into finite element codes which model the overall mechanical and thermal conditions of the working process.

Several other major deliverables will be developed, e.g. reproducibility of data for industrial processing using laboratory scale equipment, exactness of the use of total equivalent plastic strain for both flow stress and microstructural evolution, and role of texture development in determining recovery and recrystalisation kinetics.

KEYWORDS

Manufacturing; Recovery & Recycling; Non ferrous metals; Materials science; Mathematical modelling; Thermodynamics

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Proposal no: BE-4514

LOW COST MMC MADE BY SPRAY DEPOSITION

Starting date: June 1990 ***Duration:*** 30 months

OBJECTIVES

The objectives of the programme are research into and development of an MMC (Metal Matrix Composites) production route through spray deposition involving a relatively low price, distinct improvement of mechanical properties, such as a preliminary increased elastic modulus, and high strength at RT up to elevated temperatures. The interaction of partners with expertise in material production (Alcan, Pechiney, Fuchs), and product applications (MBB, AS, BAe) with two European institutes (INSA, LNETI) having extensive material engineering experience provides the basis for rapid and successful development from research to application.

ACHIEVEMENTS TO DATE

The first achievement to date is the definition of target properties. 7075 MMC has been supplied and investigated for initial evaluations. Billets of 8090 MMC and 7049 MMC have been produced and supplied. The forging subprogramme on 8090 MMC is underway and on 7049 MMC has just been started. The first hand forgings of 8090 are undergoing testing. The extrusion programme for producing a thin-section extrusion is currently being launched. A subgroup has defined a work sharing programme for studying and testing the heat-treatment performance. The current fundamental studies include modelling for further understanding of the microplastic behaviour of materials according to particle size, density, etc., and the measurement of elastic constants. The next topics to be handled are mainly production of forgings and extrusions for characterizing of the material in tests-supported by theoretical studies. The programme will be completed by data sheets and a cost evaluation.

KEYWORDS

Metal matrix composites; Osprey; Stiffness

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FATIGUE PROPERTIES OF HIGH STRENGTH ALUMINIUM TRANSITION METAL BASE ALLOYS PRODUCED BY RAPID SOLIDIFICATION PROCESSING

Starting date: January 1989 ***Duration:*** 42 months

OBJECTIVES

To accelerate the commercial exploitation within Europe of rapidly solidified (RS) aluminium alloys for elevated temperature fatigue applications by:

- Predicting and assessing the use of alloying additions to enhance fatigue performance through dynmanic strain ageing (DSA)
- Optimising the alloy processing (both RS feedstock production and consolidation by thermomeechanical processing) with respect to fatigue properties.
- Understanding the physical ,etallurgical basis for the response of these materials to dynamic forces (fatigue).

ACHIEVEMENTS TO DATE

- Alloying element additions to promote (DSA) have been predicted.
- Batches of candidate alloys have been produced by melt spinning to optimise ribbon quality.
- Kinetics of microstructural degradation of ribbon during processing after RS have been determined.
- Extrusion conditions have been identified to give full consolidaqtion of flake feedstock; and minimise microstructural degradation.
- Degassing requirements have been investigated in situ by X-rqy photoelectron spectroscopy and in bulk.
- Mechanical properties have been determined for 2618 and tzo RS alloys provided by sponsors, as well as for extrudes of a range of new alloys. The Most promising new compositions have shown evidence of DSA (sharp fatigue limit).
- Metallurgical studies have identified deformation mechanisms during deformation of RS materials.

KEYWORDS

Processing (minerals and metals); Powder metallurgy; Metallic structural materials; Rapid solidification processing; Materials characterisation/Testing; Aluminium alloys fatigue (S-N).

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AMORPHOUS WIRES OF R-TM ALLOYS - SEARCH FOR NEW APPLICATIONS

Starting date: May 1988 ***Duration:*** 46 months

OBJECTIVES

1. Fabrication of amorphous wires based on R-TM-TM' alloys.
2. Study of their crystallization processes, which are different from the corresponding ribbons.
3. Develop magnetic sensors based on the excellent magnetic properties-magnetization, linearity- of the amorphous wires.

ACHIEVEMENTS TO DATE:

We have prepared a number of amorphous wires and we present here representative data for the following amorphous wires

- $Fe_{77.5}Si_{7.5}B_{15}$
- $Fe_{31}Co_{40}Cr_7Si_{10}B_{12}$
- $Fe_{0.063}Co_{0.927}Nb_{0.1})_{77.5}Si_{7.5}B_{15}$.

Scientific progress

Detailed studies of:

- helical magnetic anisotropy induced by current annealing
- stress annealing dependence of magnetic properties of amorphous wires
- small angle magnetization rotation in samples annealed under torsion
- the influence of the applied torsional stress on the Inverse Wiedemann Effect.

Applications-

Development of sensors based on the amorphous wires of the type 1) displacement measuring techniques (MDL) 2) low noise level LVDT sensor and 3) magnetic field measurement based on the Inverse Wiedemann Effect.

KEYWORDS

Magnetic; Materials characterization/Testing; Super alloys/Special alloys; Materials processing

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Proposal no: P-0653

IMPROVED AND NOVEL MATERIALS FOR PERMANENT MAGNETS BASED ON RARE EARTH ALLOYS

Starting date: February 1988 ***Duration:*** 36 months

OBJECTIVES

The application of present NdFeB magnets is significantly hampered by the temperature dependence of the magnetic properties and by an insufficient resistance against oxidation and corrosion. This project aims at an improvement of these limitations following two basic routes. First, novel compounds and phases will be studied and secondly investigations will be performed to improve the existing NdFeB materials. Investigations will include meltspun metastable compounds and novel ternary alloys as well as phase relations with oxygen and corrosion protection of the existing materials. Such improved materials could considerably extend applications in areas such as automotive, consumer electronics and industrial automation.

ACHIEVEMENTS TO DATE

The coercivity and corrosion resistance of sintered NdFeB magnets have been improved by introducing the concept of two-phase magnets in which the eutectic Nd containing intergranular region is replaced by a ternary intermetallic compound. A new magnetic material based on FeB has been developed which has a 50% higher remanence than magnequench but only a modest coercivity. The applicability of this material is limited to rod or ring shaped magnets. We have discovered several new classes of intermetallic compounds that may lend themselves for future permanent mmgnet applications. The peculiar phase relationships in the NdFeC have been utiliized to prepare a novel type of rare earth base magnet in which large coercivities (800 KA/M OR 1T) are obtained already in the ingot after annealing.

KEYWORDS

Automotive components & parts; Magnetic; Powder metallurgy

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Proposal no: P-0047

NOVEL TECHNIQUES FOR PREPARATION AND CHARACTERIZATION OF HIGH-PERFORMANCE MAGNETS

Starting date: January 1988 ***Duration:*** 36 months

The objectives of the research are to develop new iron-based magnetic materials in bulk and in thin film form. Emphasis is placed on rapid solidification, and an exploratory evaluation of novel laser methods of film preparation. The intrinsic magnetic properties of these materials are to be determined and studies carried out of their metallurgical microstructure and its relation to hysteresis. Theoretical modelling of both intrinsic and extrinsic magnetic properties is to be run in parallel with the experimental studies, as a guide to optimizing the magnetic properties.

ACHIEVEMENTS TO DATE

Extensive work on the $ThMn_{12}$ structure family of alloys $R(Fe_{12-x}M_x)$, where R is a rare earth, $1 \leq x \leq 2$ and M = Ti, V, Mo... has established the crystal field and exchange interactions for this family. For permanent magnet applications, the composition $Sm(Fe_{11}Ti)$ has the best intrinsic properties, and useful coercivity is obtained in nanocrystalline, melt-spun ribbons. Each grain is a single domain, and a new model of coercivity is based on an analogy with the random magnetic anisotropy model of amorphous magnetism. Other new materials include a series of derivatives based on the Th_2Ni_{17} and Th_2Zn_{17} structures, including interstitial nitrides and carbides, and the $R_6Fe_{11}Ga_3$ compounds. A new gas phase interstitial modification process has been developed to produce powders of 2:17 and 1:12 compounds with greatly enhanced Curie temperature and anisotropy field. Iron -based thin films have also been made by thermal evaporation laser sputtering and laser chemical vapour deposition.

KEYWORDS

Magnetic; Thin films; Melt spun magnetic material

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Proposal no: P-0300

NOVEL HARD MAGNETIC MATERIALS WITH IMPROVED PROPERTIES

Starting date: May 1988 ***Duration:*** 36 months

OBJECTIVES

A promising approach to improve permanent magnets is to investigate new compounds. Structural chemistry and phase equilibria in ternary systems RE-(Fe,Co)-M will be studied in order to find highly anisotropic structures with easy axis magnetization. Metastable materials with ultrafine microstructures will be prepared by rapid solidification and suitable annealing treatments. Sintering of the materials will be studied to produce pinning-type magnets with improved coercivity and temperature stability.

ACHIEVEMENTS TO DATE

The systematic investigation of thermodynamic phase equilibria, structural chemistry and magnetism of ternary systems RE-(Fe,Co)-M (which are essentially formed by one of the early rare earth elements and a metal preferably from the 3rd,4th and 5th main group) has been completed.

The elaboration of the promising permanant magnet material $Sm_2Fe_{17}N_x$ by rapid quenching of Sm_2Fe_{17} alloys and subsequent nitrogenation treatment has been studied.

Finally, addition of alloying elements (Ni+Al, W+B, Cr+Si) to $Nd_2Fe_{14}B$ alloys has been investigated with the hope to precipitate compounds which could pin the magnetic domains and increase the coercivity of these industrial alloys.

KEYWORDS

Electrical/Electronic industry; Materials processing; Processing (minerals and metals); Magnetic; Materials characterization/testing; Research/ Development

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INVESTIGATION OF THE CORROSION OXIDATION AND THERMAL STABILITY OF NdFeB TYPE MAGNETS AND DEVELOPMENT OF IMPROVED MAGNET MATERIAL THROUGH PROCESS MODIFICATIONS AND COATINGS

Starting date: November 1988 ***Duration:*** 36 months

OBJECTIVES

The project can be considered in three parts:

- study of the protective coatings and process modifications, which includes coating magnets with a thin protective coating; coating the powder or ribbon with a protective layer; and modified ribbon processing
- corrosion behaviour studies and structural investigation of the magnets and coatings, which includes atmospheric and electrochemical tests and surface analysis studies
- magnetic characterization and further structural studies.

The technical advantages of solving the corrosion-oxidation problems for these types of magnet will lead to the wider application of magnets in devices and motors.

ACHIEVEMENTS TO DATE

Zinc and zinc alloy electrodeposited coatings have been used, with a suitable cycle, to protect sintered magnets. Good results were obtained after salt spray and industrial atmosphere corrosion tests.

An electrochemical method for corrosion behaviour assessment of magnets of this type,as such passivated or coated, is proposed. It is based on cathodic treatments and transient voltage response to double amperostatic square pulses.

Encouraging results have been obtained for very thin inorganic coatings on MQ type powder which, when polymer bonded, led to a marked improvement in corrosion resistance compared with commercial MQI based magnets. Further development and evaluation are in progress.

KEYWORDS Magnetic; Coatings; Powder metallurgy; Materials characterization; Surface treatment technnologies; Corrosion

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Proposal no: P-0049

BASIC INTERACTIONS IN RARE EARTH MAGNETS

Starting date: January 1990 ***Duration:*** 48 months

OBJECTIVES

A study is proposed on magnetic interactions and thermo-magnetic properties of hard magnetic materials which are of technical interest. The emphasis will be on new classes of materials like the $Rd_2Fe_{14}C$ and the $RFe_{10}M_2$ compounds. The study of high-field magnetization and neutron-scattering phenomena on RCo_5 and R_2T_{17} are emphasized in order to deduce consistent sets of microscopic parameters by which the basic intractions in hard materials can be understood. The search for new crystal -growth techniques is essential for this study.

ACHIEVEMENTS TO DATE

By means of the Czochralski method single crystals of RNi_5, with R=Y, La, Pr, Nd, Gd, Tb, Dy Ho and Er have been grown. Also large single crystals of Y_2Fe_{17}, Ho_2Fe_{17} and Er_2Fe_{17} have been obtained. Pseudo binary single crystals have been made of $R(Co_{1-x}Ni_x)_5$, with R=Y, Gd, Pr. Intense-field magnetization measurements have been performed on crystals of $Pr(Ni_xCo_{1-x})_5$ and PrNi5 at low temperature. Exotic behaviour is observed, associated with the crystal field level scheme of Pr^{3+}. SPD experiments have been done $REFe_{1-V_x}$ compounds, to study the influence of small deviations from the nominal composition. A complete charaacterization of the temperature dependence of the magnetic properties was carried out for R-Fe-V (R=Y, Er, Tb). The spin reorientation transition was studied, using susceptability measurements. The temperature dependence of the saturation magnetization and of the RE and Fe-sublattice anisotropies were studied using a standard VSM and SPD technique respectively. The parallel and perpendicular magnetostriction in $R_2Fe_{14}B$ and $RFe_{10}V_2$ were measured in high pulsed magnetic fields. Exchange and crystal field interactions were studied by polarized neutron diffraction measurements on $DyFe_{11}Ti$ and Er_2Co_{17}. The moments obtained for RE ions are in agreement with magnetization measurements on these materials.

KEYWORDS

Magnetic; Special alloys; Materials science; Powder metallurgy

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Contract no: BREU-0068
Proposal no: BE-3039

DEVELOPMENT OF NEW SM-FE-N PERMANENT MAGNETS

Starting date: May 1991 ***Duration:*** 36 months

OBJECTIVES

Following the discovery of a new family of interstitial rare earth iron nitrides by the prime partner in early 1990 and the achievement of remarkable hysteresis in the mechanically-alloyed samarium compound by one of the main industrial partners (Siemens), a coherent programme of research is proposed involving a rare-earth supplier (Rhône Poulenc), a major magnet manufacturer (Vacuumschmelze) and two specialized research institutes. The aim is to develop a new generation of rare-earth iron permanent magnets based on $Sm_2Fe_{17}N_{3-9}$.

Two approaches will be advanced in parallel: the one involves nanocrystalline powder produced by mechanical alloying or melt spinning, which may be textured before processing into bonded or compacted magnets; the other uses monocrystalline powder which may be oriented in a magnetic field and fabricated into polymer- or metal-bonded magnets. Both approaches promise a low-cost processing route to magnets that integrate form and function.

Magnet development will be supported by research to optimize the new alloys with respect to microstructure, magnetic performance and cost, and to upscale the gas-phase nitrogenation reaction. Materials and magnets will be extensively tested in various working environments.

KEYWORDS

Magnetic; Processing (minerals & metals); Chemistry; Rare-earth iron permanent magnets; Gas phase interstitial modification

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Contract no: BREU-0405
Proposal no: BE-4393

CONCERTED EUROPEAN ACTION ON MAGNETS - APPLICATIONS, PROCESSES, NEW MATERIALS

Starting date: May 1991 ***Duration:*** 36 months

OBJECTIVES

The previous phase of the Concerted European Action on Magnets (CEAM) was very successful in stimulating research on all aspects of rare-earth iron permanent magnets, including materials development, magnet processing and engineering developments. We intend to build on the earlier achievements in a new and final phase of CEAM which will last for three years. There are approximately 70 participating laboratories from 12 countries, including some 25 industrial firms, all of whom are actively engaged in work in this area. The concerted action involves general meetings, specialized topical meetings, a regular Newsletter, bibliographical data base and short and medium-term exchanges of research personnel between participating laboratories. A key feature of this final phase of CEAM is that advances made in the earlier phase will now be moved towards the stage of industrial exploitation. Special emphasis is to be placed on promising new developments-rare-earth iron nitrides, thin film magnets, low-cost processing routes and micromotors-all of which have significant economic potential.

The overall aim of the new concerted action is to focus development of the research base which will allow European industry to participate fully in a rapidly-evolving sector, which is set to expand dramatically in the 1990s.

KEYWORDS

Electrical/Electronic industry; Materials processing; Engineering (electrical); Magnetic; Powders; Powder metallurgy; Research/Development

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Proposal no: BE-4155

ANALYSIS OF COERCIVITY AND OF THE MICROSTRUCTURE OF HIGH-TECH HARD MAGNETIC MATERIALS

Starting date: June 1990 ***Duration:*** 36 months

OBJECTIVES

Permanent magnets based on the $Fe_{14}Nd_2B$ intermetallic compound will be produced by four different techniques: sintering, melt-spinning, extrusion and mechanical alloying. Due to the deteriorating effects of the microstructure these different techniques have so far led to only 10-20% of the theoretically achievable coercive field. Investigations of magnetization processes, hysteresis loops, magnetic after-effects and domain patterns will be performed on these different materials as a function of temperature and different types of pretreatment. These magnetic measurements will be combined with studies of the microstructure by transmission electron microscopy. In particular, the role of non-magnetic precipitation, misaligned grains, incompletely magnetically decoupled grains, structure of the intergranular phase will be studied in detail. From a comparison of the different types of permanent magnets a deeper insight into the role of the microstructure with respect to their hard magnetic properties will be obtained. Combining the results of the microstructural and the micromagnetic analysis of the different types of permanent magnets the procedures for optimizing the coercive field will be determined.

ACHIEVEMENTS TO DATE

So far, the above-mentioned types of magnets have been prepared with different compositions. Melt-spun materials have been prepared and analysed in a wide range of preparation parameters. By a well-defined optimization of the microstructure the coercive field of a melt-spun $Fe_{76}Nd_{15}B_9$- magnet could be increased up to 830 kA/m at a temperature of 150°C.

KEYWORDS

Materials processing; Magnetic; Special alloys; Materials characterization; Materials science; Powder metallurgy; Research

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Proposal no: BE-3115

DEVELOPMENT OF POWDER PASSIVATION AND SPRAY FORMING TECHNIQUES FOR RE-TM-X MAGNETS

Starting date: March 1988 ***Duration:*** 42 months

OBJECTIVES

The objectives of this project are:

- to improve the ease of handling of pyrophoric RE-TM-X powders for magnet production. This will be achieved by depositing a passivating metal film on the powder particle surfaces using a Metal Organic Chemical Vapour Deposition (MOCVD) technique
- to develop an alternative route for the production of RE-TM-X magnetics based upon the Osprey spray forming route.

ACHIEVEMENTS TO DATE

Spray forming, using the Osprey process, has been shown to be a feasible method for producing Nd-Fe-B magnet Tubes, in various sizes, have been successfully spray formed and found to have appropriate microstructures and energy products up to roughly 9MGOe. The magnetic properties were found to be slightly anisotrpic and efforts are presently being made to improve the crystalline anisotropy.

The powder passivation work has succeded in coating powders with Ni by MOCVD and in developing a thermogravimetric method of assessing the degree of passivation. Coating of the powders with Co from its acetyl acetonate has proved more difficult and efforts are continuing in this area.

KEYWORDS

Materials processing; Forming/Shaping/Casting; Magnetic materials; Characterization/Testing; Materials science; Research/Development

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Contract no: MA1E-0062
Proposal no: P-0320

NOVEL PROCESSING TECHNIQUES AND ALLOY ENGINEERING APPLIED TO ADVANCED RARE EARTH IRON BASED PERMANENT MAGNET SYSTEMS

Starting date: March 1988 ***Duration:*** 39 months

OBJECTIVES

Overall objectives of the project are to develop techno-economically viable magnets based on NdFeB or other Rare-Earth-Transition Metal-Metalloid systems, through alloy engineering and process innovation. Aims are improved thermal stability, better corrosion/oxidation resistance and cost effectiveness. Main tasks

- modification or replacement of the rare-earth rich phase
- investigate the possibilities for precipitation hardening systems
- feasibility of producing anistropic material directly from rapid solification processes
- process studies of novel raw material casting techniques, hydrogen decrepitation, hot pressing, RST and resistance sintering
- through magnetic and microstructural characterization of commercial and experimental materials
- consideration of 'fitness for purpose.'

ACHIEVEMENTS TO DATE

Achievements to date are:

- development and understanding of the Hydrogen Disproportionation Desorption Recombination process (HDDR)
- investigation of the link between microstructure, chemistry and magnetic behaviour of commercial sintered NdFeB. Incremental recoil permeability technique developed to study demagnetization behaviour
- development of hot pressing techniques and brief study of Resistance Sintering
- development of Disc Casting process for control of ingot microstructure
- quantification of the recrystallisation process in prior amorphous melt spun alloys
- confirmation that anistropic as cast melt spun alloys are unlikely to be feasible
- precipitation hardening system discovered.

KEYWORDS Magnetic; Material science; Materials processing.

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Contract no: MA1E-0061
Proposal no: P-0329

DEVELOPMENT OF ECONOMIC PRODUCTION TECHNIQUES OF HIGH PERFORMANCE RE-MAGNETS FOR MASS APPLICATIONS

Starting date: December 1990 ***Duration:*** 36 months

OBJECTIVES

The main goal of the project is the development of an economic production technique for near net-shape magnets from mechanically alloyed Nd-Fe-B powders. Besides the manufacture of polymer bonded isotropic magnets, hot pressed isotropic magnets and anisotropic magnets prepared by hot deformation processes will be examined. The essential tasks are:

- development of an economic production route of powders for mechanical alloying
- mechanical alloying of Nd-Fe-B and reaction heat treatment
- manufacture of polymer bonded magnets
- investigation of different compaction techniques for the production of isotropic or anisotropic Nd-Fe-B-magnets, respectively
- characterization of the physical and magnetic properties
- corrosion and handling tests of magnets and magnet-systems
- investigation of pinning type magnets.

ACHIEVEMENTS TO DATE

Appropriate powders for mechanical alloying of Nd-Fe-B have been produced in 5 kg batches. In pilot production facilities the mechanical alloying of such powders has been performed. The optimization of the processing parameters and of the reaction heat treatment are under investigation. In laboratory conditions polymer bonded magnets with a remnant polarization of 0.67 T and a coercivity of 13.1 kA/cm were prepared by mechanical alloying from the newly developed powders. By hot-pressing combined with a hot-deformation process anisotropic magnets with a remnant polarization of 1.17 T and an energy density of 260 kJ/m^3 have been achieved up to now.

KEYWORDS

Electronic industry; Materials processing; Magnetic; Material science; Mechanical alloying; Hot-compaction; Corrosion test

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Contract no: BREU-0156
Proposal no: BE-3466

PREPARATION AND CHARACTERIZATION OF RARE EARTH TRANSITION METAL MAGNETIC FILMS AND MULTILAYERS

Starting date: April 1988 ***Duration:*** 42 months

OBJECTIVES

The overall objectives include:

- improved methods of thin film preparation, including laser ablation deposition
- development of new techniques for the magnetic characterization of thin films, including ^{57}Fe depth sensitive conversion electron Mössbauer spectroscopy and bulk magnetic property determination using SQUID magnetometry and the Kerr effect
- preparation of thin film magnetic materials, for applications (magnetic recording, permanent magnets, soft magnetic applications.).

ACHIEVEMENTS TO DATE

The achievements are:

- rare earth(R) transition metal(M) multilayers have been prepared by different techniques. High quality films have been obtained using laser ablation deposition. Resistively heated evaporation cells have been developed for the preparation of materials with a high melting temperature
- DCEM spectrometers have been built and used for the characterization of R-Fe multilayers. A tranverse Kerr effect magnetometer has been built. It is working in an entirely automatic mode, from 15K to 300K and in a maximum magnetic field of 2T. The magneto-optical properties of R-Ni and R-Co amorphous films have been studied
- novel magnetization processes have been observed in R Co/R Co/RCo sandwich films, associated with creation or annihilation of domain walls at the interface between individual layers
- perpendicular anistropy has been obtained in Fe/Tb multilayers resulting from the low symmetry environment for Tb atoms close to the interface.

KEYWORDS

Magnetic; Multilayers/Multimaterials; Materials science

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Proposal no: P-0325

NEW MAGNETIC MATERIAL STRUCTURES FOR STATIC SENSING HEADS

Starting date: August 1991 ***Duration:*** 36 months

OBJECTIVES

New magneto-resistive materials, with an effect at least five times larger than the conventional Permalloy, will be developed in order to make highly efficient magnetic sensors.

These materials - and the associated magnetic structure - will be used in a new multiplexed magnetic read-out head organisation. Such a component fixed in front of a low speed running tape, and integrating a large number of parallel tracks -, in association with a similar writing head previously developed at THOMSON-CSF/LCR, will constitute a real break-through towards the production of a new fully digital recording system.

KEYWORDS

Magnetic recording; Sensors; Thin films; Magnetic; Multilayers

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Proposal no: BE-4112

MAGNETIC MULTILAYERS: FUNDAMENTAL AND TECHNOLOGICAL ASPECTS

Starting date: April 1990 ***Duration:*** 36 months

OBJECTIVES

Multilayers (ML) are prepared by different techniques such as, evaporation under UHV coditions and sputtering. Extensive X-ray diffraction and electron microscopy studies are made in order to correlate the properties to the structure. Magnetic and magneto-optical and transport properties are also studied.

ACHIEVEMENTS TO DATE

- in Ni/Cu for relatively thin layers the coherency strain influences the growth mode. For 6 atomic layers of Ni a perpendicular anisotropy and an enhancement of Ni moment are observed
- non-monotonous dependence of the plasma frequency on the Ni layer thickness in Ni/Pd was found by such synchrotron studies
- study of TM/Ag with TM=Ni, Fe, Co showed that there is no surface anistropy in Ni but for the other two a contribution was observed
- in Co/Pt ML for t(Co) < 8Å, a strong perpendicular anistropy is obtained and the perpendicular M-H loops are rectangular with coercivities on the order of 2 kOe. The surface anistropy contribution is +0.65 erg.cm^{-2}
- in Fe/Ni ML, grown with [1 1 1] epitaxy, Fe layers thinner than 16 atomic layers become fcc. with consequences on the magnetic properties
- Nd-Fe-B type hard magnetic materials have been sputter deposited followed by appropriate post heat treatments
- resistivity and thermopower measurements have been carried out on Co/Ag ML.

KEYWORDS

Magnetic; Multilayers; Nanotechnology; Magneto-optics; Anisotropy, Ferromagnetic resonance

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Proposal no: BE-3432

HIGH PERFORMANCE MAGNETIC FLUIDS AND COMPLEMENTARY DEVICES

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

The project is concerned with the development of ultrastable colloidal dispersions of magnetic particles in perfluoropolyether carrier liquids and of new devices based on these materials. Its aim is to provide the basis for a new class of magnetic fluids having significant benefits with respect to the ferrofluids available from conventional materials. The novel systems will take advantage of chemical inertness, thermal stability, immiscibility and low vapour pressure of the perfluoropolyethers. The research will involve the development surfactants compatible with the carriers and able to stabilise ultrafine magnetic particles. All components will be prepared and characterized by the most advanced technologies available to date. An alternative route for the preparation in-situ of dispersions is to be examined.

The dispersions will be characterized for their physico-chemical behaviour and their performance will be tested in devices. Data generated will then feed back into the optimization studies.

The result will be a range of ferrofluids with enhanced properties which will enable the design and evaluation of prototype devices having a wide range of uses in specialized engineering applications.

A European source of high quality materials will be the result of the future industrial development of the achievements of the project.

KEYWORDS

Mehanical engineering/Machinery; Prototyping; Magnetic; Smart materials; Particle technology; Colloidal systems; Flourinated fluids.

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Proposal no: BE-4122

ELABORATION AND STUDY OF SOFT MAGNETIC MATERIALS OBTAINED BY RAPID SOLIDIFICATION AND BY CHEMICAL VAPOUR DEPOSITION FOR APPLICATIONS AT MEDIUM AND HIGH FREQUENCIES

Starting date: August/September 1991 ***Duration:*** 36 months

OBJECTIVES

The basic aim of the project is the laboratory scale development of high quality iron-based soft magnetic alloys, for prospective use in medium and high-frequency devices (400Hz - 1MHz). Basically, such alloys will be required to have high saturation induction, high permeability, low losses, medium to low magnetostriction and good mechanical properties, in order to compare favorably with current materials. Applications might include medium and high-frequency transformers, actuators, inverter transformers, switched-mode power supplies, saturable reactor cores, magnetic switches.

The following key objectives are envisaged:

(i) elaboration by planar flow casting of thin (≤ 20μm) FeB-based amorphous ribbons, having low losses at high frequencies (10 KHz - 1 MHz)

(ii) elaboration by planar flow casting of crystalline high Si ribbons (4.5 wt%<Si<6.5 wt%), having good magnetic properties at medium frequencies (400 Hz - 10 KHz)

(iii) elaboration by CVD of Si (or Al) enriched conventional grain-oriented FeSi laminations, with properties optimized at medium and, if possible, power frequencies

(iv) assessment of the microstructural properties of the elaborated alloys

(v) comprehensive magnetic characterization

(vi) theoretical assessment of magnetic vs. microstructural properties.

On the he project is intended to enhance European know-how in the field of innovative soft magnetic materials.

KEYWORDS

Magnetic materials; Ferrous materials; Rapidly solidified alloys

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Proposal no: BE-4378

ADVANCES IN LASER ABLATION DEPOSITION INNOVATIONS (ALADIN)

Starting date: July 1990 ***Duration:*** 36 months

OBJECTIVES

Laser ablation deposition (LAD) has tremendous, but largely unrealized potential as a simple and versatile method of thin film preparation. This project associates five groups with complementary experience in different aspects of LAD. The aims are to develop a sound physical understanding of the process as applied to metallic and insulating compounds, and to exploit LAD for the preparation of a range of novel materials and multilayer structures for application in magnetics, microelectronics and X-ray optics.

ACHIEVEMENTS TO DATE

- study of the nature and energy of the species evaporated in LAD, by use of a CMA-QMS spectrometer
- development of particle filters for elimination of droplets ejected from the target during ablation
- growth of epitaxial films of the YCo_5 and YNi_5 compounds and layers of W, Nb, Y and Sm
- preparation of diamond-like carbon films exhibiting a long range crystalline order
- preparation of high-quality epitaxial films of 1-2-3 superconductors with Y,Pr and Eu as well as Bi-Sr-Ca-CuO films doped with Pr and Li. Preparation of off-stoichiometric multilayers of the Bi superconductors interspaced with PbO layers, with the aim of producing high-T_c superconductors without the need to perform annealing under lead vapour.

KEYWORDS

Carbon/Graphite; Coatings/Thin Films; Magnetic; Multilayers/Multimaterials; Optical; Superconductors; Materials Characterization/Testing; Materials Science

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Proposal no: BE-3560

NEW RED PHOSPHOR FOR CATHODE RAY TUBES

Starting date: December 1989 ***Duration:*** 36 months

OBJECTIVES

A new European capability for producing efficient phosphors involves:

- synthesis and characterisation of current, advanced and new phosphors;
- scaling up of the synthesis of current and advanced phosphors, and optimisation of the production parameters;
- fitting of the phosphor efficiency to the new need of contrast and brightness;
- characterisation and quality control of phosphors in a cathode ray tube;
- replacement of rare-earth matrix for the red phospher by an alkaline earth matrix;
- decrease of the doping level of the rare-earth activator;
- research of new families of cathodoluminescent materials such as alkaline-earth silicon (or yttrium) sulfides or similar compounds associated with a better knowledge of the luminescent mechanisms.

ACHIEVEMENTS TO DATE

- New synthesis of the current red no-mill phosphor Y_2O_2S:Eu with appropriate CIE colour coordinates and visual efficiency. Physico-chemical and luminescent properties.
- New red phosphor CaS:Eu : choice of the synthesis route, doping agents and concentration. Physico-chemical and luminescent properties.
- Development of a new industrial red phosphor (Y_2O_2S:Eu or CaS:Eu) and on-tube measurements.

KEYWORDS

Processing; Powder; Phosphor; Television; Optical; Material.

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Proposal no: P-2278

ULTRAFINE CATHODO-LUMINESCANT POWDERS FOR VERY HIGH RESOLUTION SYSTEMS

Starting date: 1991 ***Duration:*** 36 months

OBJECTIVES

This project aims to develop powder materials (phosphors) with homogeneous ultra fine particle sizes for very high resolution Cathode Ray Tubes (CRTs). These tubes will have significant advantages in brightness, stability, and optical clarity over those currently available. This will bring the European research consortium up and beyond the forefront of this technology.

The ultrafine particles will be synthesized using three techniques-optimized firing process, solvothermal process and sol-gel process. Particular emphasis will be placed on obtaining green phosphors. The powders will be characterized for their electro-optical, physical and chemical properties. The optimized process will be selected and a pilot plant constructed for manufacturing the phosphor. After developing suitable coating processes for the CRT screens, prototype CRTs will be assembled and tested. This project will lay the foundation for the development of cathodoluminescent materials emitting in other colours.

KEYWORDS

Chemical/Petrochemical; Manufacturing; Prototyping; Powders; Surface treatment technologies; Phosphors; Cathodo-luminescence.

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Contract no: BREU-0475
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HIGHLY REACTIVE RARE EARTH OXIDE POWDERS FOR MORE EFFICIENT LUMINESCENT MATERIALS

Starting date: May 1990 ***Duration:*** 48 months

OBJECTIVES

The first objective of this project is to develop more reactive rare earth oxide powders with improved morphology and a reduced level of those impurities that have a detrimental effect on the luminescent performance.

The second objective is to use these improved rare earth oxide powders to develop a process for the preparation of more efficient luminescent powders with narrower particle size distribution.

ACHIEVEMENTS TO DATE

Improved raw materials for the red lamp phosphor yttrium-europium oxide have been made and specifications for the best material have been fixed.

The use of co-precipitated mixed oxides instead of mixtures of oxides in the preparation of the phosphor offers important advantages: better control of particle growth in the phosphor preparation process and better luminescent performance of the final phosphor powder.

The lumen efficiency of the phosphor powder was found to be very sensitive to the presence of very small amounts of transition metals such as iron.

Raw materials have also been made for a number of green lamp phosphors. These are now being evaluated.

KEYWORDS

Chemical/Petrochemical; Electrical/Electronic industry; Engineering (Chemical); Optical; Powders; Materials Characterization/Testing; Particle technology

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Contract no: BREU-147
Proposal no: BE-3336

ERASABLE POLYMERIC MEDIA FOR ANALOG INFORMATION STORAGE AND RETRIEVAL

Starting date: April 1988 ***Duration:*** 36 months

OBJECTIVES

This project concerns the development of an optical recording, storage and retrieval system. The system incorporates erasable polymeric storage media, laser based data recording components, and data retrieval components. The main objective is to develop easier to handle and more efficient recording materials (optical polymers) than the presently available ones (e.g. photographic films). Key features are: no additional wet chemical processing during or after recording, erasability of the stored information, and hook-up to digital memories. The recording mechanism consists of laser induced thermo-optic effects in thin film liquid crystalline polymers. Novel, infrared diode laser light absorbing polymers are being developed for this purpose. These polymers will be shaped into free standing multilayer polymeric films comprising a substrate, the recording layer and eventually a protective cover layer, thus forming the integrated optical storage media. Scanning components will be developed to allow the recording laser beam to be directed over the storage media. In addition, a read system will be developed in order to retrieve the stored information and make, for instance, hard copies. A mechanism to erase the stored information will be developed, enabling use of the same spot for the storage of new data. Applications of this type of polymeric optical storage media, the recording and retrieval components, are in computer memories, the recording of engineering drawings, and office data storage. A market study and techno-economic assessment will be conducted.

ACHIEVEMENTS TO DATE

Several types of novel polymers have been developed, enabling the recording with infrared solid state diode lasers. Writing tests with lasers on the media show required recording energy densities of the order of 1 $nJ/\mu m_2$. Test films have been prepared. Polymers, scanning and writing improvements are under study.

KEYWORDS Electrical/Electronic industry; Logistics/Management/Prod. plan; Dielectrics/Ferroelectrics; Optical; Polymers; Data bases/Expert systems

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Proposal no: P-2119

FAST RESPONSE ELECTRO-CHROMIC DEVICES ON POLYMERIC SUBSTRATE (FREDOPS)

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

New optical composite materials are needed to obtain a dynamic control of light and energetic transmission properties of glazed systems. Electro-Chromism (EC) is a promising technique to obtain variable transmittance, or different colours, by electric voltage switching. Nevertheless several open problems still remain in this technology, namely in the lifetime and reliability aspects.

Specific goal of the project is to develop a Fast Response EC Device On Polymeric Substrate (FREDOPS), opening a new R & D path respect to the more diffuse line, based on coatings on glass substrates.

FREDOPS could be widely applicable: from building or transport glazing systems to communication display, light control systems for visual protection (visors, spectacles,etc.), architectural applications,etc. In order to satisfy the required range of specifications, in term of fast response (from 1 to 10 seconds), long term reliability (10^6 cycles, 5 to 10 years lifetime), high contrast level (at least 1 to 5) max operating temperature (from 70 to 110°C) three different basic system have been selected as candidates for FREDOPS.

The obtained FREDOPS systems will be submitted to an extensive performance and durability test sequence.

The most promising solutions will be selected.

An optimization phase will follow, subdivided in three application areas: curved substrates for visual protection, display, in transmitting systems. The final objective is to obtain a prototype FREDOPS for each application area, in the maximum active surface size 270 x 270mm, satisfying the specifications required by the respective sector.

KEYWORDS

Materials processing; Engineering (optical); Optical; Smart materials; Surface treatment technologies; Vision/Optical systems; Electrochromic

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GRIN MATERIAL AND TECHNOLOGY R & D FOR GRADIENT INDEX OPTICAL GLASS LENSES

Starting date: January 1992 ***Duration:*** 36 months

OBJECTIVES

The use of gradient index would significantly improve the characteristics and properties of optical mineral glass components, namely ophthalmic lenses.

The goal of the research programme is to design optical components and to develop corresponding materials for creating new glass lenses with a spatially varying (gradient refractive index) (GRIN) for use in ophthalmic optics.

The work plan covers three main areas which are interdependent and complement one another :

- design tools will be developed to model optical ray tracing in an inhomogeneous medium and to calculate the imaging properties of gradient index lenses
- suitable glass systems will be identified and three potential ways will be investigated for processing these systems to give raw glass bodies with various radial and axial index profiles suitable for ophthalmic lenses. This task will form the largest share of the total project
- an instrument will be designed and built specificallly to measure the index distribution in the raw glass bodies created in the previous activity

Through an interactive coordinated programme samples of GRIN lenses will be designed, fabricated and measured.

KEYWORDS

Materials processing; Engineering (optical); Ceramics/Glasses; Optical; Opthalmic optics; Optical index; Gradient refractive index

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LIGHTWEIGHT MIRRORS MADE OF CARBON-FIBRE COMPOUND FOR OPTICAL APPLICATION

Note: Updated information was not provided in time for publication.

Starting date: May 1988 ***Duration:*** 36 months

OBJECTIVES

The project aims to develop new composites for manufacturing large (D 7m) mirror blanks, made of Carbon-Fibre-Compound (CFC), coated with thin layers of glass or ceramic materials. The CFC provides the mechanical strength, while the glass/ceramic materials offer a polishable surface. The intial stages of the work will concentrate on the selection of the most suitable glass- and ceramic-materials, which can be combined with CFC. Small pieces of the new composite material will be investigated and later will be extended to the development of prototype mirrors with sizes of 300 mm. Parallel to the development of the glass/ceramic covered CFC material another method will be studied, namely to combine the glass/ceramic material with the CFC material itself. This process is expected to permit a continuous gradient from the CFC to the glass/ceramic structure (carbon-fibre-glass compounds CFG). The properties of the CFC material, covered by the inert material glass, offer these new composites a wide range of industrial applications.

KEYWORDS

Aeronautics/Aerospace; Composites (polymer matrix); Optical; Surface treatment technologies

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Proposal no: P-0831

LIGHTWEIGHT REFLECTORS OF CARBON FIBRE REINFORCED PLASTIC

Starting date: January 1989 ***Duration:*** 36 months

OBJECTIVES

Quality requirements in the field of radio and optical astronomy, in measurements for meteorology, oceanography and earth exploration, and in instrumentation are increasing constantly. To receive and transmit the wide variety of signals and data and to carry out measurements, telescopes and reflector systems are needed which display improved properties. Working on the basis of lightweight, carbon-fibre reinforced plastics, it is intended to develop methods of construction and structures, work out specific manufacturing techniques and processing steps, and manufacture models and samples. For the purpose of verification it is intended to measure their long-term geometric shape accuracy under operating conditions.

ACHIEVEMENTS TO DATE

Using selected fibre-resin systems numerous CFRP plates of varying thickness and structure were manufactured and examined for their suitability as reflector substrates. The surfaces of the planar plates were measured on a 3-coordinate measuring machine to an accuracy of 1µm. The measured values can be represented as Zernike polynomials, with the aid of which an error analysis can be performed as the basis for optimising structure and manufacture. Finite element calculations and sensitivity analyses complete the project work, which includes materials testing to verify the calculations. Mirror coatings have been successfully deposited on the CFRP substrates. To what extent the mirror-coated and non-mirror-coated CFRP plates will meet the optical requirements when subjected to external loading is still to be examined.

KEYWORDS

Composites (polymer matrix); Optical; Instruments/Sensors/Precision equipment; Mathematical modelling.

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Proposal no: P-2413

SUPERIOR ALUMINIUM NITRIDE WITH SPECIAL MICROSTRUCTURE DESIGN FOR IMPROVED MACHINING BEHAVIOUR

Starting date: 1991-1992 ***Duration:*** 30 months

OBJECTIVES

1) Development of AlN gradient material which exhibits an improved surface machining behaviour and simultaneously has excellent bulk properties.

2) Optimization of the mechanical (bending strength ≥ 400 MPa, fracture toughness ≥ 3.5 MPa $\sqrt{m}$) and thermal properties (thermal conductivity ≥150 W/mK).

3) Production of high quality surfaces (R<1µm) with the least possible damge only by grinding.

4) Characterization of the strength and degree of damage in ground surfaces on specimens as well as on components, especially to obtain information on the reliability.

5) Technology transfer with respect to ductile mode grinding from special to conventional grinding machines.

KEYWORDS

Optical industry; Machining; Ceramics; Laser technology; Materials science; Development

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AN ELECTROCHROMIC GLAZING SYSTEM SUITABLE FOR TRANSPORT AND ARCHITECTURAL APPLICATIONS

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

The main objective of this project is to develop glazings whose transparency can be controlled by the application of an electrical potential. This could lead to imroved comfort for individuals in transportation vehicles and within buildings, and reductions in energy consumption. The project has the specific objective of producing an electrochromic window based on lithium insertion measuring 30 x 30cm^2, capable of transmitting between 70% and 15% with a life time of 10^5 cycles and withstanding to extreme temperatures of -40°C and 100°C.

ACHIEVEMENTS TO DATE

(i) Determination of an adapted counter electrode for lithium insertion

(ii) Improvement of the environmental and electrochemical stability of sputtered deposited WO3 layers

(iii) Development of a technique of fabrication for the windows

(iv) Development of an intelligent power supply system.

KEYWORDS

Energy; Coatings/Thin films; Multilayers; Polymers; Smart materials

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Proposal no: BE-4042

NOVEL PROCESSING AND TESTING PROCEDURES OF OPTIMIZED CERAMIC OR METAL POLYMER COMPOSITES FOR ACOUSTO-OPTICAL ELECTRICAL AND MAGNETIC APPLICATIONS

Starting date: February 1989 ***Duration:*** 36 months

OBJECTIVES

In this project materials for application in integrated optics and wave guides are to be developed and their properties investigated. The materials are intended for use in electro-optic, nonlinear-optic and acousto-optic switches and modulators, as well as in photosensors and photocopiers.

The coordination is as follows: The composites proposed and developed by the partner at the University of Duisburg are being compacted by a special pressing and welding technique with superimposed high frequency (ultrasonic) vibration, developed at the University of Vienna. The macro- and microcharacterization of the materials is performed at the Max- Planck-Institute Stuttgart and at the CNRS Grenoble respectively.

ACHIEVEMENTS TO DATE

Recently an enormous development in the field of non-linear light guides took place. For electro-optic switches or modulators, poled polymers with oriented chromophore molecules have been developed. The dye orientation is achieved by poling the polymer films in high electric fields. During the last year the research programme in this project was adjusted to this actual field of interest. A multilayer stack containing optical transparent, electrically conducting ITO electrode films and ferroelectric ceramic/polymer composite layers was investigated. The polymer polymethyl-styrene was investigated as a possible electrically orientable matrix material. Using these layers an improved dipolar orientation of chromophores could be achieved.

Additionally the group in Vienna produced one by one and two by two couplers of polymer lightguides by ultrasonic welding. A method was proved by the group in Stuttgart to characterize the bonding strength substrate/layer by bending tests and that of the couplers by tension tests. The partner in Grenoble developed and proved a method to characterise defects and microcracks in ceramics and composite materials by impedance spectroscopy.

KEYWORDS

Engineering (optical); Optical; Polymers; Ceramics; Coatings; Electrical; Magnetic.

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Contract no: MA1E-0066
Proposal no: P-0157

NEW APPLICATIONS OF POLYMERS IN ELECTRONICS AND OPTICS

Starting date: May 1990 ***Duration:*** 36 months

OBJECTIVES

Very coherent and concerted research is the dominant feature of this project. Its aim is the build-up of electric, electronic, and optical devices using polymer technology. The different partners are experienced in complementary fields, from the chemical synthesis of new polymers to the manufacture of sophisticated polymer devices. The scientific fields involved in this project cover the solid state theory applied to the polymers, the electrochemistry, the chemical and physical characterization of electro-optical devices, the ion optics, the optical waveguiding and the ion implantation techniques. The practical applications are in the field of low voltage electrical connection techniques, the electronic and electro-optical devices using monolithic and hybrid technology, planar optical wave guides and contact lenses.

ACHIEVEMENTS TO DATE

- Synthesis of: - PPV samples by the precursor route
  - PTh samples by electrochemical processes
- Theoretical study of PPV doped by the chemical way
- PPV and PTh samples doped by ion implantation
- Mechanical state of the construction of an ionic column of 30 keV.

KEYWORDS

Electrical; Optical; Polymer; Micro Engineering

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Proposal no: P-3369

INTRINSICALLY CONDUCTIVE POLYMERS FOR ELECTROMAGNETIC INTERFERENCE SHIELDING

Starting date: June 1991 ***Duration:*** 36 months

OBJECTIVES

Intrinsically conductive polymers - ICPs - offer many advantages compared to materials containing conductive inclusions such as metal or carbon. However, although ICPs are already well known in laboratories, production on industrial scale is not yet possible because, among other things, the transformation process remains unknown. The aim of this project is the production of ICPs on a industrial scale for electromagnetic interference shielding (EMI).

The aims of the project are:

- Good synthesis of ICPs
- a better knowledge of the transformation process
- good knowledge and control of the physical properties of ICPs and their EMI shielding efficiency.

KEYWORDS

Electrical/Electronic industry; Carbon/Graphite; Electrical; Multilayers/ Multimaterials; Polymers

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Proposal no: BE-4577

DEVELOPMENT OF IMPROVED MATERIALS FOR HIGH VOLTAGE MULTILAYER CERAMIC CAPACITORS

Starting date: November 1988 ***Duration:*** 36 months

OBJECTIVES

Multilayer ceramic capacitors based on barium titanate dominate the low voltage (<300V) market. Their use in high voltage applications (e.g. energy storage) is limited by the relatively poor electric strength of high permittivity ceramics when compared with plastic films.

The objective of the proposed research is the development of ferroelectric materials of controlled microstructure which offer higher electric strength than currently available ceramic materials combined with a decreased dependence of permittivity upon electric field. The objective will be achieved by the development of two new materials: an ultra-fine grain ferroelectric glass ceramic at ERA Technology; a fine grain ferroelectric ceramic made of chemically derived barium titanate powders having tightly controlled morphology and composition at Istituto Guido Donegani (IGD). Complete multi-layer capacitor units will be fabricated from the most promising materials and their performance compared with the currently available commercial items made by the third partner, Morgan Matroc, Unilator Division (UTC).

ACHIEVEMENTS TO DATE

Morgan Matroc have fabricated trial multi-layer capacitors from glass-ceramic compositions developed by ERA. These units have been sintered at relatively low temperatures (700-900°C) giving a range of dielectric properties within the X7R classification. Low cost silver/palladium electrodes have used. Preliminary evaluations of energy storage indicate the target of $0.6MJm^3$ should be achieved.

The fabrication of chemically precipitated powders by IGD has met difficulties and thus a substitute powder has been obtained. Trial units from this powder are currently being fabricated. Comparison units fabricated by UTC using a conventional mixed oxide route are also being evaluated.

KEYWORDS

Electrical/Electronic industry; Ceramic/Glasses; Dielectrics/Ferrolectrics; Particle technology; Capacitors; Energy storage; High voltage.

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Contract no: RI1B-263
Proposal no: P-2344

PREPARATION AND USE OF POLYMERIC ALLOYS FOR ELECTRICAL ENGINEERING APPLICATIONS

Starting date: November 1988 ***Duration:*** 48 months

OBJECTIVES

The project is intended to show the superiority of polymeric alloys over polymer-additive mixtures in electrical engineering applications such as electric cables, insulating materials for supports, high-voltage insulators, capacitors. Mixing different kinds of polymers may bring enhancement of their electrical properties, unless alloyed by appropriate compatibilizing agents such as sequenced block copolymers. Such agents may also be used for 'alloying' inorganic, polymeric materials. The aim of the project is the optimization of polymer alloys containing polyolefinic material and another phase such as a polar polymer, a thermally conductive inorganic material, etc.

ACHIEVEMENTS TO DATE

After evaluation of different compatibilizing agents (HPB-b-Ps block copolymers), an alloy composition has been selected: LDPE : 80 parts PS : 20 parts and compatibilizing agent : 8 parts (by weight). This alloy has better electrical properties than presently used insulating materials and shows satisfying mechanical properties. Compounding has been optimized on 50kg mass scale by Werner & Pfleiderer. The 'Laboratoire de Chimie macromoléculaire et de catalyse organique - Université de Liège' prepared a whole series of diblocks copolymers HPB-b-PMMA. A selected block copolymer gives PE/PMMA alloys with good mechanical properties. Incorporation of inorganic filler encapsulated with a partially hydrolyzed PMMA in such an alloy is under investigaton. 'Université de Liège' has recently begun the synthesis of pure diblocks copolymers HPB-b-PA 6. Alcatel Alsthom Recherche has prepared, in close relation with Werner & Pfleiderer several series of PE/PA 6 alloys with available compatibilizing agents. These materials displayed satifying mechanical properties at room temperature. Work is in progress to improve low temperature mechanical properties.

KEYWORDS

Electrical/Electronic industry; Materials processing; Electrical; Polymers; Materials science;

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Proposal no: P-2226

HIGHLY ORIENTED HIGHLY CONDUCTIVE POLYMERS - A NEW CLASS OF ELECTRO-ACTIVE MATERIALS

Starting date: January 1991 ***Duration:*** 48 months

OBJECTIVES

Two years ago conductivity values nearly as high as copper were published for highly oriented polyacetylene, a prototype material for conducting polymers. The reasons for this elevated conductivity are still not clear. The objective of our proposal is to discover the mechanisms responsible for these high values, to connect them with other material properties and to improve systematically the quality of synthesis. Only the combination of different specialized experimental methods on exactly the same type of samples allows the evaluation of these parameters and requires the collaboration of different groups. These proposed methods are optical spectroscopy and Raman investigations, DC- and AC- conductivity, transient photoconductivity and photoinduced absorption, nuclear magnetic resonance and electron spin resonance, electron energy loss spectroscopy, and structural investigations. The results obtained for polyacetylene should then, hopefully be transferred to other conducting polymers.

KEYWORDS

Engineering (electrical); Electrical/Electronic industry; Electrical; Electronics; Materials science; Nanotechnology

PRIME PARTNER

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MEDIUM VOLTAGE POLYMERIC POWER CABLES – CLARIFICATION OF THE CAUSE OF WATER TREEING AND METHODS OF ITS PREVENTION

Starting date: February 1989 ***Duration:*** 48 months

OBJECTIVES

Europe supplies about 50% of the extruded polymer medium voltage power cables to a competitive and growing world market (1,200 MECU per annum). The life of cables can degrade from the requisite 40 to less than 10 years through the formation of 'vented water trees' at the semi-conducting screen. Current solutions are based on the use of tree growth inhibitors which have yet to demonstrate their long term benefits. The solution proposed here is based on recent work on electrochemical oxidation and on ion penetration which suggests that control of the ionic content and permeability to ions of the screen material, coupled with inclusion of ion traps in the polymer, should suppress water treeing. This would increase the competitiveness of European manufacturers while requiring only limited modification of the manufacturing process. To gain acceptance for this novel technique manufacturers must establish the links between oxidation processes, ion penetration and tree growth and demonstrate to cable purchasers through mutually acceptable cable tests that sheat control and additives that will overcome this problem.

KEYWORDS

Electrical/Electronic industry; Dielectrics/Ferroelectrics; Electrical; Polymers.

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Proposal no: P-2245

SOLID ELECTROLYTIC CAPACITORS WITH CONDUCTING POLYMERIC ELECTRODE SYSTEM

Starting date: January 1989 ***Duration:*** 36 months

OBJECTIVES

Solid electrolytic capacitors are characterized by a high capacitance to volume ratio . The demand is very high and met mainly by aluminium capacitors based on thin aluminium oxide in combination with a contact medium (electrolyte). Currently used solid semiconducting electrolytes are formed by costly and time consuming processes and such capacitors also exhibit large leakage currents, limited reliability and relatively high power losses.

The main objectives of this project are:

- To synthesise novel organic semiconductors showing good thermal stability (>260°C) and electrical conductivity (>1 S cm^{-1}).
- To develop deposition techniques for such organic semiconductors.
- To assess the behaviour of dielectric organic semiconductor interfaces.
- To fabricate and characterize the performance of a prototype aluminium electrolytic capacitor using novel electrically conducting organic electrolytes leading to a considerable improvement in performance and stability, saving in manufacturing cost and time.

ACHIEVEMENTS TO DATE

Capacitors with solid organic electrolytes have to be fabricated and are undergoing long-term testing. The capacitors show lower loss and higher capacitance per unit volume than their counterparts based on the more conventional manganese dioxide technology. In addition capacitor fabrication is both simpler and cheaper.

Research into improved organic semiconductors is continuing and materials are now available which are stable at temperatures in excess of 280°C, fulfilling the requirements of surface mount devices.

KEYWORDS

Electrical/Electronic industry; Manufacturing; Electrical; Chemistry; Dielectrics/Ferroelectrics; Materials characterization/Testing; Materials science.

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IMPROVEMENTS IN SURFACE PREPARATION OF ELECTRICAL CONTACTS AND ORGANIC THIN FILM DEPOSITION

Starting date: September 1990 ***Duration:*** 36 months

OBJECTIVES

The aim is to improve surfaces of electrical contacts, in order to achieve better reliability against corrosion, aging, wear and vibration, and to decrease production cost through noble metal saving or improvements of plating. This will be done by better control of undesired film formation, selection of surface additives (such as lubricants thin film deposition procedures set up).

Influence of film thickness, in the range of 1 to 100 nm, will be studied for various layers such as lubricants, oxidation or conversion products, grafted polymers. An original procedure based upon electropolymerisation, presently at the research stage, will be developed. Degradation mechanisms in an agressive automotive environment will be studied on a quantitative basis; test methods will be developed; effect of applied voltage and current will be taken into account.

ACHIEVEMENTS TO DATE

- Preparation and characterization of metallic surfaces is finalized.
- Formation and study of passivated films is under way.
- Automotive test procedure is defined.
- Test benches are close to achievement.

KEYWORDS

Electrical/Electronic; Electrical; Coatings/Thin films; Lubricants; Materials science; Surface treatment technologies

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Contract no: BREU-0205
Proposal no: BE-3476

ELECTRONIC AND ELECTRICAL APPLICATIONS OF ADVANCED CONDUCTING POLYMERS

Starting date: December 1989 ***Duration:*** 36 months

OBJECTIVES

Advanced conducting polymers which are processable and thermally stable with good ageing properties will be synthesized.

Their use will be assessed for two industrial applications:

- cable technology: production of semi-conductive jackets for high-voltage energy transportation: Alternating current (AC) and direct current (DC).
- Microelectronics: manufacturing of supercapacitors and energy microstorage devices.

ACHIEVEMENTS TO DATE

Chemical preparation has been achieved in one litre scale reactors for different conducting polymers in doped conductive form: polypyrrole (PPY), polythiophene (PT), poly octyl thiophene (POT) (Solvay) and polyaniline (PA). Chemical undoping of PT, POT, PA is possible.

- High quality PPY has been obtained which reliably yields to more than 90 Ah/kg of electrochemical capacity and 200 Farad/gram of double layer capacitance.
- Composite materials have been obtained with insulating thermo-plastics and PT, POT or PA. Polyethylene insulator in contact with these materials has better dilectric rigidity and is more reliable when it is in contact with the usual semi-conducting materials made from carbon black.

KEYWORDS

Chemical/Petrochemical; Electrical/Electronic Industry; Energy/Power generation; Electrical; Polymers; Chemistry; Materials science

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Contract no: BREU-0048
Proposal no: BE-3286

OPTIMIZED PROCESSING OF POLYMERIC FILM DIELECTRIC FOR AC POWER CAPACITORS

Starting date: August 1990 ***Duration:*** 36 months

OBJECTIVES

This co-ordinated activity covers the development of improved dielectrics with optimisation of conditions across the whole manufacturing process to include:

- polymer resin type, purity and additives;
- film extrusion, orientation and morphology;
- capacitor winding, impregnation and heat-treatment;
- criteria for customer acceptance.

The coordination of work involving manufacturing and interactive processes carried out by different manufacturers is a key element in achieving the rapid development of materials, enabling the production of power capacitors with increased operating stress, improved reliability and increased temperature range.

ACHIEVEMENTS TO DATE

Test specimens have been prepared based on alternative resin formulations and film extrusion parameters. The chemical and physical characterisation of samples is well advanced and special equipment and methodology has been developed for assessing components in polymers. The evaluation of model capacitators has started using stress and temperature accelerated testing.

KEYWORDS

Chemical/Petrochemical; Electrical/Electronic Industry; Processing (Rubber & Plastic); Dielectrics/Ferroelectrics; Materials Characterisation/Testing

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Contract no: BREU-0166
Proposal no: BE-3587

POLYMER ELECTROLYTES INVOLVING MULTIVALENT CATIONS

Starting date: 1990 ***Duration:*** 42 months

OBJECTIVE

Polymer electrolytes is the name given to a new range of solid state materials in which ionic salts are dissolved in suitable coordinating high polymers; in many cases, the salt solubility is very high. Research on these materials to date has concentrated on lithium ion- and sodium ion-containing systems. These generally have relatively high ionic conductivities and are being developed as potential electrolytes for all-solid-state high energy batteries. In this programme we propose to study analogous systems based on salts of alkaline earth, transition metal and lanthanide cations.

We anticipate that polymer electrolytes based on such salts will have interesting and useful electrical and optical properties. The particular advantage of these materials from a practical point of view is that, unlike, for example, crystalline solid electrolytes, they may be readily fabricated into useful shapes of forms, such as thin films using established techniques.

ACHIEVEMENTS TO DATE

During the first nine months of the project, methods for preparation and characterisation of materials have been established. Preliminary studies on a range of transition metal ion and lanthanide ion containing systems have been made. Studies on alkaline earth based conductors using plasticised PVC membranes have also started.

KEYWORDS

Electrical; Polymers; Polymer Electrolytes

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Contract no: BREU-0167
Proposal no: BE-3247

RESEARCH ON A CATHODIC MATERIAL FOR SECONDARY LITHIUM CELL, METHOD OF SYNTHESIS AND FEASIBILITY OF AN INDUSTRIAL PROCESS

Starting date: February 1990 ***Duration:*** 36 months

OBJECTIVES

This proposal concerns research on a cathodic material for a lithium secondary cell, as well as the process for its preparation.

Lithium secondary cells present considerable interest in terms of energy density when compared to existing secondary cells (2 to 3 times that of nickel-cadium, i.e. 120 Wh/Kg versus 40 Wh/Kg).

One of the problems to be solved in order to develop a practical secondary cell, for the general market, is the development of a new cathodic material capable of satisfying a number of criteria, notably: electrochemical reversibility, specific capacity (>600 Ah/dm^3), a potential of 2.5 to 3.5 volts versus lithium, non-toxic and non-polluting, having a reasonable production cost and stability in organic electrolyte media.

ACHIEVEMENTS TO DATE

During the first year, the work has been oriented towards the preparation of many samples of cathodic materials based on Manganese dioxide, and testing in electrochemical coin cells, on a limited cycle life.

The behaviour of the different phases α, ß and MnO2 has been studied. Chemical lithiation of these materials led to compounds of general formula LixMnOy, which are identified to be reversible cathodic materials.

Among the different products tested, it has been shown that the α MnO2 lithiated material gives superior performances (up to 170 Ah/Kg, 640 Ah/dm^3) versus all the MnO2-based materials known to date. EMD or CMD-based materials are also under investigation, which was the objective of the contract.

The manufacturing processes of these products has been evaluated on a pilot production basis, and proved to be compatible with an industrial processing.

KEYWORDS

Power generation; Processing (minerals & metals); Chemistry; Electrochemistry; Lithium; Manganese dioxide

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Proposal no: BE-3372

NEW MANUFACTURING TECHNOLOGIES FOR ADVANCED SOLID OXIDE FUEL CELLS

Starting date: May 1990 ***Duration:*** 36 months

OBJECTIVES

The Solid Oxide Fuel Cell (SOFC) provides a new and exciting option for the conversion of fossil fuels, including natural gas, into electricity. It does this with higher efficiency and lower pollution (virtually no NO_x) than conventional means. The SOFC has not been commercially successful yet because the fabrication costs for the existing designs and technologies are prohibitive. We have recently developed a new design which has the potential to solve the cost problem. The objective of this research is to develop the associated manufacturing technologies.

ACHIEVEMENTS TO DATE

The new dseign uses a flat plate, rather than a tubular, geometry which allows low cost, high volume ceramic processing technologies to be used (extrusion, screen printing, tape casting, etc.). The support is the largest and most complex component in the design (typically 100x200x17 mm) and has been successfully extruded. The support's thermal expansion coefficient has ben optimzed to closely match that of the active cell.

Cell components have been obtained by the tape casting and tape rolling techniques. These foils are strong (450 MPa), gas-tight, 150 μm-200μm thick, flat when sintered and relatively large (80x80 mm). Single active cells were successfully produced from these electrolyte foils by coating either side with the electrodes. These single cells were operated at 1000°C with a H_2/Air combination to produce electricity.

KEYWORDS

Energy/Power generation; Processing (ceramic & glass); Ceramics/Glasses; Electrical; Materials Science; Research/Development; Fuel Cells

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Contract no: BREU-0185
Proposal no: BE-3589

MANUFACTURING TECHNIQUES FOR COMPONENTS OF FLAT PLATE, SOLID OXIDE FUEL CELL (SOFC) REACTORS

Starting date: July 1991 ***Duration:*** 36 months

OBJECTIVES

The project will investigate reproducable manufacturing techniques for components (electrodes, electrolyte, metallic bipolar plate, gas manifolding) for upscaled, flat plate, solid oxide fuel cells (SOFC). For larger SOFC reactors (+-1 kW) these components are needed in greater quantities, with enlarged dimensions. New manufacturing techniques for SOFC powders and assembled SOFC composites are necessary.

- Techniques for powder preparation will be investigated for the fabrication of ceramic electrode materials. These techniques are available on laboratory scale, but are not state-of-the-art for the quantities (kg/day) needed for a sufficient homogeneity of larger quantities of ceramic components
- for the ceramic components, manufacturing of surface-enlarged, thin, sintered electrolytes will be investigated using tape casting techniques. Reproducibility of the fabrication technique for larger quantities of sintered electrolytes will also be investigated
- coating techniques of the electrolyte with electrode materials will be investigated, which finally leads to reproducable fabrication of batches of ceramic composites
- given the boundary conditions of SOFC, new metal alloys with a coefficient of thermal expansion very close to that of the ceramic components will be investigated to come to a suitable metal/ceramic compound. In addition, manufacturing techniques for the bi-polar plate and joining techniques of electrolyte and electrodes with the metal are not state-of-the-art and will be investigated.

KEYWORDS

Solid oxide fuel cell; Tape casting; Powders; Ceramics/Glasses; Composites (ceramic matrix); Metallic structural materials; Multilayers/Multimaterials

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Proposal no: BE-4439

FERROELECTRIC POLYMER AND COMPOSITE SENSORS AND TRANSDUCERS

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

This research programme is designed to produce a new generation of piezoelectric and pyroelectric sensors and transducers by developing new materials based upon ferroelectric polymers and polymer composites. These materials will combine the advantages of polymers (flexibility, large area capability, ease of shaping into a variety of forms and low cost) with the electrical properties which are normally associated with ferroelectric ceramics or single crystals. This will be done by using new techniques such as polymer evaporation onto crystal substrates and oxide crystallite orientation processes in the composites, making use of controlled morphology crystallites. The new materials will be applied to the preparation and testing of acoustic and infrared device demonstrators.

ACHIEVEMENTS TO DATE

A range of ceramic formulations has been prepared in bulk and powder form and been assessed for use in 0-3 composites. Of those assessed one ceramic system has shown particular improvements over the conventional ceramic system and is being further investigated. Significant differences have been observed between bulk ceramic properties and the predicted behaviour of this system in a fabricated composite, particularly in poling characteristics, and these differences are being examined. Novel routes to the preparation of highly anisotropic composite structures are being investigated and samples have been successfully fabricated but are proving difficult to pole successfully, this problem is being addressed. Good quality thin ferroelectric thin films are being deposited on a range of substrates, alternative substrates and surface preparation techniques to give improved growth characteristics have been identified. Optimisation of the deposition parameters is being undertaken to allow films with improved morphology for device applications to be fabricated. Investigation of the pyroelectric properties of composite materials has shown initial problems with reliable measurement of pyroelectric coefficient, a measurement technique for reliable characterisation has been developed and is now producing consistent results. Useful pyroelectric properties have been demonstrated and work to improve the overall material performance is progressing.

KEYWORDS Ferrolelectrics/Dielectrics; Composites (polymer matrix); Polymers; Ceramics; Sensors.

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Contract no: BREU-0140
Proposal no: BE-3096

PIEZOCERAMICS FOR SAW DEVICES - HYDROTHERMAL SYNTHESIS AS A METHOD TO ACHIEVE SUBMICRON GRAIN SIZED POWDER

Starting date: January 1992 *Duration:* 36 months

OBJECTIVES

The aim of the project is to increase the frequency range for which piezoceramics can replace single crystals in bulk and surface acoustic wave (SAW) devices. Piezoceramics offer advantages over single crystals such as tailoring of properties through changes in chemical composition and relative ease of fabrication. However, at present, their use is limited to frequencies below 20 MHz for bulk devices due to the low mechanical strength 0.05-0.1 mm thick samples and to the coarse grain structure which leads to inhomogeneous properties in this thickness range. For SAW devices coarse grains lead to high propagation losses and limit their use to <100MHz.

The project will concentrate on the fabrication of fine grained ceramics with high mechanical strength using powders prepared by hydrothermal synthesis. This technique gives uniform, reproducible submicron particles at relatively low cost compared to other chemical preparation methods. In addition to powder preparation and characterization, studies will also be carried out to correlate the powder process and ceramic fabrication with material properties. Prototype devices for both bulk and SAW devices will be manufactured and their performance tested.

KEYWORDS

Materials processing; Piezoceramics; Hydrothermal; SAW devices

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Contract no: BREU-0504
Proposal no: BE-4222

MAGNETIC MATERIALS FOR ACTIVE CONTROL OF ANTI-VIBRATION SYSTEMS

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

The overall objective of the project is to demonstrate the potential for using magnetostrictive materials in industrial processes, such as high-speed machinery, robotics, acoustic devices and anti- vibration control systems.

This will be achieved by designing and optimising a high-energy system to demonstrate active anti-vibration control over a wide frequency band-width. Actuators will be designed around highly magnetostrictive materials. In order to assess vibrations, sensors and high-speed control systems will also be built and included in an experimental facility fitted with sensors. The project will produce a fully documented demonstration device which will illustrate the capability of anti-vibration systems.

The enabling technology which is developed in actuation and control will be applicable to the other industrial processes mentioned above. Companies working in these fields will be involved in project working parties to ensure the early utilization of the technology within Europe.

ACHIEVEMENTS TO DATE

Phase 1. Design, production and measurement of a high-energy actuator building of an experimental facility Months: 0 to 16.

Phase 2. Preparation of the control system Months: 6 to 16

Phase 3. Active control experiments.

Improvements to the actuator design and the control system Months: 14 to 36.

KEYWORDS

Vibration analysis; Acoustics; Magnetic; Instruments/Sensors/Precision equipments; Sensors/Signal processing; Computer science/Software; Research/Development

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Contract no:
Proposal no: BE-4012

THE FABRICATION OF COMPOSITE ELECTRO-MECHANICAL DEVICES FOR MICROMOVEMENT APPLICATIONS IN MANUFACTURING PROCESSES

Starting date: February 1990 ***Duration:*** 36 months

OBJECTIVES

To establish technologies for the fabrication of low voltage, high reliability, ultra-precise micromovement devices which utilise functional ceramic elements in multilayer configurations.

ACHIEVEMENTS TO DATE

(1) Certain doped lead zirconate titanate (PZT) systems combine good electrical/electromechanical properties with ability to be cofired with AgPd electrode systems. Chemically prepared materials show great promise for low firing temperature and very thin active layers.

(2) The major fabrication effort has been to develop ceramic tape casting with electrode screen printing. Multilayer screen printing of thick film pastes is a promising alternative technique. Experiments using laser ablation-deposition have revealed difficulties in forming coherent electrode layers.

(3) Consolidation routes by conventional firing have been successfully established for laminated tape and multilayer screen printed forms. Laser ablation-deposition structures have been successfully annealed.

(4) Routine electrical/electromechanical measurements have been made on initial devices. Force measurements as a function of frequency and lifetime testing under load have commenced.

(5) Finite element analysis has been used to compute 20 field and stress distributions for sections in the vicinity of an electrode discontinuity.

KEYWORDS

Processing (ceramic & glass); Dielectrics/Ferroelectrics; Multilayer/ Multimaterials; Mathematical modelling; Laser technology/Power beams; Reliability; Precise micropositioning & micromovement

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Contract no: BREU-0079
Proposal no: BE-3467

STUDY OF NEW MATERIALS AND DESIGNS FOR ADVANCED MICROMOTORS

Starting date: July 1990 ***Duration:*** 48 months

OBJECTIVES

For various applications very small motors or actuators are required. Due to different loads the speed and torque capabilities may vary between broad limits. The size of the motor/actuator should be as small as possible, e.g. in the region of millimetres and submillimetres. Only with advanced materials (high energy permanent magnets, thin layer technology), can integrated microcomputer control and latest design considerations such micromotors and microactuators be achieved. The main objective of the project is, taking into account the recent developments of improved Nd-Fe-B and bio-compatible materials and microelectronic and micromechanical fabrication techniques, to make research-type millimetre and submillimetre micromotors/actuators, using electromagnetic and electrostatic principles. In order to make these microdevices of practical use in the foreseeable future, we investigate certain fundamental problems, such as micromechanical properties, mechanical handling and loading, design procedures, assembly strategies, friction and wear of microdevices.

ACHIEVEMENTS TO DATE

During the first year of the joint research activities the first prototypes were designed and built. Work concentrated on electrostatic and electromagnetic motors. Special miniature disc-windings were also designed and produced. However, the etched windings or multi-layer windings are not restricted to the disc-type motor design. They can also be used for cup-type motors with reduced length of the end winding. Design studies were also undertaken to compare the specific power for electromagnetic and electrostatic motors. Depending on the motor geometry, from a rotor diameter of 3mm onward the electromagnetic motor is more advantageous. The electrostatic devices are superior below 1mm of rotor diameter.

KEYWORDS

Multilayers; Micro engineering; Mathematical modelling; Micro motor; Micro actuator; Electrostatic motor

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Contract no: BREU-0207
Proposal no: BE-3360

ECONOMIC ELECTRICAL DRIVE FOR HIGHLY DYNAMIC APPLICATIONS

Starting date: January 1992 ***Duration:*** 36 months

OBJECTIVES

The aim of the proposed R & D project is to further develop Switched Reluctance (SWR) drives for highly dynamic and very high speed applications and to boost its use in a wide application area.

Although much broader in its application, it will be demonstrated that the SWR drive will outperform the classical drive solution in the textile industry as a machine drive, in the process industry as a valves actuator and in the chemical industry as a very high speed vacuum pump.

Compared to classical drive the new drive will be shown to be more energy efficient, more robust and simpler to manufacture, to have a higher controllability of the torque and to have a higher dynamic behaviour.

Its development and implementation in Europe can improve the competitive position of the European industry in several sectors where drives are used and of the drive manufacturers.

KEYWORDS

Magnetic; Prototyping; Switched Reluctance Motor; Research/Development; Electrical; Design

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Proposal no: BE-4640

SEGREGATION IN OXIDE CERAMIC MATERIALS AND ITS EFFECT ON PROCESSING AND PROPERTIES

Starting date: 1990 ***Duration:*** 48 months

OBJECTIVES

This programme will investigate interfacial segregation in oxide ceramics and evaluate the effect of this segregation on processing, reactivity and final properties. The objective is to study in depth the crystals chemistry of the interfaces in order to optimize the parameters which are important for specific applications. The project involves a review of the present state of knowledge of defect chemistry for near-surface and grain boundary regions, the derivation of a theory of segregation and the determination of the effect of segregation on the heterogeneous kinetics. The construction of a prototype surface sensitive equipment will allow in situ surface characterization of materials at elevated temperatures and under controlled gas atmospheres. The emphasis will focus on model oxide systems such as NiO, CoO, TiO_2 and perovskites such as $BaTiO_3$ and their solid solutions.

ACHIEVEMENTS TO DATE

It has been documented that non-stoichiometry, determined for materials in equilibrium with oxygen pressure, has a strong effect on the segregation profile, as established by previous authors regarding Cr-doped CoO equilibrated at 1500 K under different oxygen activity.

Preliminary experiments have also indicated that, in given experimental conditions, the segregation leads to the formation of bidimensional surface structures and even to precipitation of a second phase.

It has also been published that diffusivity in the bulk is substantially different from that within the interface region as a result of changes in both composition and structure. But little is known of the effect of segregation on the diffusion of defects both along and across interfaces.

KEYWORDS

Ceramics, Materials processing; Processing (ceramic & glass); Diaelectrics/ Ferroelectrics; Materials science; Segregation

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Contract no: BREU-0144
Proposal no: BE-3595

AN INVESTIGATION INTO METHODS OF TEXTURING HIGH-T_C SUPERCONDUCTORS FOR HIGH J_C APPLICATIONS

Starting date: December 1990 ***Duration:*** 36 months

OBJECTIVES

The objective of the proposed project is to increase the transport critical current density, J_C, of high T_C bulk superconductors up to values sufficient for industrial applications by aligning the grains of these materials, in order to ensure practical continuity of the superconducting a-b planes and to reduce, as much as possible, the atomic disorder at the interface of the grains.

ACHIEVEMENTS TO DATE

Three methods have been investigated: magnetic alignment at room temperature of single crystalline grains, sintering under a heavy load, and melt texturing of YBaCuO. With the first two processes we have achieved very good alignment of the a-b planes, but the transpot critical current density is still rather low: about 1000 A/cm^2, at 77k. With melt texturing we currently attain 10 000 A/cm^2, but the alignment of most of the grains is still random; however, using Bean's method we found that J_C parallel to the a-b plane is about 100 000 A/cm^2 at 77k. Association of melt texturing with either magnetic alignment or "creep sintering", to try to combine the advantages of the different methods, is now in progress.

KEYWORDS

Materials processing; Ceramics/Glasses; Superconductors; Powder metallurgy.

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EUROPEAN RESEARCH PROJECT ON 'HIGH TEMPERATURE' SUPERCONDUCTORS FOR POWER CABLES

Starting date: March 1990 ***Duration:*** 21 months

OBJECTIVES

The newly discovered superconducting ceramic materials are of immediate technological interest because they can maintain their superconductivity up to temperatures where applications based on this property become technically and economically attractive. This fact is widely appreciated in Japan and the USA, where substantial funds are being committed to research and development of these novel materials. This project would promote a concerted European research effort in one of the main potential applications of high temperature superconductors, namely power cables, with the aim of developing superconducting power cables that will operate at above 77K, and ideally at ambient temperature or higher. The project will focus on the basic research that needs to be done towards reaching this goal. Emphasis will be placed on identifying and characterizing new materials with improved superconducting properties and on developing technologies for fabricating experimental cable conductors that incorporate these advantageous materials. Efforts will be made to optimize these in terms of current carrying capability and minimise AC power loss. If successful, this pre-competitive research will represent a major step towards the realization of superconducting power lines that could save a large proportion of the 2.5 billion Ecu, or more, that is lost annually in electricity transmission throughout the EC.

KEYWORDS

Superconductors; Ceramics/Glasses; Materials science; Electrical.

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Contract no: BREU-0095
Proposal no: BE-3092

CERAMIC SUPERCONDUCTING FILAMENTS AND RIBBON PRODUCED BY SUSPENSION SPINNING AND TAPE CASTING

Starting date: January 1990 ***Duration:*** 28 months

OBJECTIVES

The objective is to produce a shaped superconducting material with a thickness between 0.05 and 0.5 mm and a critical current density of 10^6 to 10^7 A/m^2 at liquid nitrogen temperature by a low cost shaping technology which can be used for mass production. Suspension spinning and tape casting provide the possibility to produce free self-supporting filaments or ribbons which can be subjected to further upgrading treatments to increase the critical current density of the ceramic superconducting material without contamination from other composite materials. The filaments and ribbons produced are not a final product but part of a complex composite conductor of ceramic superconducting material and metallic materials.

ACHIEVEMENTS TO DATE

- Progress of the development of a suspension for tape casting, but some problems remain to be solved.
- A suspension for wire spinning has been formulated which allows the production of batches of wire. Work continues in order to obtain a higher density.
- Experiments show that binder and additives can be removed almost completely at temperatures between 300°C and 500°C. Sintering may be performed on a number of substrates. Optimum results are obtained on Y_2BaCuO_5.
- Material with T_c of 90 K and J_c of 300 A/cm^2 is obtained after sintering.

KEYWORDS

Forming/Shaping/Casting; Ceramics/Glasses; Superconductors

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Proposal no: BE-3236

IMPROVEMENT OF THE PERFORMANCE OF PLASMA SPRAYED CERAMIC SUPERCONDUCTIVE LAYERS DEPOSITED ON METALLIC SUBSTRATES

Starting date: March 1990 ***Duration:*** 36 months

OBJECTIVES

The objective of this project is to develop the plasma spraying deposition technique and the subsequent materials processing parameters in such a way that the superconductive properties are sufficiently good for practical applications.

ACHIEVEMENTS TO DATE

The achievements to date are that the basic problems of interaction and adherence of the High-T_c layers, deposited by means of plasmaspraying, have been identified. These problems are related to the choice of substrate and interlayer materials and the processing parameters.

The first steps have been taken to solve these problems. The next step will be adapting the post-deposition processing conditions in order to improve the superconductive properties.

KEYWORDS

Materials processing; Coatings; Superconductors; Materials science

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Proposal no: BE-3503

GENERATION AND CRITICAL EVALUATION OF THERMOCHEMICAL AND PHASE DIAGRAM DATA PERTAINING TO THE FIELD OF HIGH T_C OXIDE SUPERCONDUCTORS (SUPERDATA)

Starting date: July 1990 ***Duration:*** 36 months

OBJECTIVES

The purpose of the SUPERDATA project is:

- to provide information on the optimum thermochemical conditions for preparation of known (YBaCuO based) superconducting phases
- to define stability ranges of these phases as a function of process parameters
- to provide a basis for phase equilibrium calculations in other potential superconducting oxide systems.

For this purpose experimental thermochemical methods as well as data assessments and ab initio calculations are employed.

The expected results are:

- critically assessed and consistent thermochemical data for all relevant phases, i.e. Gibbs energy data as a function of composition and temperature
- a comprehensive specialised literature database for thermochemistry and phase diagrams.

ACHIEVEMENTS TO DATE

Literaturebase.

First data assessment for metallic subsystem Y-Ba-Cu and Me-O subsystems.

KEYWORDS

Electrical/Electronic industry; Superconductors; Thermodynamics; Research/ Development

PRIME PARTNER

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Contract no: BREU-0203
Proposal no: BE-3378

DEVELOPMENT OF CVD, METAL-ORGANIC PRECURSORS AND PATTERNS TECHNIQUES FOR HIGH T_C APPLICATIONS

Starting date: 1991 ***Duration:*** 48 months

OBJECTIVES

The overall objective of the project is to demonstrate the capability of producing patterned, high Tc, layered, superconducting materials.

This will be achieved through the development of:

- novel, volatile precursors suitable for high Tc, mixed metal oxides;
- a prototype, metal-organic chemical vapour deposition (MOCVD) reactor designed to suit the novel precursors;
- a fundamental understanding of the effect of deposition parameters on layer characteristics and properties and
- novel patterning techniques suitable for both thin and thick films.

KEYWORDS

Superconductors; Organometallic materials; Thin films; Metal-organic chemical vapour deposition (MOCVD); Film patterning techniques.

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Contract no: BREU-0438
Proposal no: BE-4020

HIGH CRITICAL TEMPERATURE SUPERCONDUCTORS FOR ELECTRICAL POWER APPLICATIONS : - SUPERCONDUCTING OXIDE BASED CURRENT LEADS

Starting date: June 1991 ***Duration:*** 24 months

OBJECTIVES

The improvements in the development of the high temperature superconductors especially with regard to the critical current densities in bulk material at 77 K, which have been obtained in the last three years, are encouraging to aim at short term applications in addition to the long term development of technical conductors.

The goal of the four companies during the course of this two years project is to develop current leads for 4.2 K-systems from high Tc superconducting materials, to manufacture them and to demonstrate the performances and the benefits in comparison with metallic current leads. They will be designed to real applications like current limiters and small and medium sized superconducting magnetic energy storage devices (SMES).

ACHIEVEMENTS TO DATE

The expected advantages of high Tc superconducting current leads are based on the low thermal conductivity of the ceramics, on their good current carrying capacity in low magnetic fields and on the disappearance of ohmic losses in the temperature range of 4.2K to 77K.

On laboratory scale, a critical current density of about 1000A/cm^2 at 77 Kelvin and below 20 Millitesla has been achieved, both for YBCO and BSCCO bulk material. This performance is promising for application in leads.

KEYWORDS

Electrical industry; Power generation; Electrical engineering; Ceramics; Superconductors; High temperature superconductors; Current leads

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Contract no: BREU-0460
Proposal no: BE-4071

MICROWAVE DEVICES BASED ON HIGH TC SUPERCONDUCTORS

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

The overall objective is to develop the deposition and processing of thin film high temperature superconductors on novel substrates with large relative permittivities. Two superconducting materials $Y_1Ba_2Cu_3O_{7-x}$ and $Bi_2Sr_2Ca_{n-1}O_Y$ will be deposited by laser photoablation, molecular beam epitaxy and radio frequency sputtering and spin spray techniques. Four deposition techniques are being employed to establish which will yield the best large area, single phase, high critical current superconductors. Chemical engineering of the superconductor will also be carried out to optimise their electrical properties, processability and stability.

Electrical, physical and chemical properties of the superconducting films will be carried out using all the major assessment techniques. However, the ultimate test is to fabricate microstrip microwave components and assess their performance. Device fabrication will necessitate accurate patterning of the superconducting films. This will be achieved by eximar laser ablation or etching using wet or reactive ion etchants.

The significance of this work is reflected in the large $670 M worldwide (1990) market for filters and delay lines alone. The projected market in Europe ($150M) is comparable to the markets in the U.S.A. ($281 M) and Japan ($239).

KEYWORDS

Electric/Electronic industry; Materials processing; Processing (ceramic & glass); Prototyping; Ceramics/Glasses; Superconductors; Electronics

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COMPATIBILITY OF ECONOMIC MANUFACTURING METHODS WITH WEAR AND FATIGUE RESISTANCE OF SILICON NITRIDE BASED CERAMIC BALL BEARING COMPONENTS FOR CRITICAL APPLICATIONS

Starting date: February 1988 ***Duration:*** 48 months

OBJECTIVES

Silicon nitride has proved to be a very promising material for ball and roller bearing applications. Up to now only a few uncritical applications have come up, due to unknown reliability and high production cost. It is to be feared that Japanese and American companies will develop an exclusive stranglehold in this field. In the proposed development programme the main aim is to optimise reliability properties by development of specific silicon nitride materials, processing and design and calculation of ball bearings. The success in this will open up a whole field of critical applications, which cannot be solved by conventional bearings. The expected cost reduction in material processing and machining will lead to large scale applications and will be the key to making Europe competitive with major overseas producers.

ACHIEVEMENTS TO DATE

As a first step the investigations concentrated on finding the best composition of the silicon nitride. Although this part of the programme should be already completed, rising demands from customers and market make it constantly necessary to improve starting powders and processing.

Experience shows, that the most critical aspect in bearing materials is purity and homogenity. The material used now represents the state of the art. As regards moulding processes of ball and rings, economic reasons impose changes from initial considerations. Cold isostatic pressing of ball blanks results in superior geometry, but this process is too slow for mass production. For that reason alternative processes are under consideration.

Machining and finishing processes of balls and rings are under control. The results show that excessively close tolerances for the blanks, as the machining of silicon for the blanks should not be demanded, as the machining of silicon nitride in the densified state is essentially not a problem.

KEYWORDS

Materials processing; Mechanical engineering/Machinery; Forming/ Shaping/Casting; Processing (ceramic & glass); Ball bearings; Ceramics/ Glasses

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Proposal no: P-2148

OPTIMIZATION OF THERMOMECHANICAL PROPERTIES OF INJECTION-MOULDED SILICON NITRIDE PARTS BY ADJUSTMENT OF THE PHYSICO CHEMICAL CHARACTERISTICS OF THE STARTING MATERIAL

Starting date: February 1988 ***Duration:*** 37 months

OBJECTIVES

The aim of this work was to develop a silicon nitride powder manufacturing route, namely carbothermal nitridation, and a compound forming route, injection moulding, which are capable of providing low cost shaping. Diesel engine precombustion chamber was selected as a demonstrative part.

ACHIEVEMENTS TO DATE

A carbothermal nitridation process has been chosen which gives excellent control of morphology and particle size distribution of Si3N4 powders. Si3N4 powder PyrofineR grade S 1-3 was chosen after several interchanges between partners.

After numerical optimisation of the mould design, prechambers were injected, pyrolysed and sintered. ATOCHEM Pyrofine S 1-3 and Starck LC12 silicon nitride powders were used for comparison. The time available to optimise the injection moulding conditions of the prechamber was too short. It has therefore not been possible to produce uncracked sintered prechambers starting from Pyrofine S 1-3 or Starck LC12. Nevertheless we believe that better quality prechambers could be produced if a mouldable mix with a powder loading of around 60% (maximum of 53.8% today), or more, could be used. Pyrofine S 1-3 seems to be too fine and to have too narrow a particle size distribution for an "ideal" silicon nitride injection moulding powder. It did, however, have superior pyrolysis characteristics to the Starck blend of Si3N4 powders used in this work.

There will be an opportunity for the part manufacturer to continue with this work within an outgoing BRITE project. The Si3N4 powder producer will continue its powder quality optimisation.

KEYWORDS Ceramic powders; Injection moulding; Automotive/ Components & parts; Processing (Ceramic & Glass); Ceramic/Glasses; Mathematical modeling.

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Contract no: MA1E-0038
Proposal no: P-0461

DEVELOPMENT OF ADVANCED CERAMICS FROM SIALON-BASED 'COMPOSITE POWDERS'

Starting date: December 1987 ***Duration:*** 36 months

OBJECTIVES

This project seeks to develop a low-cost, high strength, ß'-sialon ceramic of improved fracture toughness. This objective will be approached through the use of a dispersion toughening mechanism, with the incorporation within a ß'-sialon matrix of titanium nitride and/or carbide particles. The ß'-sialon matrix phase with its dispersed toughening phase will be derived, in powder form, from naturally occurring oxide materials by a single step carbothermal nitridation process. The sintering to full density of this 'composite powder' will then be optimized to yield a toughened ceramic matrix composite. The ready availability of a low-cost, high strength and relatively high fracture toughness ceramic, produced from low-cost raw materials, will assist the wider acceptance of these materials as substitutes for metallic engine materials in applications where higher efficiency and longer life are required.

ACHIEVEMENTS TO DATE

The synthesis of sialon based 'composite powder' were optimized for various titanium nitride contents between 0 and 50 vol.%. The shaping and the sintering of these powders has been achieved and the physical properties of the ceramic matrix composites are under investigations. The study of sintering mechanisms, sintering aids and microstructure developments will be achieved in 1990, as well as the manufacturing of large components and their test under realistic conditions of use.

KEYWORDS

Materials processing; Composites (ceramic matrix); Powders; Materials science.

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Proposal no: P-0083

RELIABILITY OF BULK CERAMICS FATIGUE BEHAVIOUR IN CORROSIVE MEDIA

Starting date: November 1988 ***Duration:*** 36 months

OBJECTIVES

In order to provide the mechanical data needed to design a ceramic component for a combustion engine, mechanical testing of a silicon nitride material and a sialon material will be performed in various conditions — static and cyclic loading, high temperatures, diesel exhaust gas environment — with special attention paid to the specific influence of the aggressive atmosphere.

The fracture behaviour will be examined under two approaches assuming that the failure is dictated (1) by a subcritical crack growth law, (2) by a creep law, the subcritical crack growth being a consequence of a local creep.

These approaches will be developed with a view to their application in finite-elements programmes for the lifetime prediction of ceramic components. In parallel, the physico-chemical mechanisms responsible for the degradation of the mechanical properties of ceramics in the aggressive environment will be identified.

ACHIEVEMENTS TO DATE

This programme will finish at the end of 1991. Most of the experimental work is now ended and gives important results on:

- Tensile and bending creep.
- Influence of the environment (air or exhaust gases and temperature) on corrosion and subcritical crack growth (static or cyclic).
- Relation between microcracks ('natural' flaws) and macrocracks (test specimens).
- A post processor to a 3-D finite element programme which gives failure probabilty of components is in testing.
- Specific numerical post treatments are being developed to give a failure probability of components after damaging (creep and crack growth in static and cyclic loading).

KEYWORDS

Automotive/Components & parts; Ceramics/Glasses; Silicon; Material science; Mechanics/Solid mechanics; Fatigue at high temperature.

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Proposal no: P-2417

CREEP AND FATIGUE BEHAVIOUR OF SILICON CARBIDE AND SILICON NITRIDE IN NORMAL AND CORROSIVE ATMOSPHERES

Starting date: June 1989 ***Duration:*** 30 months

OBJECTIVES

The proposed research is intended to analyse creep and fatigue behaviour of silicon carbide and silicon nitride ceramics in normal and corrosive atmospheres at temperatures of 1400° and 1600°C. Specific attention is paid to the use of such ceramics in gas turbines.

ACHIEVEMENTS TO DATE

After extensive effort a reproducible method of manufacturing silicon nitride suitable for creep and fatigue characterisation up to 1400°C has been developed. The composition has been tailored to yield a β-Si_3N_4 and a crystalline intergranular phase of yttrium disilicate. Four point bend test results give a mean nominal strength in excess of 900MPa. SENB testing yielded fracture toughness levels of 6.5PMa $m^{1}/_{2}$ confirming the enhancement predicted using a moderate sintering liquid volume.

Sintered silicon carbide produced for this project has a mean nominal bend strength of about 520MPa. Oxidation trials at 1400°C for up to 500 hours have resulted in strength increases while 200 hours at 1600°C has reduced the strength. Ion implantation was found to improve the bend strengths yielding over 590MPa. At 1400°C formation of a 3 µm SiO_2 (cristobalite) surface layer was observed while at 1600°C erratic development of the oxide layer was found. Creep testing of SiC at 1400°C has commenced, no results are currently available.

KEYWORDS

Aeronautics/Aerospace; Ceramics/Glasses; Materials characterization/ Testing; Surface treatment technology; Research/Development; Creep fatigue.

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Proposal no: P-0386

COMPLEX SHAPED ADVANCED CERAMICS

Starting date: December 1990 ***Duration:*** 36 months

OBJECTIVES

The primary objective is the development of an improvement process for producing near net-shaped components from advanced ceramics using injection moulding. This will be achieved by:

- the development of a temporary organic binder system with improved burnout characteristics, which is capable of imparting the required rheological properties to the moulding mix
- the synthesis of advanced oxide ceramic powders with characteristics specifically adapted to injection moulding
- the development of optimized binder removal procedures
- the establishment of a data for mould design.

The project is expected to enable the high volume production of complex-shaped advanced ceramics at low cost.

KEYWORDS

Forming/Shaping/Casting; Ceramics/Glasses

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Proposal no: BE-3086

DEVELOPMENT OF NEW CERAMIC COMPONENTS WITH BETTER LIFETIME TO CONTROL MELTED METALS CASTING

Starting date: April 1990 ***Duration:*** 36 months

OBJECTIVES

This project aims at developing new ceramic components with better lifetime, better macro-cracks resistance and no tap air-pollution.

This new design, based on thermal considerations, leads to the exclusive use of axial symmetrical ceramic components resulting in largely improved thermal shocks resistance.

ACHIEVEMENTS TO DATE

Operated works, through exploring thermophysical properties, has led to determination of temperature and thermal stress distribution.

By computer simulation it has been possible to find out that for all materials, cracks will appear within a few seconds.

These simulations also showed that a ceramic plate will remain crack-free if a compressive load, provided by a steel bandage, is applied.

In the thermomechanical field the new axisymmetrical concept plate has already proved highly valuable.

KEYWORDS

Ceramics; Refactories; Casting

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Proposal no: BE-3536

HIGH TEMPERATURE MECHANICAL BEHAVIOUR OF TiO_2, CaO OR MgO CONTAINING REACTION SINTERED MULLITE ZIRCONIA TOUGH CERAMICS COMPOSITES FOR ENGINE APPLICATIONS

Starting date: April 1988 ***Duration:*** 36 months

OBJECTIVES

1. To obtain at laboratory and at pilot level close to theoretical density Mullite, Mullite-Zirconia, Mullite-Zirconia-Alumina and Mullite-Zirconia-Titania(ss) reaction sintered composites.
2. To determine the room and high-temperature mechanical properties—σf, K_{IC}, slow crack growth and thermal shock—of the selected composites.
3. To study the relationship between high-temperature mechanical properties and microstructure of the selected composites in order to evaluate these materials as candidates for structural parts in adiabatic engines.

ACHIEVEMENTS TO DATE

Mullite and Zirconia-doped Mullite as well as Mullite-Zirconia, Mullite-Zirconia-Alumina and Mullite-Zirconia-Titania(ss) reaction sintered composites close to theoretical density (≥98%th.) were obtained at laboratory and at pilot plant level. The effect of a small amount of alkaline impurities on the Zircon+Alumina reaction sintered process, microstructure and room and high-temperature mechanical properties were established. The σf (280-350 MPa) and Kic (2.5-5.5 MPa√m) values were kept almost constant up to 1300°C in all compositions studied.

In the particular case of Zirconia-doped Mullite (0.6wt.%) a drastic increase in the σf value (~2.5 times) was obtained at 1200°C after 8h annealing at 1500°C without any change in the creep rate value (~$10^{-9}S^{1}$).

KEYWORDS

Automotive, Components & parts; Composites (ceramic matrix); Materials science

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Contract no: MA1E-0058
Proposal no: P-0113

IMPROVEMENT OF THE RELIABILITY OF DIFFERENT SILICON CARBIDE GRADES FOR AUTOMOTIVE APPLICATIONS

Starting date: January 1988 ***Duration:*** 42months

OBJECTIVES

Reliabillity of polycristalline ceramics was looked into as a volumetric effect resulting from the distribution in volume of single microcracks (-say defects-) or from the coalescence of microcracks. They may also induce generalised damage under load or arise at the tip of a moving crack exhibiting an R-curve, before catastrophic failure. A general methodology, based on experimental and computational work in conjunctiion with fracture mechanical model considerations, has thus been developed.

ACHIEVEMENTS TO DATE

In the case of post-hipped α–SiC, it was shown that the distribution of the rupture stresses is the image of the microstructure only if the internal stresses are considered. Experimentally the Weibull modulus varies with temperature. The reliability of post-hipped α–SiC may thus be enhanced by improvement of powder sieving.

Often microcracks are induced by mechanical loading. Their size and density depend on the material, the processing route and the resulting microstructure.

Finite element methods, taking into account the specific reliability of each part of a complex structural piece, like a rotor, have been developed. In addition, simulation of predefined grain size distributions and their damage under load or during cooling have been studied formally.

Provided the constitutive law of damage of given microstructures are correlated experimentally, the possibilty to forecast failure by a deterministic approach is now availlable.

KEYWORDS

Ceramics; Engineering; Reliability; Computer science.

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Proposal no: P-0224

X-SIALON MULLITE CERAMICS – PRECURSORS, POWDERS AND COST EFFECTIVE COMPONENTS WITH IMPROVED MICROSTRUCTURE AND PROPERTIES

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

The aim of the project is to develop new types of high quality, cost effective ceramics with improved thermomechanical properties based on the two phases x-sialon and mullite. The project should provide the necessary background for a later Type 1 BRITE/EURAM project on the use of advanced x-sialon/mullite ceramics for high temperature engineering or other advanced applications. The project involves:

- Developing cost effective methods for the fabrication of high quality powders for advanced high-temperature x-sialon/mullite ceramics with improved microstructure and enhanced properties.
- Developing shaping technology and pressureless sintering as well as sinter-hip techniques for the fabrication of near theoretical density, high strength components of reliable shape and geometry in x-sialon and x-sialon/mullite ceramics.
- Developing of x-sialon/mullite composites with tailored microstructure composed of prismatic mullite 'whiskers' in a fine grained matrix to achieve improved mechanical strength, thermal shock resistance and oxidation resistance at high temperatures.
- Special emphasis on the control of fine particles in the fabrication process.

KEYWORDS

Aeronautics/Aerospace; Forming/Shaping/Casting; Processing (ceramic & glass); Ceramics/Glasses; Composites (ceramic matrix); Powders

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Contract no: BREU-0064
Proposal no: BE-3269

MICRO DEFECT-FREE CERAMIC COMPONENTS

Starting date: March 1988 ***Duration:*** 39 months

OBJECTIVES

The aim of the project is to determine the extent to which the quality and reliability of ceramic microelectronic components and their rejection rates during manufacture can be improved by new powder processing methods involving primarily the production of the components in 'clean room' conditions and the use of new chemical production methods for the production of higher grade 'advanced' ceramic powders. In particular the economic advantages obtained by using these improved processes will be assessed. The study will be performed on barium titanate powder which has been chosen because of its common usage in the field of microelectronic components.

ACHIEVEMENTS TO DATE

Samples of barium titanate powders, doped with dysprosium to inhibit grain growth, were prepared both by a conventional (mixed oxide process) and an advanced (co-precipitation) process. The most important physico-chemical characteristics of the powders, as well as their sintering behaviour, have been determined. Tape casting has been performed on both powders, in conventional clean room conditions and multilayer components obtained.

The advantages and disadvantages of the powders, as well as of the clean room processing, have been assessed.

KEYWORDS

Materials processing; Processing (ceramic & glass), Ceramics/Glasses; Multilayers/Multimaterials; Dielectrics; Materials characterisation/Testing.

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Contract no: MA1E-0036
Proposal no: P-0677

DESIGN METHODS FOR CERAMIC MATRIX COMPOSITES

Starting date: February 1991 ***Duration:*** 36 months

OBJECTIVES

The objective of the project is to generate design methods for selected advanced ceramic matrix composites which encompasses component performance, production routes and materials. The objectives are:

- new and enhanced ceramic matrix composites with flexural strengths and fracture toughness up to 500% greater than unfilled matrix materials with Weibull moduli in excess of 20
- ceramic matrix composites capable of continuous operation in air at temperatures above 1000°C
- composites which when over-stressed, fail by a relatively controlled 'non-brittle' mechanism
- quantified mechanical property data of new and enhanced composite systems suitable for materials design
- design codes/computer programmes to enable economic design of composites developed in the project and new composites
- demonstrators which assess the performance of design codes.

ACHIEVEMENTS TO DATE

The achievements to date include:

- a broad range of reinforcing fibres and particulates have been sourced. Evaluation has been initiated of inclusion compatibility with selected glass and ceramic matrices
- ceramic fibre-ceramic matrix combinations have been identified which are not detrimentally affected by temperatures up to and including 1200°C
- composites made employed techniques suitable for the fabrication of complex geometry components requiring 2 and 3-D fibre architecture
- preliminary mechanical evaluation of fibre reinforced composite material has yielded mean 4-point flexural strengths about 700% greater than the unfilled matrix material.

KEYWORDS

Aeronautics/Aerospace; Automotive, components & parts; Electrical/ Electronic industry; Design; Composites (ceramic matrix); Computer science/Software; Reliability

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Contract no: BREU-0349
Proposal no: BE-3119

NEW FIBRE REINFORCED TRADITIONAL CERAMIC PRODUCTS WITH SUPERIOR MECHANICAL PROPERTIES

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

The objective of this project is that of experimenting with the possibility of improving the mechanical characteristics and performance of selected ceramic materials for the building industry (ceramic floor and wall tile and sanitaryware) by applying the mechanism of fibre reinforcement. This objective will be realized through the development of seven different products, all fibre-reinforced, having mechanical characteristics that are superior to those of corresponding commercial products without fibre reinforcement. Five of these seven products are ceramic tiles shaped by dust pressing, one is a ceramic tile shaped by extrusion and one is an article of sanitary ware shaped by slip casting. After complete characterization of the commercially available fibres, carried out to determine those those fibres most suitable as reinforcement for each of the products to be developed, the work will proceed first with experimentation on a laboratory scale, involving the preparation, firing and characterization of small-size fibre-reinforced test pieces . Based on the results obtained , the work will progress to industrial scale experimentation (pilot production line) with the fabrication of fibre-reinforced components (ceramic floor and wall tile and sanitaryware). The research project will be concluded with a study on the prospects for industrialization fo the products developed, as well as their technical and commercial impact on the European ceramic industry.

KEYWORDS

Processing (ceramic & glass); Fibres/Reinforcing materials; Ceramic/Glasses; Composites (ceramic matrix)

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Proposal no: BEÒ-4066

FABRICATION AND JOINING OF GRADED CERMETS BY A TECHNIQUE OF METAL INFILTRATION

Starting date: January 1988 ***Duration:*** 36 months

OBJECTIVES

To improve the effectiveness of joining ceramics to metals and reduce the tendancy to adhesive failure resulting from interfacial tresses arising from mis-matching of thermal expansion co-efficient and elastic modulus.

Develop forming techniques for graduated joints composed of layers of cermets made either by co-sintering or pressure infiltration of porous ceramic preforms which can be used to effect joints between ceramics and metals.

ACHIEVEMENTS TO DATE

Cermets have been produced by both co-sintering of nickel and zirconia and the infiltration of molten metal (aluminium) into porous preforms of alumina. Crack propagation studies show the preponderance of ceramic type (brittle) behaviour up to 70% metal (nickel/zirconia).

Porous preforms of graduated porosity havebeen successfully prepared on small sample size (up to 50mm diameter) by die pressing, assembly of tape cast layers, pressure filtration and the use of burnable porosifiers. Delamination between layers of different composition has been prevented by the use of a corrugated boundary.

This was achieved by pressure infiltration by gas, pressure failed to fully infiltrate fine porosity. Mechanical pressurisation of the molten metal (squeeze casting), a high failure rate results because of thermal shock of the ceramic preforms. This technique was only successfully applied to samples up to 50mm diameter. Larger ones were always cracked.

KEYWORDS

Automotive, components & parts; Materials processinng; Assembly/joining; Ceramics/Glasses; Composites (ceramic matrix); Composites (metal matrix); Materials science.

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Contract no: MA1E-0042
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CHEMICAL VAPOUR INFILTRATION IN NEW DESIGNED COMPOSITES WITH REDUCED INFILTRATION TIMES BY PRESSURE GRADIENTS AND MONITORED BY INSITU ANALYSIS WITH SPECTROSCOPIC MEANS

Starting date: 1991 ***Duration:*** 36 months

OBJECTIVES

Chemical vapour infiltration (CVI) is a superior technique for densifying newly designed 2d and 3d carbon fibre preforms in order to get a composite with properties such as shear strength and damage tolerance which are unattainable with conventional 2d laminates.

The main disadvantages of CVI (long process times and process instabilities) have to be overcome, especially if complex shaped components of these preforms have to be infiltrated. This will be in this programme by applying pressure gradients to direct the gas flow and to install automatic pressure gradient control. Furthermore, process instabilities e.g. gas phase nucleation will be detected by in-situ IR-spectroscopic analysis in a very early process stage. These CVI process improvements will be an important prerequisite for the production of the newly designed 2d and 3d carbon fibre composites. Their mechanical and physical properties will be gained by testing and by finite element calculations.

KEYWORDS

Chemical vapour infiltration (CVI); Materials processing; Process/Product monitoring; Composites (ceramic matrix); Mathematical modelling

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Contract no: BREU-0447
Proposal no: BE-4068

COST-EFFECTIVE PRODUCTION TECHNOLOGIES FOR CERAMIC MATRIX COMPOSITES

Starting date: 1991-1992 ***Duration:*** -

OBJECTIVES

High performance ceramic matrix composites (CMC's) are currently produced by CVI. However, only simple shapes can be produced, the production times are long and strict quality control is required. This leads to high production costs and restricts their use to costly aerospace applications.

CMC's can be produced by methods other than CVI. However, to obtain material of comparable properties is difficult and very costly. A promising route is the infiltration and subsequent pyrolysis of Si-based polymers to form the ceramic matrix. Material with comparable properties may be achieved at a much reduced cost.

The main objectives of this project are to develop cost-effective manufacturing routes for CMC's including:

- development of semi-finished products
- development of various manufacturing routes such as lamination, liquid infiltration and filament winding
- continuous monitoring of materials and process quality to improve the product.

Economic and ecological aspects will also be considered during the project.

The ultimate aim of the project is to produce larger demonstrator parts by the various manufacturing routes. The merits of these routes will be compared to each other and to existing routes.

KEYWORDS

Composites (ceramic matrix); Processing (ceramic & glass); Manufacturing; Economics; Materials characterization/Testing; Quality assurance; Mechanics/Solid mechanics

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METAL REINFORCED CERAMICS

Starting date: August 1987 ***Duration:*** 46 months

OBJECTIVES

One of the major objectives of research into advanced structural ceramic materials is to achieve a sufficient degree of toughness, strength, thermal and mechanical shock resistance and corrosion resistance so that the beneficial aspects of ceramics such as low density and high melting point, can be exploited in the design of critical high temperature components. The aim of this project is to improve the mechanical properties of ceramic materials, especially at elevated temperatures, and their resistance to corrosion by incorporating ultrafine particles of metals with high melting points in a ceramic matrix based on Al_2O_3, ZrO_2. The production and the incorporation of the metals in an extremely finely divided form calls for a special manufacturing technology.

ACHIEVEMENTS TO DATE

Colloidal metal particles in the range of nm (e.g. Rh, Pd, Pt, Mo) could be deposited onto ceramic powder by a special manufacturing technique. Al_2O_3/ZrO_2-based composites with a homogeneous, finely divided metallic phase up to 5 mass-% were produced via the combined sinter HIP/technique. These materials show fracture toughness and flexural strength improvements of up to 25%, high corrosion resistance in molten metals, glass melt, and hydroflouric acid and improved thermal shock resistance.

KEYWORDS

Mechanical engineering; Composites (Ceramic matrix); Particle technology; Reinforcement technology; Tribology.

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Proposal no: P-1253

DEVELOPMENT OF TECHNOLOGY TO PRODUCE 2- AND 3-D CARBON REINFORCED GRAPHITE STRUCTURES FOR HIGH STRENGTH AND HIGH TEMPERATURE APPLICATIONS

Starting date: March 1989 ***Duration:*** 48 months

OBJECTIVES

The project is to develop high-temperature and high-strength two dimensional (2-D) and three dimensional (3-D) carbon reinforced graphite (CRG) structures. The initial objective is to extend the current level of understanding of the relationship between process parameters and product characteristics to allow modification and optimisation of product perfomance. This knowledge will be used to develop high temperature oxidation resistant 2-D CRG materials and simultaneously to develop to develop 3-D anologues of both CRG and the structure modified high temperature CRG. These 3-D products will include both high strength, thin wall tubing and layered or sandwich structures comprising a low-density former contained in a high strength 2-D CRG skin.

ACHIEVEMENTS TO DATE

Relationships between process parameters and mechanical properties have been established by developing methods of characterisation of both physical and mechanical properties for the examination of a wide range of CRG samples.

Materials with resistance to oxidation have been prepared and effects of structural modification on mechanical properties are being measured.

3-D structures have been prepared in the form of tubes or honeycomb light-weight sheets using both woven and non-woven materials.

KEYWORDS

Carbon/Graphite; Composites (ceramic matrix); Fibres/Reinforcing materials.

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Proposal no: P-2086

DEVELOPMENT AND CHARACTERISATION OF CMC AND C/C COMPOSITES

Starting date: November 1990 ***Duration:*** 30 months

OBJECTIVES

The goals of the proposed programme are to develop and characterize structural high performance fibre reinforced ceramics (CMC) and Carbon-Carbon (C/C) with antioxidation protection.

Material 1a: 2, 5-D-C/C-INOX (SiC)

The development of this C/C material with three fibre directions (2,5-D) and a SiC protection layer will be chosen for long time applications (>30 hours) at temperatures up to 1550°C. Fibre content: min. 45%.

Material 1b:. 2, 5-D-C/C-INOX (SiC/HfC)

Development of material 1a, but with multilayer SiC/HfC protection for short time applications (20 minutes) at temperatures up to 1800°C.

Material 2: 2, 5-D-C/SiC

Development of carbon fibre reinforced SiC composite with three fibre directions (2, 5-D) for long time applications (>30 hours) at temperatures up to 1200°C.

Material 3: SiC/GC

Development of SiC fibre reinforced glass-ceramic composite for long time applications (>30 hours) at temperatures up to 1200°C. Fibre content: min. 35%.

KEYWORDS

Aeronautics/Aerospace; Processing (Creamics/Glass); Carbon/Graphite; Materials characterisation/Testing; Reinforcement technology

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Contract no: BREU-0334
Proposal no: BE-3243

DEVELOPMENT OF CERAMIC AND CERAMIC COMPOSITE MATERIALS FOR STRUCTURAL APPLICATIONS AT HIGH TEMPERATURES WITH IMPROVED CREEP RESISTANCE, CHEMICAL STABILITY AND RELIABILITY

Starting date: March 1988 ***Duration:*** 48 months

OBJECTIVES

The use of thermo-mechanical ceramics in critical, high temperature, structural applications is currently hindered by a combination of factors depending on the type of ceramic: mechanical degradation, environmental degradation and reliability. The proposed research is directed towards the development of new oxide-based ceramics and composites for structured applications at elevated temperatures with the following objectives: *(i)* to produce oxide based ceramic composites that exhibit high chemical stability, improved reliability and enhanced creep strength; *(ii)* to adapt new non-destructive testing methods.

ACHIEVEMENTS TO DATE

Six ceramics systems are under study: SiC whisker-reinforced alumina, zirconia-reinforced alumina, mullite, zirconia-reinforced mullite, zircon and zirconia-reinforced zircon. The physico-chemical characterisation and optimisation of suitable raw materials as well as the physico-thermomechanical and reliability characterisation have been performed for the different ceramic systems. From high-temperature corrosion tests, a selection of the most promising ceramics has been made, i.e., zircon and zirconia-based materials. However, their creep properties are not yet suitable for the target application.

KEYWORDS

Ceramics/Glasses; Composites (ceramic matrix); Materials characterization/ Testing.

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Proposal no: P-2219

ORGANOMETALLIC PRECURSORS FOR THE PREPARATION OF HIGH PERFORMANCE NON-OXIDE CERAMICS AND CERAMIC-MATRIX COMPOSITES

Starting date: March 1990 ***Duration:*** 36 months

OBJECTIVES

This proposal is concerned with four principal lines of research:

- the synthesis of polymeric, organometallic precursors with a high ceramic yield and the study of their pyrolysis and conversion to ceramic;
- the direct conversion of the precursors into dense ceramic materials;
- the use of precursors as an interparticulate bond as well as acting as an injection-moulding binder in the fabrication of pressureless-sintered silicon nitride;
- the infiltration of precursors into unidirectional, 2-D and 3-D fibres, preforms to fabricate carbonitride-bonded fibre composites.

ACHIEVEMENTS TO DATE

A small pilot plant has been built to produce 5-6kg of ceramic precursor per batch. A fusible solid precursor has been developed for the injection moulding phase. Dense ceramics have been successfully produced from pressed, crosslinked ceramic precursor powders. Work is underway on the fabrication of pressureless sintered silicon nitride using precursors and the injection of fabric preforms by precursors.

KEYWORDS

Materials processing; Forming/Shaping/Casting; Processing (ceramic and glass); Ceramics/Glass; Composites (ceramics matrix)

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Contract no: BREU-0106
Proposal no: BE-3266

IMPROVED HIGH TEMPERATURE CORROSION RESISTANT SILICON NITRIDE-SILICON CARBIDE COMPOSITES

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

1. To determine the surface reactivity of silicon nitride matrices and corresponding silicon nitride-silicon carbide composites in environments representative of fossil fuel conversion systems.
2. To determine how the presence of impurities such as sulphur vapour, sulphur dioxide and chlorine within the corrosion environment affects the surface reactivity of silicon nitride and silicon nitride-silicon carbide composites.
3. To elucidate the mechanisms of high temperature chemical degradation in corrosive environments, which contain either oxygen or sulphur or chlorine.
4. To optimise the composition of composites in terms of additive and silicon carbide content for use in aggressive situations.

ACHIEVEMENTS TO DATE

1) Oxidation data relating to the datum matrix material (silicon nitride densified with 7 w/o yttria, 4 w/o) and the datum composite material (i.e. datum matrix material containing 10 w/o silicon carbide particles).

2) Chloridation data relating to the data matrix and composite materials.

KEYWORDS

Ceramics/Glasses; Materials science; Composites (ceramic matrix); High temperature corrosion

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Contract no: BREU-0180
Proposal no: BE-3549

COATING OF SILICON CARBIDE MATRIX COMPOSITES FOR INDUSTRIAL USE IN CORROSIVE ENVIRONMENTS

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

Ceramic Matrix Composites (CMCs) make up a new family of composites whose behaviour to mechanical and thermal shock, fatigue resistance, etc., is superior to the best technical ceramics obtained by Powder sintering process.

First developed for applications in the aeronautical and space fields, some CMCs are beginning to be mass produced (C/SiC and Sic/SiC). They are also of interest for applications in other sectors of activities which aim at improving their production technologies, reducing their cost prices and saving the energy required for their manufacturing-as is the case for the metallurgy industry and gas burner systems.

In order to benefit from the performance exhibited by CMCs it is, however, necessary to protect them against high-temperature chemical corrosion from metals, alloys and molten glasses. The expected research involves a CMC Manufacturer, 3 Companies and Research Centres already producing coatings with various processes (mainly some Oxides and rare metals using laser techniques, plasma spraying, sputter ion plating, and plasma assisted chemical vapour deposition), and two end user companies in charge of carrying out assessment testing.

The first spinoff expected is in metal cast elements and gas burner systems.

KEYWORDS

Composites (ceramic matrix); Coatings/Thin films; Surface treatment technology; Laser technology/Power beams; Processing (ceramics and glass); Energy/Power generation

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Proposal no: BE-4124

INDUSTRIAL PRODUCTION PROCESS FOR SILICON CARBIDE WHISKERS FOR COMPOSITE MATERIALS REINFORCEMENT

Starting date: January 1989 ***Duration:*** 48 months

OBJECTIVES

PEM's aim this year was to design and start up a pilot plant producing SiC whiskers.

ACHIEVEMENTS TO DATE

The pilot plant including synthesis and morphological sorting of silicon carbide whiskers is built.

In a second heating run, the continuous pilot furnace has worked perfectly for two weeks and has produced silicon carbide in various conditions. Raw materials and heating conditions have been tested to obtain different qualities of products. All these products were oxidised to continuously remove the excess of carbon black successfully.

KEYWORDS

Manufacturing; Fibres/Reinforcing materials; Whiskers; Silicon-carbide.

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Proposal no: P-2401

ENGINEERED FIBRE STRENGTHENED CERAMIC COMPOSITES - STRUCTURAL INTEGRITY AND PERFORMANCE IN ENERGY CONVERSION AND PROCESSING SYSTEMS

Starting date: 1991-1992 *Duration: -*

OBJECTIVES

A key strategic route forward in creating ceramic based materials is through closely engineered fibre reinforced composites such as those based on glass ceramic matrices and chemical vapour infiltration reinforced with Sic fibres (e.g. Nicalon). The potential for engineered monolithic ceramic alloys is now likely to be limited mainly because of their inability to enhance integrity levels beyond a toughness of 10MPam 1/2. This work creates a new European research consortium to develop near commercial CMC materials to industrial application. Performance enhancement will be based on an interactive programme of tasks to understand creep, creep rupture, fatigue, thermal cycling, creep-fatigue, environmental degradation and creep-fatigue synergisms. The theoretical foundation is microstructural analysis of damage and study of weak interfaces plus predictive damage modelling. The project will be instrumental in enhancing European industrial competitiveness.

KEYWORDS

Composites; Fracture mechanics; Creep; Manufacturing; Performance; Materials science; Fatigue; Corrosion

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OPTIMIZATION OF CERAMIC ZIRCONIA POWDERS FOR THERMAL BARRIER COATINGS IN IC-ENGINES AND GAS TURBINES

Starting date: April 1988 ***Duration:*** 36 months

OBJECTIVES

- A study of spray drying, including: characterisation of starting powders and powders produced.
- A study of the plasma densification process in air, under water, and in a controlled atmosphere.
- The production of these characteristics on the plasma spray process and the coating properties.
- The reproducibility and reliability of the powder production.

ACHIEVEMENTS TO DATE

Yttria and magnesia-stabilized zirconia powder have been processed by spray drying. A densification process of the agglomerated particles shows a dense structure with a smooth spherical surface. Parameters and spraying criteria for coating production have been developed. The microstructure of the deposits meets the aerospace standards. With round robin tests, ceramographic methods are developed to obtain reproducible results in coating characterisation. The coatings produced are tested and characterised by thermal behaviour, corrosion, internal stresses, thermal shock and bond strength properties.

KEYWORDS

Aeronautics/Aerospace; Automotive, Components & Parts; Ceramics/ Glasses; Coatings/Thin films; Powders; Refractories; Particle technology.

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Contract no: RI1B-205
Proposal no: P-2280

MODELLING AND CHARACTERIZATION OF THE MANUFACTURING PROCESS OF CERAMIC THERMAL BARRIER COATINGS

Starting date: August 1991 ***Duration:*** 36 months

OBJECTIVES

This project proposes a detailed investigation of certain industrial systems for the production of plasma-spraying coatings to improve the understanding of the process of coating formation and so build more reliable correlations between the process parameters that can be directly controlled and the quality of coatings produced.

To this end a combined experimental and theoretical programme is set out :

- a limited set of coatings will be manufactured under control specifications
- they will be analyzed and characterized in various laboratories with several techniques
- physical models and simulation techniques will be developed to model the process as a whole and to correlate the process parameters with the coating characteristics.

The programme will compare between experimental results and theoretical modelling at all stages of the work. We will use the knowledge gained on the correlations between the process parameters and the quality of coatings to build an expert system to be used both as an intelligent data base of the knowledge produced in the present project and as a prototype tool for coating fabrication.

KEYWORDS

Manufacturing; Ceramics; Coatings; Expert systems; Materials characterization & Testing; Mathematical modelling; Research & Development

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Contract no: BREU-0418
Proposal no: BE-4212

IMPROVEMENT OF THE RELIABILITY OF HEAT ENGINE COMPONENTS UNDER SERVICE CONDITIONS USING FINITE ELEMENT MODELLING OF CERAMIC THERMAL BARRIER COATINGS

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

The modelling of thermal barrier coating microstructure, mechanical and thermal properties and behaviour under service conditions will be developed and used to design coatings for heat engine applications with improved high temperature and durability. This approach will provide a new tool in addition to empirical optimization and will overcome its limitations such as high cost and difficulty in interpreting complex deposition-microstructure-property relationships.

The overall programme consists of five major tasks:

- production, characterization and testing of state-of-the-art coatings
- model development
- assessment of model predictions
- improvement of TBC's performance based on the global model for reciprocating engine and gas turbine components
- assessment of project results.

KEYWORDS

Aeronautics; Automotive; Ceramics; Coatings; Materials characterization & Testing; Mathematical modelling

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HIGH PERFORMANCE THERMAL AND CHEMICAL BARRIER COATINGS FOR DIESEL AND GAS TURBINE ENGINES

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

The main objective is to lower the operating and maintenance costs of diesel and gas turbine engines, by improving the engine efficiency, increasing component lifetime, using cheaper fuels and reducing cooling requirements.

The goal is to improve existing zirconia thermal barrier coatings in terms of thermal shock, thermal fatigue, hot corrosion, oxidation and erosion.

ACHIEVEMENTS TO DATE

- Surface sealing and strengthening of plasma-sprayed zirconia coatings by CO_2 laser surface melting and alumina addition.
- Further strengthening obtained by adding a mixture of alumina and chromia.
- Comparison between Yttria and Ceria-stabilised zirconia.
- Study of Zirconia-Hafnia mixtures.
- Better thermal shock resistance of lasered than sprayed coatings, in gas turbine conditions up to 1200°C.
- Hot corrosion and oxidation tests in progress.
- Application to piston crowns and exhaust valves (truck engine), and to combustion chambers, guide nozzle vanes and flaps (helicopter engine).

KEYWORDS

Energy power generation; Materials processing; Ceramic coatings; Laser technology; Surface treatments; Gas turbine engines.

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Proposal no: BE-3012

THE DEVELOPMENT OF ENVIRONMENTALLY TOLERANT PVD THERMAL BARRIER COATINGS

Starting date: July 1991 ***Duration:*** 48 months

OBJECTIVES

To develop second generation physical vapour deposited (PVD) thermal barrier coatings. This will be achieved through the development of coating microstructures, coating compositions and PVD process technology. The programme is structured in four phases:

- Phase 1: Trialling of thermally evaporated PVD datum coating and the study of ion plating and its effects on structure property relationships.
- Phase 2: Thermal cyclic testing of candidate coatings
- Phase 3: Corrosion, fatigue and erosion testing of datum and most promising development coating
- Phase 4: Development of lifing methodology.

ACHIEVEMENTS TO DATE

To date the substrates and source materials have been manufactured and the initial work on the modification of coatings structures is under way. The preliminary results show that the TBC structures and textures can be modified through ion plating.

KEYWORDS

Aeronautics/Aerospace; Manufacturing; Coatings/Thin films; Materials science; Surface treatment technologies.

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Proposal no: BE-3337

DESIGN AND EVALUATION OF SELF REINFORCING THERMOSETS THROUGH THE CROSSLINKING POLYMERIZATION OF LIQUID CRYSTALLINE MONOMERS

Starting date: July 1991 ***Duration:*** 36 months

OBJECTIVES

Inherent problems in processing and undesired orientation of thermoplastic liquid crystalline polymers require innovative solutions to overcome these drawbacks while maintaining their beneficial properties of high stiffness and strength allied to a low coefficient of thermal expansion.

The project has the goal of scientifically investigating the manufacture of self reinforcing thermosets by network formation from low molecular weight liquid crystalline compounds in a mesophase. The thermosets will consist of microscopic frozen nematic (smectic) domains which are internally anisotropic whereas the domains are randomly oriented and give a macroscopically isotropic material.

The strategic aims of the project include the following:

Synthesis and evaluation of suitable mesogenic structures with different functional groups to provide structure property relationships to control and predict the phase behaviour in a wide range of curing conditions.

Investigation of the morphology of the thermosets as a function of chemical structure and extent of reaction.

Determination of relevant mechanical properties of the thermosets in relation to the structure of the thermosets, modelling of network formation.

The processing of the new materials will be the same as that of conventional thermosets.

KEYWORDS

Polymers; Materials processing; Liquid crystals; Chemistry; Materials characterization.

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Contract no: BREU-0449
Proposal no: BE-4143

NEW LIQUID CRYSTAL POLYMER/ELASTOMER COMPOSITES

Starting date: August 1991 ***Duration:*** 36 months

OBJECTIVES

The programme is designed to verify the possibility of using Liquid Crystal Polymers (LCPs) both as processing aids and reinforcing agents of conventional elastomers.

The main goals are:

- the creation of reinforcing species in the elastomeric matrix during processing by taking advantage of the fibrous morphology of LCPs
- the use of mild processing conditions due to the low viscosity of LCPs, by saving energy while avoiding possible damage of products and machines
- the production of satisfactory adhesion between reinforcing species and elastomeric matrices, and consequently, out standing perormances in comparison with conventionally reinforced elastomers

Intermediate goals are:

- synthesis of tailored structures of LCPs
- design of machines for a proper processing of LCPs and elastomers
- development of optimal processing conditions
- evaluation of the new materials performances in pneumatic tyre prototypes and in technical articles.

KEYWORDS

Automotive, Components & Parts; Processing (rubber & plastic); Composites (Polymer matrix); Fibres/Reinforcing materials; Rubbers; Liquid Crystal Polymers; Materials characterization/Testing

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Contract no: BREU-0425
Proposal no: BE-4377

FLOW AND FLOW-INDUCED STRUCTURE DURING THE PROCESSING OF LIQUID CRYSTALLINE POLYMERS

Starting date: April 1990 ***Duration:*** 36 months

OBJECTIVES

The project should provide a scientific basis for dealing with processing problems of LCPs such as: development of materials, design of moulds, selection and optimisation of injection moulding. These constitute the basic elements of a CAD/CAM programme, which could be developed in a subsequent Type I project.

The specific aims of the project include:

- a scientific basis for rheological modelling and CAD/CAM analysis of the processing of LCPs;
- guidelines to predict the effect of the flow history on the resulting microstructure.

ACHIEVEMENTS TO DATE

Two very complete sets of rheological data on LCPs are available. They provide insight into the flow behaviour of these materials and constitute the basis for the scheduled structural and modelling investigations. For the first time systematic data on velocity profiles in LCPs have been obtained (1-dimensional and 2-dimensional flows). Deviations from the expected behaviour have been identified which need to be resolved before flow simulations can be made. For the analysis of the flow-induced structures a device for SALS measurements on flowing systems has been designed. Finally, orientational distribution functions have been calculated for 2-D flows in both steady and transient conditions. A first approximation for dealing with polydomain structures has been introduced. The major rheological features can be described now. A simplified approach, suitable for CAD/CAM application has been explored and seems very promising.

KEYWORDS

Chemical/Petrochemical; Plastics/Rubber; Rheology; Processing (rubber/plastic); Polymers; Mathematical modelling.

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Proposal no: BE-3137

DEVELOPMENT AND CHARACTERIZATION OF MELT-PROCESSABLE RIGID ROD POLYMERS WITH IMPROVED MECHANICAL PROPERTIES

Starting date: July 1991 ***Duration:*** 42 months

OBJECTIVES

The development of melt-processable liquid crystamers has received a great deal of attention in the past few years. Melt processability is usually attained by disrupting the regular structure of the rigid main chain by means of random copolymerization and/or the introduction of crankshafts or kinks. The copolymeric nature of the present LCPs inhibits a full understanding of the relation between the chain parameters and the macroscopic properties and as such hampers the further technical improvement of the present LCPs.

In this project optimization of macroscopic (mechanical) properties is pursued by retention and systematic variation of very high rigidity in the main chain. The polymers to be developed will all be based on the rigid phenylene group.These groups can either be polymerized directly, or with the aid of various linking groups (ester, amide, imide). With proper attachment of (small) side chains during the designing of the synthesis routes, a sequence of melt-processable polymers with distinct, very high chain rigidities results. These polymers will be characterized thoroughly, both with respect to the molecular (i.e. chain flexibility) and the macroscopic (mechanical thermal) properties.

The results of this project may be applied to the improvement of present commercial LCPs, and to the development of new, innovative materials.

KEYWORDS

Polymers; Liquid crystal polymers; Structure-property relationship

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Contract no: BREU-0505
Proposal no: BE-4490

NEW FAMILY OF POLYMERS OBTAINED BY MEANS OF AN ORIGINAL TECHNIQUE FOR LIVING ANIONIC POLYMERIZATION OF ACRYLIC MONOMERS - DEVELOPMENT OF PRODUCTION AND APPLICATIONS

Starting date: November 1988 ***Duration:*** 36 months

OBJECTIVES

The development of acrylate-based block copolymers has so far been limited by the poor living character of the polymerization when anionically performed. The aim of the work is to develop a new family of polymers on a pilot plant using the method of living anionic polymerization of methacrylates and acrylates in the presence of specific additives. The new polymeric materials to be developed are as follows: thermoplastic elastomers, impact modifiers, additives for adhesives and hot-melts.

ACHIEVEMENTS TO DATE

On a laboratory scale, the homo and block copolymerization of MMA and bulky acrylates (di, tri or stars coploymers) is well controlled thanks to the optimisation of the operating conditions (solvent, temperature, addition of lithium chloride). Products amounting to a few kilograms were prepared in our pilot plant, for evaluation of their characteristics, after transalcoholysis. Only the stars copolymers exhibit good thermoplastic elastomer properties. ESPCI has shown that an interphase of miscibility exists between acrylic and methacrylic domains. Molecular mobility measurements are in progress.

Using a new additive, it is now possible to obtain well controlled living anionic polymerization of primary acrylates, such as ethyl-2, hexylacrylate or n-butylacrylate. Thus, triblocks (Hard-Soft-Hard) have been directly synthesised without the transalcoholysis step. Ten patents have so far been filed.

Transfer of these new operating conditions from laboratory to pilot plant and evaluation of products as adhesives have to be achieved.

KEYWORDS

Plastics/Rubbers; Polymers; Block copolymers; Acrylic.

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Contract no: RI1B-227
Proposal no: P-2168

LUBRICATED LIQUID CRYSTAL POLYMERS FOR HEAVY DUTY HIGH PRECISION BEARING SYSTEMS

Starting date: June 1990 ***Duration:*** 36 months

OBJECTIVES

The goal of this research project is to develop integrated LCP sliding systems with both specially formulated lubricants and optimized LCP microstructure and filler contents (such as PTFE, MoS_2, graphite, talcum, glass fibres, lubricants, etc.) for the application in precision machines under high loads and temperatures up to 150°C; at a cost of 50% less, such sliding systems are expected to have the same or better qualities than currently used ball bearings or sinter bearings.

ACHIEVEMENTS TO DATE

Three base oils in three different viscosity ranges were chosen and equipped with wetting modifying additives. Out of these base oils PFTE thickened greases in varying consistencies were made. Nine LCP-compounds were developed with different molecular weight and fillers and investigated on their microstructure, their mechanical and tribological properties and their compatibility and wetting behaviour with the lubricants. Two moulds were designed with different runner and gate systems to prevent problems with jetting and welding lines. The best results were achieved with a high viscous polymer and a special nap gate. The injection process was optimised by low injection moulding speed and by injecting against a wall in the mould. As a design for the precision bearings two bearing types were chosen for the practical tests: a cylindrical bearing with a diameter of 5mm and a triangular bearing which may carry both radial loads as well as axial loads.

KEYWORDS

Instruments/Sensors/Precision equipment; Design; Lubricants; Polymers; Data bases/Expert systems; Materials science; Tribology.

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Proposal no: BE-3231

LASER INDUCED COLOURING OF PLASTICS AND LACQUERS (LICOPAL)

Starting date: January 1992 ***Duration:*** 36 months

OBJECTIVES

This objective of this project is to develop a reliable and flexible production line system for Laser Induced Colouring, based on the use of suitable additives (pigments, dyes, and photochromic and prechromic compounds) in polymer matrices. For this purpose:

- Insight has to be gained into the phenomena occuring during the laser irradiation of synthetic materials
- the right combinations of materials have to be developed
- laser parameters have to be evaluated thoroughly.

The project proposed here deals with three main objectives, contained in the priority list of BRITE/EURAM:

(i) 4.2.4. innovations in laser beam technology with surface treatment as the application

(ii) 1.4.2. the developmentof polymeric materials with optimized packages of functional properties, i.e. they become laser-markable in a reproducible way

(iii) 1.4.3. the development of polymeric materials suitable for automated processing by means of selecting additives for improved processibility.

In order to achieve the project aim, the following objectives are defined:

(a) Multicolour Laser Induced Decoration on a dark background of a synthetic material, demonstrated on laboratory scale

(b) multicolour Laser Induced Decoration on a light background of a synthetic material, demonstrated on laboratory scale

(c) demonstration of the possibilities of Multicolour Laser Induced Decoration in a pilot production multicolour laser system.

KEYWORDS Laser technology/Power beams; Processing (rubber & plastics); Chemical/ Petrochemical; Electrical/Electronic industry; Polymers; Vision/Optical systems

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Proposal no: BE-4441

REACTIVE POLYMERS FOR HIGH-PERFORMANCE BINDING AND GLUEING

Starting date: February 1990 ***Duration:*** 40 months

OBJECTIVES

The main objectives of this project are to develop production processes to obtain new polymer structures with reactive functional groups designed to react with surfaces which require binding, to gain better knowledge of the parameters affecting adhesion performance and to enable overall cost-efficient formulations with the new structure polymers. Research is focused on binding problems found in European manufacturing industry; plasticized PVC, polyurethane and other self-releasing thermoplastics as well as on some natural substrates such as wood and cork.

ACHIEVEMENTS TO DATE

Synthesis of pre-selected structures took place on a pilot laboratory assembly. Polymer samples amounting to a few Kilograms were prepared in order to evaluate their characteristics after adequate formulation.

Isocyanate prepolymers, reactive polyurethane dispersions as well as other polymeric structures were tested on cork, wood and thermoplastic materials surfaces.

Significant improvement was found on adhesion test results, when compared with the ones obtained with the equivalent structures without reactive groups.

KEYWORDS

Adhesives/Bonding; Assembly/Joining; Shoe/Leather; Wood/Paper/Furniture; Flexible/Non-rigid materials; Polymers.

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Proposal no: BE-3072

THE ROLE OF THE METAL-POLYESTER INTERFACE IN NEW TECHNOLOGIES

Starting date: January 1988 ***Duration:*** 48 months

OBJECTIVES

Several of the major uses of PET film, like film capacitors, barrier packaging and metel evaporated video tapes require its metallisation. The role of the interface in these applications is crucial: as capacitor films become thinner, the importance of the interface grows; it determines gas barrier and metal adhesion in packaging applications as well as epitaxy of magnetic alloys in video tapes. This project will therefore investigate the chemical and physical phenomena at the interface in order to sustain the fast technological change in the above industries..

ACHIEVEMENTS TO DATE

- A model of the aluminium-polyester interactions has been developed.
- Values of volume and surface conductivity applicable to Al metallized ultra-thin films have been determined.
- Variations in the insulation resistance of heat treated and compressed capacitors have been explained and eliminated.
- A model for carrier injection at the interface has been established.
- Appropriate adhesion measurement techniques have been developed.
- Different surface treatments to improve adhesion have been compared.
- The influence of the polyester manufacturing and processing conditions on gas barrier and metal adhesion has been assessed.
- The surface topography needed for the epitaxial growth of magnetic alloys has been defined.
- A metal evaporated tape based on Co-Ni-O on PET has been developed.

KEYWORDS

Adhesives/Bonding; Dielectrics/Ferroelectrics; Magnetic; Plastics/Rubbers; Polymers.

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Proposal no: P-2019

QUALITY CONTROL OF POLYPROPYLENE PHOTOSTABILITY BASED ON LASER EXPOSURE

Starting date: August 1991 ***Duration:*** 48 months

OBJECTIVES

The main objective of the project is to develop a quick quality control test based on laser exposure, in relation to natural weathering, to judge the photostability of given polypropylenes (given formulations and processing conditions) used for unpainted external applications in the car industry.

Accelerated ageing tests require several thousands of hours (at least 3000 hours in a Xenotest1200 with the test method 1380 from Renault, for stabilized polypropylenes).

The objective is to reduce irradiation times for ageing tests to several hours by using only a laser source.

Correlations between the different conventional ageing tests the most commonly used in the car industry, the UV-testers developed at the University of Clermont Ferrand for fundamental applications (Sepap units) and the laser test methos will be established.

KEYWORDS

Quality Control; Plastics; Automotive; Laser technology; Photoageing; Polypropylene

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QUALITY ENHANCEMENT AND PROCESS AVAILABILTY IN LLDPE STRETCH FILM OUTPUT BY MULTISENSORS AND COMPUTERIZED SYSTEMS

Starting date: 1991 ***Duration:*** 48 months

OBJECTIVES

Development of factory complete automation with all actions working under control is designed to improve product quality and process availability. To assure high quality and good availability some critical areas will be pinpointed and studied in an experimental way and simulated with the purpose of prototyping the whole process.

Once scientifically analysed, tested and optimized, the results will provide a comprehensive system able to improve the stretch film features and to integrate the new technology perfectly.

To make the design a reality, manufacturing interprets the product definition data to plan the orderly sequence of events that must occur to convert the "raw materials specifications" into a "production definition data document". The only way of doing this is to change the work organization and to improve the technology - automation is preeminent and CIM is the solution.

By this approach CIM can achieve its purpose and a programmable automation system provides the best means of leveraging both the information assets and fixed assets of manufacturing enterprise.

In particular: product and process control and performance, data flow and SW / HW integration, factory communications.

In order to achieve these objectives the research has highlighted the main critical areas attempting solutions that represent significant advances on current and foreseen practices in the scientific applied field :

- new CIM architecture implementation, - new extruder process control, - multilayer measurement control, - chill roll and pre-stretching improvement, - stochastic analysis, - extruder process simulations;

Tests and practical proofs will confirm the results and will give greater efficiency to the specific field.

KEYWORDS

Materials processing; Process/product monitoring; Quality assurance; Polymers; Automation/CIM

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Contract no: BREU-0394
Proposal no: BE-4104

NEW REINFORCED THERMOPLASTIC MATERIALS

Starting date: April 1988 ***Duration:*** 36 months

OBJECTIVES

The main objective of the project is to verify the possibility of employing Liquid Crystal Polymers (LCPs), due to their fibrous morphology and low melt viscosity, both as reinforcing agents and processing aids of conventional Thermoplastic Polymers (TPs).

ACHIEVEMENTS TO DATE

The main objectives of the project have been completely fulfilled. Both qualitative and quantitative information on processing aid effect of different LCPs when blended with different TPs have been obtained: viscosity of melt blends is constantly much lower than that of TP alone and also the processing temperature is reduced. Processing aid effect is meaningful when considering the advantages: reduced energy consumption, less degradation of polymers and easy filling of large or complex moulds.

The achievement of self reinforcing composites depends on the ability to melt process blends in such a way that LCPs form the reinforcing phase. The main factors which affect the formation of fibrils have been fully investigated and understood; reinforced materials which compete with glass fibre-reinforced plastics have been obtained; these blends represent a convenient method for exploiting some of the outstanding properties of LCPs, but at a reduced cost.

KEYWORDS

Materials processing; Electrical/Electronic industry; Composites (polymer matrix); Fibres/Reinforcing materials; Plastics; Liquid crystal polymers (LCPs); Materials characterisation/Testing.

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Contract no: RI1B-180
Proposal no: P-2199

HIGH PERFORMANCE REINFORCED THERMOPLASTICS FOR AEROSPACE STRUCTURAL APPLICATIONS PROCESSED BY INJECTION MOULDING

Starting date: February 1990 ***Duration:*** 30 months

OBJECTIVES

One of the most cost-saving techniques for manufacturing certain aerospace structural parts will probably be in the near future the injection moulding technology. The use of such a process in the aerospace industry requires:

- increased mechanical properties of injection moulded parts;
- design data and tools to predict the properties which could be obtained with such a process.

The first point will be reached either by using aerospace high performance fibre reinforced thermoplastics, by increasing the fibre length in the mould or by using the Multi Live Feed System which permits better control of the fibre orientation. Thus different processes will be developed and investigated in order to decrease the fibre degradation during the injection moulding phase.

The second requirement will be met by developing simulation software for filling and fibre orientation. Emphasis will especially be placed on weld line modelling and characterisation. The models and software will first be developed for short fibre high performance thermoplastics and then tested with the other processes.

ACHIEVEMENTS TO DATE

- Injection moulding and mechanical characterisations in simple moulds have been performed for short carbon fibre reinforced PEEK and PEEKK. Mechanical properties are mainly influenced by the fibre orientation in the finished part.
- A model for fibre orientation prediction in simple moulds has been developed. Results are in accordance with observations.

KEYWORDS

Aeronautics/Aerospace; Materials processing; Processing (Rubber&plastics); Plastics/Rubbers; Injection moulding.

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Contract no: BREU-0097
Proposal no: BE-3203

DEVELOPMENT OF CFRC MATERIALS WITH PARTIALLY REDUCED CARBON FIBRE CONTENT FOR USE IN CAR BRAKE SYSTEMS

Starting date: February 1989 ***Duration:*** 43months

OBJECTIVES

The objective of the project is to develop CFRC materials and components for use in car brake systems by:

- Selection and investigation of suitable CFRC materials with a lower content of carbon fibres and treated with additives.
- Development of samples and components with integrated friction pads.
- Characterisation of the material including tribological testing.

ACHIEVEMENTS TO DATE

The manufacture of prototype components of brake pads and brake discs of different C/C materials supplied by the partners. The brake pads were tested on a friction tester under varying conditions, regarding the friction properties, mechanical wear and the influence of additive as well as post-impregnation on these properties. A cast iron brake disc is employed as a standard and the conclusions are:

1. There are oxidation problems primarily at the outer surface of the pad.
2. The additive TiN in a C/C composite homogenizes the friction properties and raises the cold friction coefficient, but catalyses the oxidation at elevated temperatures.
3. The impregnation with polymers lowers the porosity, reduces wear and homogenizes the friction coefficient, while lowering its value.
4. The contact pattern during braking is not complete enough.
5. The heat transfer is too high (overheating of the the braking fluid).

Points 1), 2) and 3) require further material development while 4) and 5) require an adapted system, e.g. new back plates for brake pads.

KEYWORDS

Automotive, Components & parts; Carbon/Graphite; Fibres/Reinforcing materials; Tribology.

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Contract no: MA1E-0068
Proposal no: P-0148

OPTIMISING STRUCTURAL FIBRE COMPOSITES BY HYBRIDISATION

Starting date: April 1989 ***Duration:*** 30 months

OBJECTIVES

The aim of the project is to produce cost effective high performance polymer composites by judicious reinforcement and mixing (hybridization) of both high and low performance fibres in the same matrix system. To achieve this objective it is proposed to fabricate a systematic series of mixed fibre (E-glass, carbon, aramid, etc.) composites based separately on both thermoplastic and thermosetting matrices. Detailed studies will then be carried out to investigate the mechanisms by which loads are transferred between fibres and matrix under compressive, tensile and flexural loading. The failure processes will be quantified by surface fracture analysis, acoustic emission, and electronic speckle pattern interferometry techniques, etc. This will allow the development of mathematical models to predict mechanical behaviour. Thus in the long term it is hoped that the project will provide data to identify novel cost competitive lightweight hybrid materials with improved buckling resistance and damage tolerance.

ACHIEVEMENTS TO DATE

Pressure/temperature conditions have been optimised for carbon and glass fibre reinforced polypropylene composite production so that ply misalignment is minimised.

At this stage of reporting, all partners are actively involved in those aspects of the mechanical testing sub-programmes assigned to them. Thus data is now available on tensile, flexure, compression and falling weight impact behaviour. Early impressions are that some of the sample combinations are exhibiting synergistic "hybrid effects" in the sense that certain mechanical properties are not necessarily predictable in terms of the mechanical performance of their components (weighted in terms of their volume fractions present in the composite). Predictive behaviour models and graphs produced to represent falling weight impact behaviour, however, look very promising and initial examples are available for comparison purposes. Future reports will fully disseminate all the mechanical data and additional evidence provided by acoustic emission analyses and detailed fractographic examination will be used to refine and develop behavioural models and the prediction of "optimum" material combinations.

KEYWORDS Composites (polymer matrix); Fibres/Reinforcing materials; Materials characterisation; Research and development; Materials processing; Plastics/ rubbers; Reinforcement technology.

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Proposal no: P-0135

THE ROLE OF THE FIBRE-MATRIX INTERFACE ON THE MECHANICAL BEHAVIOUR AND DAMAGE DEVELOPMENT IN CARBON-FIBRE REINFORCED PLASTICS COMPOSITES

Starting date: April 1988 ***Duration:*** 45 months

OBJECTIVES

The principal objective of the project is to determine the extent to which damage development in CFRP laminates may be influenced by controlling the degree of bonding between the fibre and the matrix. Subsidiary objectives are to develop techniques for characterising the interface and treatments which control the interface properties.

ACHIEVEMENTS TO DATE

A large batch of intermediate-modulus carbon-fibre was manufactured and sub-batches subjected to different levels of oxidative surface treatment. Most of the fibre was converted into a prepreg using both an epoxy and a poly ethersulphone (PES) matrix. The prepreg was moulded into laminates for testing.

The strength distributions of the fibres have been determined, as also has the adhesion of the fibres to an epoxy resin. Fibre surfaces have been characterised by photo-electron spectroscopy, SEM, STM and other techniques. Surface chemistry has been correlated with adhesion.

An extensive programme of mechanical testing is being completed. Matrix cracking in cross-ply laminates has been studied as well as fracture toughness and fatigue, and the standard range of mechanical tests.

A strong influence of fibre surface treatment on adhesion and on the development of damage has been established. Most mechanical properties appear to be enhanced by fibre surface treatment; but the optima for different properties are observed at different levels. In general the best combination of properties is at a somewhat lower level than the standard commercial treatment.

Damage development occurred at relatively higher strain in the PES matrix material and toughness was higher. However, the response to the surface treatment was similar in the two systems.

The level of adhesion and damage resistance has been shown to be quite sensitive to processing conditions, especially in the epoxy matrix system.

KEYWORDS Composites (polymer matrix); Carbon-fibre; Surface-treatment; Damage development.

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Contract no: MA1E-0047
Proposal no: P-0721

DEVELOPMENT OF NEW THERMOSTABLE HIGH PERFORMANCE COMPOSITES BASED ON BISMALEIMIDE MODIFIED SILOXANE MATRIX AND CONTINUOUS CARBON FIBRES

Starting date: September 1988 ***Duration:*** 30 months

OBJECTIVES

The project aims at optimising a continuous carbon fibre composite material for use at elevated temperatures (250°C). The matrix is a thermostable bismaleimide of the newest generation. It is designed for processsing composites by a hot-melt route and giving tacky and drapable prepregs.

The resin formation, the processing conditions (impregnation and cure) as well as the sizing material which first coats the fibres will be studied and optimised. The standard sizing material (epoxy-based) has a lower thermostability than the matrix and it may weaken the interfacial region at elevated temperatures. New sizing materials will be evaluated for improving composite overall thermostability while preserving the other properties. The manufacture of a prototype part (to be determined) should close the project.

ACHIEVEMENTS TO DATE

Bismaleimides are interesting candidates for high temperature applications but suffer from relative brittleness because of their highly crosslinked structure.

The optimisation of carbon fibre composites shows that the property transposition from BMI resins to composites depends in large measure on the processing route.

Unfortunately, thermostable sizing (exhibiting the same thermostability as the resin) developed and optimised in this book does not retain the same level of properties as epoxy sizing. It dissolves during impregnation with the matrix. It has been found that it can contribute to the processability as zell as to the end use properties of the composite by modifying the region of the interface with the fibres.

High level thermomechanical properties were also shown. However, the increasing thermostability comes with decreasing toughness.

The new biphasic high temperature thermoset proposed by Rhone-Poulenc gives a marked improvement in fracture toughness.

KEYWORDS

Aeronautics/Aerospace; Composites (polymer matrix); Fibres/Reinforcing materials; Research/Development.

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Contract no: MA1E-0083
Proposal no: P-0165

INTERFACE CONTRIBUTION TO THE TEMPERATURE-DEPENDENT PROPERTIES OF CARBON FIBRE-REINFORCED BISMALEIMIDE COMPOSITES

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

The main goal of this project is to examine whether the coatings of current carbon fibres are fully adapted to the thermostable resins (bismaleimides) used for medium-range temperature structural applications. Experimental fibre surface treatment and/or coatings will be compared to the commercial ones by conducting extensive micromechanical (interfacial composites), as well as macromechanical (mechanical testing of unidirectional composites) investigations at temperatures up to 200-250°C.

Finally, the overall thermal-mechanical behaviour of the carbon fibre-reinforced thermostable composites will be modelled, taking into account the combined effects of matrix and interface characteristics, as well as the thermal stress states developed during consolidation of these composites.

KEYWORDS

Aeronautics/Aerospace; Materials processing; Composites (polymer matix); Materials characterization/Testing; Materials science

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Proposal no: BE-4016

DEVELOPMENT OF IMPROVED DAMAGE TOLERANT CARBON FIBRES-ORGANIC COMPOSITES

Starting date: February1990 ***Duration:*** 39 months

OBJECTIVES

Because of severe design limitations due to poor damage tolerance of currently used composites, development of improved damage tolerant carbon fibre-organic matrix composites has been identified as a key factor for widespread use of composites on aircraft primary structures. Independent works indicate that an increase of up to 30% of impacted resistance under compressive load is attainable by introducing new manufacturing concepts at each step of the laminate process with no need for major modifications in existing equipment. The goal of this project is to develop and characterise four pilot composites by introducing the following:

1. Improved constituents (new fibre surface treatments, toughened resins).
2. Establishing a reliable selection criteria for fibres and matrices properties to optimise interface bonding.
3. Development of transverse reinforced prepregs.
4. Use of thin thermoplastic resin films as interleaves during laminate production.

During mechanical characterisation on impacted samples of pilot composites, proper instrumentation using acoustic emission technique will be developed in order to perform accurate damage growth characterisation.

ACHIEVEMENTS TO DATE

Task 1 (development of constituents: fibres and matrices) has been done.

Main conclusions are the following:

- Preliminary selected fibres (surface treatment and finishes) have been elaborated and characterised and the final selection is: HTA and IMS with surface treatment and epoxy finishes for extensive tests during Task 3 (characterisation of laminates). HTA without and with five times surface treatment for basic understanding.
- Various matrices have been characterized with two main targets: increase of the GIC and no degradation of properties compared to the ones on the existing systems. Two matrices that fit our initial target are presenting a sensitive increase of the GIC.

System A (formulation not disclosable because of the Consortium Agreement between partners) with a GIC of 810 J/m2

System B with a GIC of 270 J/m2.

- The interface of the different combinations of fibres and matrices were characterised. This point could enable us to correlate the results with those obtained during the impact tests (during Task 3) and will help to establish reliable choice criteria on interface properties.

KEYWORDS Composites (Polymer Matrix); Impact damage tolerance

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Contract no: BREU-0089
Proposal no: BE-3194

DEVELOPMENT, CHARACTERISATION AND UTILISATION OF NOVEL MODIFIED AMORPHOUS POLYAROMATICS FOR USE AS COMPOSITE MATRICES

Starting date: May 1990 ***Duration:*** 48 months

OBJECTIVES

The overall aim is to develop new, high performance composites based on amorphous thermoplastic precursors, with advantages over state-of-the-art composites. New polymers for composites will be developed aimed at achieving, for example, advantages over semi-crystalline polyaromatics in terms of prepreg costs, upper use-temperature, quicker fabrication and easier bonding. Possible advantages over amorphous polyaromatics will be in areas of solvent resistance, creep and modulus beyond Tg.

ACHIEVEMENTS TO DATE

A variety of suitable chemical functionalities have been introduced either at the polymer chain ends or pendant to the chain of an amorphous high temperature performance thermoplastic. These functionalities are being used to introduce chemical crosslinks, or physical crosslinks through the incorporation of crystalline, grafted moieties or to achieve *in situ* chain extension of low molecular weight polymers through suitable end group chemistry. The impegnation of these polymers onto carbon fibre is now being studied and the effect of these chemical modifications on fibre/matrix interfaces established. Calibration of mechanical testing techniques has been achieved using chemically un-modified amorphous thermoplastic composites, and a semi crystalline composite.

KEYWORDS

Aeronautics/Aerospace; Composites (Polymer Matrix); Fibres/Reinforcing Materials; Polymers; Chemistry; Materials Characterisation/Testing; Amorphous polyaromatics

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IMPROVING DURABILITY AND PERFORMANCE OF THERMOPLASTIC BASED COMPOSITES USING NOVEL ADHESION PROMOTING POLYMER INTERFACES

Starting date: 1990 ***Duration:*** 36 months

OBJECTIVES

This project is concerned with mechanical performance and durability of thermoplastic-based composites under adverse and aggressive environments. The mechanical strength and dimensional stability of polymer composites are critically dependent on the nature of the fibre-matrix interface and its effectiveness in transferring shear stresses created in the matrix around the fibre ends. Modification of the polymer matrix with novel reactively processed modifiers provides a unique starting point for achieving effective fibre-matrix adhesion and enhanced composite performance.

ACHIEVEMENTS TO DATE

Two suitable polymer modifiers have been selected, and processing parameters and reaction conditions have been studied to optimise the production of the funcitonalised polymer.

Chemical reaction efficiency has been established via an exhaustive extraction procedure and other analytical techniques developed during this first year.

The results have revealed that polypropylene is sensitive to processing conditions such as shear, as well as the addition of the free radical initiator used in the grafting technique. Variations in the viscoelastic properties and lowering of molecular weight, polydispersity and intrinisic viscosity are observed.

The compatibility of the polymer and the modifying agent is shown using dynamic mechanical analysis.

The structural changes induced by the modification have been evaluated using a transmission optical microscope equipped with crossed polars. X-ray diffraction patterns were measured; in order to calculate the crystallinity of the samples; and to ascertain the crystal structure of the matrix.

KEYWORDS

Composites (polymer matrix).

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Proposal no: BE-3429

ADVANCED FABRICS FOR INTEGRAL COMPOSITE SANDWICH STRUCTURES (AFICOSS)

Starting date: June 1991 ***Duration:*** 42 months

OBJECTIVES

To prove the technical superiority and economic competitiveness of integral high-performance, light-weight sandwich panels, based on 3D-weavings. This will be done by the design, manufacturing and testing of real parts for aeronautical, marine and ground transportation applications.

Light weight sandwich panels (with honeycomb or foam cores), are not integrally technique is very expensive, and delaminations can cause serious problems in the use of these panels. Sometimes, the panels do not have the required properties (insulation for honeycombs, shear strength for foams). Recent adaptations of these materials have shown better performance, but also an increase in price and weight, and a reduction of secondary properties.

Because of the high cost, sandwich panels are mainly used in aeronautical applications. A decrease in the cost/performance ratio could facilitate the use of sandwich panels in medium and low tech area's.

A new type of sandwich panel, the Integral Composite Sandwich Panel (ICSP), will be made out of high performance composites based on 3D-weavings. This innovation leads to a construction material which is:

- cheaper than the existing sandwich materials, due to a one step manufacturing process, which can even be automated for specific applications
- technically superior: delamination and impact resistance of this material will be much higher. This will be combined with good basic mechanical properties, and improved environmental behaviour.

KEYWORDS

Materials processing; Processing (rubber & plastics); Composites (polymer matrix); Fibres/Reinforcing materials; Materials characterization/Testing; Mathematical modelling; Research/Development

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Contract no: BREU-0413
Proposal no: BE-4645

LIGHTWEIGHT HYBRID COMPOSITES WITH IMPROVED DAMAGE TOLERANCE BASED ON HIGH MODULUS POLYETHYLENE AND GLASS FIBRES

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

The primary objective is to investigate lightweight resin composites with high energy absorption and good damage tolerance properties. The composites will comprise high modulus polyethylene (HMPE) fibres with other available fibres incorporated in resin matrices. This includes the development of a continuous fibre plasma etching process to improve the fibre to resin adhesion, the development of a fibre cross-linking process to improve the fibre creep performance, the formulation and characterisation of organic matrices such as fast curing polyester resin, and evaluating HMPE fibre and HMPE cross ply fibre composite mechanical properties.

ACHIEVEMENTS TO DATE

- A continuous plasma treatment process operating at a yarn speed of 1 ms^{-1} and a yarn throughput of 0.7 kg min^{-1} has been developed.
- Cross ply composites using plasma treated HMPE fibre and epoxy resin have been made using a prepeg process.
- Electron spin resonance measurements have been initiated to identify the radical reactions during and after gamma irradiation of HMPE fibre to assist the identification of a cross-linking route.
- The curing recipe for the new polyester resin has been optimised.
- The plasticity of the polyester resin is being assessed by the effects of temperature on compressive yield stress and work hardening rate.
- Equipment has been constructed and preliminary fibre pull out tests made on samples having a range of plasma treatment.

KEYWORDS

High modulus polyethylene fibre; Reinforcing material

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Contract no: BREU-0054
Proposal no: BE-3565

SIMULATION DETECTION AND REPAIR OF DEFECTS IN POLYMERIC COMPOSITE MATERIALS

Starting date: March 1990 ***Duration:*** 42 months

OBJECTIVES

Polymeric compounds are used more and more in many industrial sectors because of their high mechanical efficiency (low density and anisotropy), high fatigue behaviour and lack of corrosion effects. The trend in polymeric composites manufacturing is to develop larger integrated parts. Key limiting factors to introduce such large monolithic composites have been identified as:

- High costs and high weight respectively in relation to the high rejection rate and design "oversize" due to the influence of in-manufacturing defects which have not been satisfactorily determined.
- High sensitivity of composites to in-service damages.
- Lack of defined application ranges of suitable repair techniques, especially when in-field intervention is needed.

Studies have shown that a better understanding of the influence of defects and the definition of related repair procedures will lower the amount of manufacturing scrap and allow the weight of the parts to be reduced.

Major objectives of this proposed research, therefore, will be:

- To define how the more important defects contribute to a decrease in strength.
- Enhance NDT accuracy and reliability confidence and optimise data evaluation in order to define a cross-correlation between their results and residual mechanical characteristics.
- To define the application ranges of repair procedures in terms of cost-effectiveness and residual life as a function of the type of damage.

KEYWORDS

Aeronautics/Aersopace; Manufacturing; Repair/Maintenace; Carbon/Graphite; Composites (Polymer matrix); Materials Characterisation/Testing; Mathematical modelling.

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Proposal no: BE-3218

NUMERICAL AND EXPERIMENTAL TECHNIQUES FOR COMPOSITE MATERIAL, STRUCTURAL DESIGN AND VALIDATION IN ADVANCED INDUSTRIAL APPLICATIONS

Starting date: April 1988 ***Duration:*** 36 months

OBJECTIVES

The objective of the proposal consists in the development of a set of numerical and experimental tools for composite materials found in advanced industrial applications. The computer code will be based on the homogenisation method.

This method will be extended to new fields of applications. In particular, the acoustic propagation in composite elastic media with inclusions, in piezoelectric media and the elastic behaviour of advanced 3-D structures of composite materials as the texture composite (aerospace, high energy physics and thermonuclear fusion applications).

The specific zones of interest of the structure can be reevaluated at microstructural level and the results of the study will be compared with those obtained through other methods (lamination methods, scattering theory) and with experimental tests.

ACHIEVEMENTS TO DATE

The seven different tasks of the project are:

- Assessment of computer techniques for composite materials.
- Physical problems.
- Extension of the homogenisation method to the new fields of application.
- Computer specifications.
- Development of the simulation package.
- Experimental tests (specification and execution).
- Validation of the computer programme and comparison with other methods.

After 36 months, tasks will be finished.

KEYWORDS

Materials processing; Composites (polymer matrix); Fibres/Reinforcing materials; Computer science/Software; Mathematical modelling; Vibration analysis.

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Contract no: RI1B-187
Proposal no: P-2150

DESIGN METHODOLOGY FOR THE IMPROVEMENT OF DAMAGE TOLERANCE WITHIN COMPOSITE STRUCTURES

Starting date: 1990 ***Duration:*** 24 months

OBJECTIVES

The objective of the programme is to develop an improved design methodology for carbon fibre composite components subject to low energy impact damage. To achieve this the programme aims to:

- Understand the mechanisms of damage formation and the effect of various parameters on the level of damage caused.
- Assess a number of hybridisation techniques to increase the damage tolerance.
- Develop techniques to predict the amount of damage caused in an impact event and to predict the residual strength following impact.

This knowledge will allow development and selection of new damage tolerant material systems with the minimum of testing and will allow engineers to design lighter weight, more efficient structures.

ACHIEVEMENTS TO DATE

Development of the analytical codes for damage and residual strength prediction is underway. Material characterisation data required as inputs to the models is being generated.

The programme of test work to assess the effect of parameters including flexural stiffness, support conditions and impact energy on the level and nature of damage formed and the residual strength of the laminate has commenced.

KEYWORDS

Aeronautics/Aerospace; Carbon fibre composites; Damage tolerance; Materials characterisation/Testing; Mathematical modelling

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Contract no: BREU-0276
Proposal no: BEO-3159

COMPOSITE MATERIAL FOR MARINE STRUCTURES AND COMPONENTS

Starting date: August 1990 ***Duration:*** 30 months

OBJECTIVES

The aim of this research activity is to investigate marine applications of composite materials, such as structural and outfitting components for large merchant and cruise ships, small and medium-size vessels.

The research is oriented towards two different fields of activity: new applications of composites in ships and improvement in existing applications.

The objectives for new applications are:

- the design and building of panel and pipe prototypes
- the definition of elements and data to implement new rules and regulations
- the validation of design procedures through the correlation of calculations and tests.

The objectives for the improvement of existing applications concern the evaluation of new safety margins to failure, the definition of methods for the qualification of structural components with respect to q.a. procedures and the review of rules and regulations.

ACHIEVEMENTS TO DATE

During the first year of the project the research has been developed as follows:

- Starting from a review of existing rules and regulations, the technical specification of selected components (pipes and structural elements) has been defined.
- An analysis of the theory and performance of some of the existing micro-macro mechanical codes has been carried out. The most suitable resin fibre combinations for the construction of the prototypes have been selected by means of experimental tests on samples and micro-macro mechanical calculations.
- Bending tests on large panel prototypes have been performed to be used in subsequent steps for theoretical and experimental correlations.

KEYWORDS

Shipbuilding; Validation; Composites (Polymer matrix); Fire resistance; Codes/Standards

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Contract no: BREU-0178
Proposal no: BE-3292

DEVELOPMENT OF NEW MATERIALS WITH IMPROVED FIRE RESISTANCE, REDUCED SMOKE AND TOXICITY FOR STRUCTURAL AND/OR FURNISHING APPLICATIONS

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

The development of new halogen-free thermoset polymers that meet the processing, thermal, flammability (fire, smoke, toxicity) and environment requirements means a basic research on the fire-retardant/matrix binary system.

Based on the synergistic effects of both nitrogen and phosphorus atoms, new telechelic phosphorylated cross-linkable monomers (reactive phosphine oxides, phosphazenes and a range of novel intumescent phosphorous/nitrogen containing reactive fire retardants) will be synthesized as an alternative to the hazardous fire-retardant systems commonly used.

Incorporation of these compounds into current thermoset resins will lead to optimized formulations. The formulations will be selected on the basis of simple thermo-mechanical characteristics (Tg wet > 170°C, fire specifications (OSU, etc.) and predictive computerized toxicity assessment.

Parallel basic studies on:

(i) the toxicity of the basic material

(ii) the degradation mechanisms and the determination of the contribution of the released products to the flamability, to the toxicity and to the smoke formed on burning will allow identification of the physico-chemical parameters involved in the basic chemical structures, and optimisation of these materials by regular feed-back with the other results obtained

The selected formulations will be fully characterized and then used for fibre impregnation of composite pieces. Moulding will demonstrate the application of this approach and indicate the level of improvement reached by this new type of fire-retardant materials.

KEYWORDS

Composites (polymer matrix); Polymers; Fire-resistance; Aeronautics/ Aerospace; Chemistry; Materials characterization

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Contract no: BREU-0466
Proposal no: P-4412

PRECOMPRESSION OF INDIVIDUAL LAYERS IN MULTILAYER CFRP COMPOSITES TO INCREASE THE THRESHOLD FOR INTERFIBRE/MATRIX CRACKING

Starting date: October 1988 ***Duration:*** 36 months

OBJECTIVES

This research project aims at delaying the onset of interfibre/matrix cracking in multilayer CFRP composites by applying design/manufacturing means, which are in analogy to the concept of prestressed concrete. Two major routes are being studied:

- Controlled expansion of a composite structure by using an expandable mandrel. Expansion is either done after filament winding, but prior to completion of gelling/curing or on a finished standard wound structure at a temperature above the glass transition point with final release of the expansion loads after cooling down.
- Stress relief of standard wound structures by submission at elevated temperatures to stresses similar to those experienced in later operation followed by cooling down to ambient temperature prior to unloading.

ACHIEVEMENTS TO DATE

A suitable expandable mandrel has been designed and a prototype build has been manufactured. A winding/expansion route has been developed and a larger quantity of multilayer CFRP samples with various prestrain levels (up to 0.8%) has been produced. The samples have been submitted to spin load tests and hydraulic pressurisation. It was shown that by controlled expansion the onset of interfibre/Matrix cracking was shifted towards higher strains, thus the aim of this project has been achieved. Stress relief tests are currently being undertaken. Modelling of the expansion process has commenced.

KEYWORDS

Composites (polymer matrix); Engineering (mechanical); Materials characterisation/Testing.

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Contract no: MAIE-0049-C
Proposal no: P-0706

DEVELOPMENT OF TECHNIQUES FOR PROCESSING 'LARGE' ORGANIC SHEETS, THERMOPLASTIC PREPREGS, RIBBONS AND FOILS

Starting date: March 1988 ***Duration:*** 42 months

OBJECTIVES

The aim of the project is the development of advanced fibre reinforced high performance thermoplastics (e.g. PPS, PEEK) and in particular the development of appropriate processing techniques of 'large' organic sheets, prepregs, ribbons and foils. The program envisaged the following aspects:

- Surface treatment of carbon fibres and the reaction on the mechanical properties.
- Melt impregnation of thermoplastics prepregs.
- Cutting and bonding techniques for thermoplastic prepregs.
- Winding techniques.
- Press and autoclave techniques.
- Endless section production techniques.

The studies are expected to permit the use of such reinforced thermoplastics in aerospace components and to increase the potential range of their application in other industrial sectors.

ACHIEVEMENTS TO DATE

An investigation of fibre finishes to evaluate the influence on the mechanical properties of composites was carried out. A melt impregnation plant for thermoplastic prepregs was installed and is in operation. Press and autoclave techniques with several layups, tool materials and process parameters were examined and the techniques were optimised. Winding techniques with cold and heated mandrels were evaluated and two fully automatic endless section production tools for L- and U-stringers were installed and are in operation.

KEYWORDS

Processing (rubber&plastics); Composite (polymer matrix); Fibres/Reinforcing materials; Plastics/rubbers.

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Contract no: MA1E-0067
Proposal no: P-0505

MULTILAYER INJECTION MOULDING

Starting date: July 1991 ***Duration:*** 36 months

OBJECTIVES

This proposal is concerned with the development of new technology for multilayer injection moulding. The technique of multilayer injection moulding itself is not new, but is yet to be explored to its full potential. The very limited use so far is due to the use of sequential injection only, the use of only two materials, and the restriction to simple axi-symmetric thick-walled products. In the proposed project technology will be developed for combined simultaneous and sequential injection of three materials allowing, for example, combinations of dissimilar polymers with an adhesive layer between them. With a single injection step, one would be able to make integrated products with, for example, built-in conductive layers (EMI shielding) or gas barrier layers (food packaging). The development of this new technology will require extensive adaptation of existing technology, including the solution of a number of technological problems concerning the design of the valve system, the strategy of injection, the pre-configuration of the material to be moulded and the computer control system controlling the process. Some computer modelling software to aid the mould design process will also have to be developed. The potential savings in production costs of a very wide range of products by the application of this technology would be very large.

KEYWORDS

Materials processing; Processing (rubber & plastic); Multilayers/ Multimaterials; Polymers; Computer science/Software; Mathematical modelling

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Proposal no: BE-4076

FILAMENT WINDING OF THERMOPLASTIC MATERIALS

Starting date: December 1988 ***Duration:*** 36 months

OBJECTIVES

The objectives of the programme are to develop new innovative processing methods for thermoplastic matrix composites using the filament winding technique. This technique has already proved to be cost effective for thermoset matrix composites and combined with the easier processing of the thermoplastics, manufacture of cost effective high performance products can be achieved for a range of applications.

Apart from the development of material processing techniques, the aim is to develop specific processing equipment with associated sensor and control systems. The choice of materials spans thermoplastics reinforced with carbon fibres to glass fibres.

ACHIEVEMENTS TO DATE

- Standard test methods and quality accept levels have been agreed upon.
- The processing parameters for different heating methods have been optimised.
- Good quality samples have been produced, including flat sections and non-geodesic winding.
- A flexible process control system has been developed and tested.

KEYWORDS

Materials processing; Composites (polymer matrix); Composites (thermoplastic matrix); Filament Winding

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Contract no: RI1B-242
Proposal no: P-2397

DESIGN OF STRUCTURES IN COMPOSITE MATERIALS WITH CAD/CAM TECHNIQUE— ACHIEVEMENT OF A PROTOTYPE OF A FULLY AUTOMATED EQUIPMENT OF PRODUCTION IN FILAMENT WINDING

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

- Extend the application of the F.W. technique for the purpose of substituting all the prevalently manual techniques, exploiting the advantages of this unique technology by placing the fibres along the geodetic lines of the structural surfaces to be created in order to obtain the maximum values of the mechanical characteristics and elastic properties of the composites.
- Develop design methodology and advanced methods of control extended to non-linear field, which take into account the anisotropy of the composite materials.
- Develop a three-dimensional CAD/CAM software to identify and handle any surface, even of complex geometric shape.
- Develop and construct F.W. prototype machine with numerical control software able to cope with up to 5 interlocked axes, with the precision now obtainable by the electronic controls of numeric type.
- Develop and realise the design of a prototype production plant utilising F.W. machines completely controlled from a central automatic station.
- Control the fibre-matrix ratio in accordance with the laminate requirements.
- Develop technologies which would be capable of extending the utilisation of F.W. techniques. For example, checking of fibre-matrix ratio in wet impregnation, the creation of low-cost pre-impregnated without 'greenlife' problems, the constant control of the bundle width of deposited fibres.
- Prepare and experiment valid hypothesis of failure as well as methods of predicting damage propagation.

KEYWORDS

Chemical/Petrochemical; Composites/Polymer matrix; Polymers; CAE/CAD/CAM systems; Chemistry; Materials science; Mathematical modelling; Research/Development

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Contract no: BREU-0114
Proposal no: BE-3381

PROCESSING STATEGY FOR FILAMENT WINDING OF THERMOSET COMPONENTS BASED ON A MATHEMATICAL PROCESS DESCRIPTION

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

The objective of this project is to confer higher quality, with lower costs, to the manufacture of filament winding components, as necessary to give them a more important role in the advanced composite market.

This aim will be reached through the:

- Development of a mathematical model that simulates the winding and curing processes. The model will provide the wound composite temperature, degree of cure, viscosity, fibre position and fibre tension as a function of position and time during the filament winding and subsequent curing, and the residual stresses and strains within the wound composite during and after the cure
- development, manufacture and setting of a sensors system able to pick up the main parameters during the winding and curing processes
- production of a complete software package for the solution of the mathematical model.

A subroutine of this programme code will compare the experimental process data, measured by the sensor system, with the equivalent process parameters evolution calculated by the mathematical model.

- Development of a data acquisition and experiments supervisor system (D.A.E.S.S.) that will transfer the values of the main parameters, measured by the sensor system, to the computer system.

KEYWORDS

Filament winding technology; Process monitoring; Fibres/Reinforcing materials; Mathematical modelling; Validation

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Proposal no: BE-4551

DURABILITY OF CONTINUOUS FIBRE REINFORCED THERMOPLASTIC COMPOSITES WITH EMPHASIS ON THE INTERFACE BEHAVIOUR AND THE METHOD OF FABRICATION

Starting date: September 1990 ***Duration:*** 36 months

OBJECTIVES

With composites on the basis of thermoplastic matrices in comparison with thermoset matrices it is possible to get a better dimensioning of structures. Thermoplastic composites are expected to have an improved damage tolerance. Replacing thermosets by thermoplastics as matrix increases the delamination energy and the residual properties after impact. This can further be improved by using longer fibres.

The objective of this project is the characterisation and modelling of the quality of the impregnation of the glass fibres by thermoplastics (polyethyleneterephthalate, polyamide-6,6 and polyetherimide) and the durability of the resulting thermoplastic composites.

Long cycle times and excess energy requirements are characteristics of the current fabrication process of the products out of semi-manufacture tape. This research focuses on the improvement of the impregnation quality of the powder impregnation of bundles of fibres and development of a short cycle stamping process with dielectric heating. In this respect carbon black is added to polyetherimide to make this thermoplastic suitable for dielectric heating.

The durability of the final product will be investigated by: hygrothermal ageing, environmental stress corrosion, fatigue, thermal cycling and creep.

Samples produced by different processing routes and after different loading histories will be investigated using simple mechanical tests, fracture surface analyses using SEM, DMTA, DSC, Raman- and FTIR-spectroscopy and microhardness.

KEYWORDS

Compsites (polymer matrix); Materials charaacterisation/Testing; Manufacturing; Hygrothemal ageing; Environmental stress corrosion; Thermal and load cycling.

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Proposal no: BE-3062

DEVELOPMENT OF TECHNIQUES FOR POLYMERIC DIAPHRAGM FORMING OF CONTINUOUS FIBRE REINFORCED THERMOPLASTICS

Starting date: July 1990 ***Duration:*** 48 months

OBJECTIVES

Preliminary work on polymeric diaphragm forming of continuous fibre reinforced thermoplastics has proved that this process has great potential for the fabrication of complex curvature components from this new generation of high performance composite materials. The equipment which has been used in the recent work has included hot autoclaves, cold autoclaves, pressclaves and modified vacuum forming machines but to date there is no clear indication as to which is the most suitable for any particular product. As this technique is very new it requires substantial development to bring it to the stage where it will become both technically and commercially viable. The major objectives which represent significant advances on current practices are, the development of (a) high temperature (300°C) resistant material forms which are tailored for the process; (b) high temperature (300°C) resistant films capable of an increase in area of 100%; (c) an overall process cycle of 20 min; (d) tools with heating and cooling rates of 20°C/min together with a coefficient of thermal expansion of 5x10-6/K.

ACHIEVEMENTS TO DATE

- The selection and design of the aircraft component was completed.
- The design and the construction of a consolidation measurement apparatus were completed.
- The design of the rig for the measurement of the shear deformation behaviour was completed.
- The software for the thermal analysis was selected and used to carry out preliminary modelling.
- The tools for the different forming routes were designed and manufactured.
- Preliminary forming trials were carried out.
- The material development is under on-going improvement.

KEYWORDS

Aeronautics/Aerospace; Materials processing; Processing (rubber&plastic); Composites (polymer matrix); Research/Development

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Proposal no: BE-3212

INJECTION AND BLOW MOULDING OF FIBRE-REINFORCED THERMOSETS AND THERMOPLASTICS WITH OPTIMISED FIBRE LENGTH AND MECHANICAL PROPERTIES —'INBLOFIL'

Starting date: April1990 ***Duration:*** 36 months

OBJECTIVES

The aim of the project is to investigate fundamental principles and to modify well-known processing steps and to make it possible to use reinforcing fibres in lengths of approx. 10mm for polymer matrices in injection and blow moulding.

Fundamentally the breakage of fibres in polymeric compounds has been investigated in capillaries, dies and couette flow as a function of processing and compounding parameters. The behaviour of fibres in a couette flow has been visualised using flourescent fibres in transparent model fluids. Using these results, properties of the compound, design of the injection moulding machine and processing conditions have to be optimised in order to reduce fibre breakage. For thermoplastics, fibre melt-impregnation and the directly following moulding step in the same heat has been one main activity. Several machines were tested and compared for their suitability. The best results (12-13mm av. fibre length) were achieved with a z-kneader. Combination of this kneader with a blow-moulding device will be investigated next. An automated method to determine fibre length and orientation has been developed. After elaboration of a specimen prepartion technique and a measuring device, using an image processing system, fibres of up to 25mm, crossed or curved, can be detected and measured. Optimisation of fibre preparation and handling is still going on, as is the elaboration of a technique to determine fibre orientation.

KEYWORDS

Materials processing; Processing (rubber & plastics); Composites (polymer matrix); Fibres/Reinforcing materials; Plastics/Rubbers; Reinforcement technology; Research/Development.

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Proposal no: BE-3103

ADAPTATION OF RECYCLED PET TO THE EXTRUSION BLOW MOULDING PROCESS

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

Polyethylene terephthalate (PET) is extensively used for the production of bottles for water and beverages and other edible products.

Industry is committed to reclaim 50 % of those bottles every year (corresponding to 900,000 tons/year by 1995). The recovered material cannot be used for remaking water and beverage bottles, and the existing recycling outlets cannot absorb such huge quantities of reclaimed PET.

In this project recovered PET will be modified through blending. The PET blends will be suitable substitutes to virgin HDPE and PVC in the production of containers for lubricants, agrochemicals, liquid detergents etc.

The project will contribute to the:

- relief of solid waste problem
- decrease of plastics consumption
- extension of the limits of extrusion blow molding technology
- increase of the knowledge on polymer blends.

KEYWORDS

Materials Processing; Packaging; Processing (rubber & plastic); Plastics/ Rubbers; Waste/Effluents; Ecology/Environment; Materials science

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Proposal no: BE-4034

DEVELOPMENT OF DESIGN AND PROCESSING TECHNIQUES FOR OVERINJECTION OF THERMOPLASTIC COMPOSITES

Starting date: June1990 ***Duration:*** 36 months

OBJECTIVES

The aim of the project is to provide essential technological and theoretical tools for industrial applications of overinjection of short fibre reinforced thermoplastics into continuous fibre reinforced thermoplastic bases. This research will lead to new capabilities in specifying a suitable heating system for the base such that the surface of the base will remain hot during the injection phase. An overinjection tool will also be designed with facilities for clamping and sealing the base. The project will also simulate the flow in a tool with a heated base fixed within the tool cavity, and consider the effects of processing conditions on the bond strength of an overinjected component. The project will conclude by design and manufacturing a real life overinjected product.

ACHIEVEMENTS TO DATE

Sample overinjection items have been manufactured and analysed by the consortium, two moulds producing different overinjected shapes have been designed, fabricated and commissioned. Work is well advanced on simulating the overinjection process by the finite element method. The thermomechanical properties of materials under consideration have been obtained experimentally.

KEYWORDS

Materials processing; Assembly/Joining; Processing (rubber & plastic); Adhesives/Bonding; Composites (polymer matrix); CAE/CAD/CAM Systems; Mathematical modelling

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Contract no: BREU-0216
Proposal no: BE-3532

DEVELOPMENT OF THE RUBBER BATCH MIXING PROCESS FOR OPTIMAL QUALITY

Starting date: January1990 ***Duration:*** 36 months

OBJECTIVES

There is a strong market requirement to increase the quality of the rubber parts as well as to tighten their tolerance.

Therefore the objectives of the project are:

- To determine close relationships between mixing parameters, dispersion measurements and mix properties.
- To develop an innovative closed-loop control system capable of providing the quality of the mix in real-time.
- To compare the efficiency of the two main types of internal mixer present on the market.
- The aim is to reduce the variability of the rubber mixes and to improve their quality level.

ACHIEVEMENTS TO DATE

- An improvement in batch variability has been found with the resulting problem of interpreting the results of the factorial experimental design. A new design is in to solve this problem.
- Dispersion measurement techniques: electrical and dielectrical methods and image analysis have been improved significantly. We are close to an optical use.
- An innovative control system has been designed and manufactured and promising results obtained. But the response time still remains to be reduced.

KEYWORDS

Rubber processing; Quality; Control systems; Materials characterisation; Instrumentation.

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Contract no: BREU-0076
Proposal no: BE-3006

HOT-WET-PRESS PROCESS

Starting date: January 1991 ***Duration:*** 27 months

OBJECTIVES

To develop an alternative process to the vacuum injection process by using the known so called "wet-press-process". The wet-press process has the disadvantage of the long hardening time. This, to improve by using hot-hardening for the product's top layer, is the main new research factor in this project. It would result in the new hot-wet-press process which in turn would give the possibility to produce large parts or products more economically. By improving furthermore the quality of the top layer and the filling material of the product, shorter production time, but combined with the advantages of the wet-press and injection process should result in good market acceptance for the final product.

ACHIEVEMENTS TO DATE

Selection, scheduling and preparation for use of technical components for the first trial runs of certain parts of equipment.

KEYWORDS

Chemical/Petrochemical; Forming/Shaping/Casting; Fibres/Reinforcing materials

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Proposal no: BE-3522

DEVELOPMENT OF MATERIALS, TOOLS, COST EFFECTIVE PROCESS DESIGN AND TECHNIQUE FOR ADVANCED STRUCTURAL COMPOSITES BY RESIN TRANSFER MOULDING

Starting date: October 1990 ***Duration:*** 36 months

OBJECTIVES

- Development of new polymeric epoxy-phenolic matrices for RTM
- Development of suitable preforming and structural fabric reinforcements
- Development of an advanced cost effective manufacturing process of advanced composites for aerospace application with high structural properties through an advanced RTM process technology
- Substantial reduction of manufacturing costs of advanced composites and solution of availability problems of raw and intermediate materials to the European industry.

ACHIEVEMENTS TO DATE

- All partners have designed and manufactured their model or reference tool for RTM technology screening
- The selected resin reference system is being compared with new synthesis of polymeric matrices for improvement of product and process difficulties
- Reference carbon and glass fibres have been selected and different fabric forms are being screened for compatibility with resins and processability
- Technological alternatives of approach of RTM are under investigation for final selection of the advanced process features
- Models of composite components are being designed for prototype manufacturing and application in aerospace industry.

KEYWORDS

Chemical/Petrochemical; Materials processing; Mechanical engineering/ Machinery; Composites (polymer matrix); Manufacturing; Prototyping; Machine tools

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DEVELOPMENT OF A CONTINUOUS PROCESS AND A PROTOTYPE FOR MANUFACTURING RUBBER COMPOUNDS FOR CAR TYRES, CONVEYER BELTS, AND TECHNICAL RUBBER ARTICLES

Starting date: June 1991 ***Duration:*** 40 months

OBJECTIVES

The purpose of the present project is the development of a continuous process and a corresponding test equipment for the manufacture of rubber compounds applied in the tyre manufacturing industry, the conveyer belt industry, the drive belt (V-belt) industry and for the manufacture of technical rubber articles.

The production of rubber compounds for the aforementioned purposes has so far been effected discontinuously with internal mixers connected in series. These internal mixers, however, can only incorporate the fillers such as carbon black etc. to an extent of approx. one third in one mixing cycle, in order to avoid an overheating of the compound.

The aim is to incorporate all components without a damaging temperature increase. This objective is to be reached by developing a process and a test equipment which will increase the surface/volume ratio by at least ten times compared to internal mixers in order to improve the mixing effect and the temperature control.

KEYWORDS

Processing of rubber; Mechanical engineering.

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Contract no: BREU-0416
Proposal no: BE-4009

DEVELOPMENT OF A NEW FILLER ELASTOMER SYSTEM FOR IMPROVED TYRE PERFORMANCE AND DRIVING SAFETY

Starting date: 1991-1992 ***Duration:*** 48 months

OBJECTIVES

Stringent European market demands for higher quality and increased safety as well as environmental restrictions give rise to an urgent need for improved tyres, especially for high performance cars.

The goal of the project is the development of a physical and chemical model which linhe raw material characteristics to the viscoelastic and final tyre properties. This model will be used to explain and predict the macroscopical behaviour of rubber compounds and will serve as a tool to speed up new tyre development, reduce costs and bring high quality tyres to the market.

Such a model has to be based on the physical and chemical interactions of polymers and carbon blacks. The relevant parameters guiding these interaction mechanisms need to be evaluated by advanced testing techniques.

The application of tailor-made polymers and carbon blacks together with an optimised mixing process will allow the design and manufacture of a new tyre tread with a good balance of wet skid and rolling resistance at significantly improved abrasion.

KEYWORDS

Automotive, Components & Parts; Processing (rubber & plastic); Plastics/ Rubbers; Materials characterization/Testing; Research/Development

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Proposal no: BE-4455

IMPROVED TYRE SAFETY AND LIFE BY A NEW WIRE RUBBER ADHESION SYSTEM

Starting date: June 1991 ***Duration:*** 48 months

OBJECTIVES

A new advanced non-copper coating for steel cord has been developed in the laboratory to improve the durability of the wire/rubber adhesion bond. Laboratory testing has shown that this coating gives:

- equal initial adhesion to rubber
- a reduction in the degradation rate of rubber by two times
- a lower corrosion rate of the wire by fifty times.

The prime objective of this project is to verify the improved safety and life of truck tyres using this new advanced coating made in a commercial manufacturing process.

In order to meet the prime objective the following sub-objectives need to be achieved in tandem:

- development of an electroplating system which can deposit a coating of two types of zinc alloy at industrial speeds and efficiencies
- development of lubricants which allow for an efficient/effective fine wire drawing process using a coating meeting the first sub-objective criteria.

These sub-objectives, in turn, require the evaluation and use of surface analysis techniques which can be used to:

- develop the physical chemical model of the drawing and wire/rubber adhesion/degradation processes
- control the quality of the wire.

KEYWORDS

Fibres/Reinforcing materials; Lubricants; Adhesives/Bonding; Coatings/Thin films, Composites (polymer matrix); Surface treatment technologies; Tribology

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Contract no: BREU-0421
Proposal no: BE-4215

DEVELOPMENT OF HIGH PERFORMANCE ISOCYANATE - FREE POLYMERS FOR NEW LOW TOXICITY PAINT

Starting date: June 1991 ***Duration:*** -

OBJECTIVES

The manufacture and use of paint has significant environmental impacts. The high performance paint sector is the most demanding in terms of application requirements and film properties. Consequently the development of new less toxic products with reduced levels of solvent emission for this sector has become a crucial issue.

The goal of the project is to produce new alternative high-solid, isocyanate-free materials to substitute polyurethane paints. Based on novel non-isocyanate, curing chemistry, new polymers will be produced to formulate paints with performance levels similar to those of currently used two-component polyurethanes but showing a lower toxicity level.

After completion of the research on basic polymers, they will be adapted to produce a development formulation paint which should meet the requirements of the general industry as well as the automobile, railway and aerospace sectors.

KEYWORDS

Aeronautics; Railways; Automotive; Engineering (chemical); Coatings; Chemistry

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Contract no: BREU-0457
Proposal no: BE-4414

SYNTHESIS CHARACTERISATION AND DEVELOPMENT OF NEW BIOCOMPATIBLE POLYAMIDES WITH CONTROLLED BIODEGRADABILITY

Starting date: 1990 ***Duration:*** 36 months

OBJECTIVES

The objectives are to obtain new polyamides and to determine their properties in order to decide on further development for practical use as resorbable biomedical materials.

The new polyamides are copolymers of glycine and related amino acids. Their molecular structure may be intermediate between proteins and traditional nylons, with an adequate balance of biocompatibility, biodegradation and mechanical properties.

ACHIEVEMENTS TO DATE

1) Nylons 1,n -$NHCH_2NHCO(CH_2)_{n-2}CO$-

Nylons with n=6,8,10 have been obtained. Biological tests show their biocompatibility. Their unique molecular structure has been determined by structural methods, mainly X-ray diffraction and electron microscopy.

Thermal analysis shows that decomposition starts at 210°C. Therefore more methylenes are required in the repeat unit in order to obtain thermally processable polymers.

2) Copolymers from 2/n ω-aminoacids -$NHCH_2CONH\ (CH_2)_{n-1}CO$-

Random copolymers of glycine and ω-aminoacids (n=6,12) have been synthesised by the active esters method. Characterisation is in progress. Biocompatibility appears to be different as a function of composition.

3) Copolymers of glycine and aminoisobutyric acid

Syntheses of sequential copolymers are in progress. Molecular mechanics calculations are used to predict their conformation.

KEYWORDS

Polymers; Polyamides; Biomedical; Biomaterials; Biocompatible; Biodegradation; Research/Development.

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AN INVESTIGATION OF THE PARAMETERS INVOLVED IN THE ENVIRONMENTAL ULTIMATE DEGRADATION OF PLASTICS

Starting date: 1990 ***Duration:*** 36 months

OBJECTIVES

With increasing public concern about the effects of plastics on the environment, a variety of new polyolefin-based packaging polymers have appeared on the market which are claimed to be photodegradable, biodegradable or both. Industry is at present unable to distinguish between the merits of such products because of the complexity of the relationship between biodegradation and other forms of environmental degradation.

The purpose of the proposed project is to establish the interrelationship between polymer oxidation, due to both heat and light, and biodegradation by defining the parameters involved scientifically. This will involve the study of the bioassimulation of the commercial films as manufactured and the change in their behaviour towards microorganisms with time of thermal and photo/oxidation. Studies will include the identification and continuous assessment of oxygen functional groups during oxidation and on exposure of oxidised polymer films to selected microorganisms. Changes in physical and mechanical behaviour of the materials will simultaneously be followed in order to establish the basis for international standard test methods.

KEYWORDS

Disposal; Packaging; Waste treatment; Polymers; Ecology/Environment; Materials science; Plasticultures.

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Contract no: BREU-0170
Proposal no: BE-3120

DEVELOPMENT OF A BIODEGRADABLE PLASTIC AND EQUIPMENT TO PROCESS IT INTO ORIENTED CONTAINERS

Starting date: March 1990 ***Duration:*** 36 months

OBJECTIVES

- To develop the process for isolating bacterial polyesters so that they are of suitable purity and melt behaviour to process into biodegradable oriented food containers.
- To develop new machinery for melting, forming and orienting these polymers in a reproducible manner.
- To characterise the physical, chemical and biodegradation properties of these new containers.

ACHIEVEMENTS TO DATE

The major species in the cellular residue that are responsible for the generation of odour during melt processing have been identified.

An instrumented technique for determining polymer colour has been developed and work is progressing to isolate the species associated with colour formation.

The thermal and physical properties of PHB/HV copolymers have been characterised and the relationship of these properties to hydroxyvalerate content quantified. The effects of organic impurities in melt stability have been quantified and the effect of inorganic impurities are under investigation.

The work on developing polymer processing has led to development of a novel device for plastification, metering and moulding preforms.

To enable the gathering of data on stress/strain behaviour and orientation at high strain rates, an instrumented high speed stretching rig has been constructed.

The work is progressing towards the goal of producing processable polymer of sufficient purity for food containers and an integrated device to convert polymer granules into oriented containers.

KEYWORDS

Processing (rubber & plastic); Orientation; Biodegradable.

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Contract no: BREU-0094
Proposal no: BE-3130

ENVIRONMENTALLY FRIENDLY HIGH PERFORMANCE WATERBORNE COATINGS

Starting date: July 1991 ***Duration:*** 48 months

OBJECTIVES

In terms of compliance with environment regulations or requirements water-based paint systems have potential as attractive replacements for the conventional solvent-based systems.

However, continuous problems with latex-based paints which impair them gaining a share in the industrial sector are their permeability (compared to solvent-based coatings) toward water-vapour and other potentially harmful pollutants, the occurrence of pigment flocculation, and their inability to impart a sufficient glossy aspect mainly due to poor rheology of the liquid paints at application and during film formation.

The objectives of the research are :

- to determine and evaluate the physico-chemical parameters governing the coalescence of the latex particles during film formation
- to evaluate and determine the parameters influencing pigment flocculation in latex paints
- to determine and evaluate the factors governing the efficiency of thickeners in controlling the rheological properties of the paints at application and drying
- to develop an explanative model based on the data derived from the experimental programme and on theoretical considerations, to formulate high performance latex paints for use by the industrial collaborators to develop their own proprietary systems.

KEYWORDS

Substrate protection; Paints; Formulation; Ecology/Environment; Promotion/ Technology transfer; Research/Development

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Contract no: BREU-0434
Proposal no: BE-4191

DESIGN, MANUFACTURING AND RECYLING OF ADVANCED THERMOPLASTIC COMPOSITE AUTOMOTIVE PARTS

Starting date: August 1991 ***Duration:*** 37 months

OBJECTIVES

Reduction of fuel consumption is one fothe main challenges to the automotive industry in the next decade. One of the answers to this challenge is the reduction of the car weight by using advanced composites for automotive structures. However, this weight saving potential cannot be used by the automotive industry today, since there are no suitable materials or high speed manufacturing processes available that will produce hundreds of parts a day. New semifinished products comprising fibres imbedded in a thermoplastic matrix with a fibre volume content higher than 50% (so called organic sheet) have been developed. The aim of this programme is to take advantage of this material development and establish manfacturing process and equipment suitable to produce automotive parts in high speed process.

A pilot production of a selected part will provide the main parameters to assess the technical and economical suitability of process and equipment for mass production of automotive structural parts made of advanced composites. The recycling of scrap materials and used parts is an integral part of the programme.

KEYWORDS

Composite with thermoplastic matrix; Forming/Shaping/Casting; Assembly; Manufacturing; Automotive parts; Quality assurance; Recycling

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Contract no: BREU-0454
Proposal no: BE-4125

REACTIVE BLENDS - A NEW WAY FOR IMPROVED AND RECYCLED MATERIALS

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

Today, blending of thermoplastic resins, miscible or not, represents a very important way of diversification for polymeric materials. Final properties of blends of incompatible homopolymers depend not only on their composition, but also on the processing conditions. All these parameters have to be adjusted to obtain the desired morphology and mechanical properties, which on the one hand must satisfy the quality requirements, but also remain unaffected during further processing and use of the final products.

To avoid the problems arising when the species are just mechanically mixed in continuous melt processing machines, we propose to study composite systems obtained by introducing preformed particles in a thermoplastic matrix. The dispersed phase can be easily prepared by the emulsion polymerization technique, which leads to spherical latex particles. The composition and morphology of the latex is determinated by the synthesis process, whose flexibility is well known.

Moreover, to improve our understanding of interfacial phenomena, latex particles which are functionalized on their surface, will be prepared and used as the dispersed phase in incompatible blends. The mutual reactivity with other polymeric species (matrix or additives) will lead to chemical reactions in situ, during processing of the blend.

The rheological and mechanical properties of the blends obtained in this way will be analysed as a function of the morphology, composition and reactivity of the particles. The expected progress in the preparation and stabilization of blends could be judiciously used for the recycling of plastics.

KEYWORDS

Chemical/Petrochemical; Materials processing; Processing (rubber & plastic); Recovery/Recycling; Plastics/Rubber; Materials characterization/Testing

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Contract no: BREU-0511
Proposal no: BE-4260

DEVELOPMENT OF RESORBABLE BIODEGRADABLE POLYMERS FOR THE PREPARATION OF COATED PARTICLES FOR DRUG DELIVERY

Starting date: January 1990 ***Duration:*** 48 months

OBJECTIVES

Drug targeting using polymeric microspheres injected into the blood circulated could have considerable impact in many disease conditions, especially cancer chemotherapy. The project aims to develop novel biodegradable polymeric coating agents based upon polyesters, polyamines and polyethers that will be absorbed or grafted to drug-loaded microspheres. The chosen polymer will cause particles injected into the blood to remain in the circulation (and thus to avoid deposition at undesired sites such as the resident ,acrophages in liver) or to be targeted passively to the bone marrow. Coated particles carrying attached homing moieties in the form of sugar residues or monoclonal antibodies will be developed for active targeting opportunities.

ACHIEVEMENTS TO DATE

(i) Biodegradable and bioresorbable polymers suitable for the coating of preformed carrier particles have been synthesised. They include poly(lactide coglycolide), polymalic acid derivatives, poly L-lysine citramide and modified polyamidoamines.

(ii) Emulsification techniques have been used for the preparation of poly(lactide coglycolide) and albumin microspheres of sizes of 100nm and 1000nm.

(iii) Biodegradation studies on related particle samples have commenced.

(iv) Chemical procedures for the coupling of polyoxyethylene groups onto linear serum albumin have been developed.

(v) Diagnostic SIMS spectra of coating polymers and particles have been obtained as background to the surface analysis of coated systems.

KEYWORDS

Biomaterials; Pharmaceuticals; Polymers; Medicine/Health; Drug Delivery

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Contract no: BREU-0053
Proposal no: P-3348

POLYMERIC SYSTEMS FOR SELECTIVE DELIVERY TO THE LARGE BOWEL

Starting date: September 1991 ***Duration:*** 48 months

OBJECTIVES

The availability of a reliable colonic targeting system, based upon biocompatible coating materials, would have a ready route for commercial exploitation in the delivery of conventional drug substances for the local treatment of large bowel disorders. Improved colonic delivery would also have a major impact on the market for oral controlled release products and more importantly a well conceived system could permit the successful oral delivery of biopharmaceuticals, such as insulin, calcitonin, growth hormone, interferons and colony stimulating factors. Novel biocompatible polymers, that degrade selectively in the colonic region of the human gastrointestinal tract, will be used as coating agents for conventional oral dosage forms so as to provide a delivery system that after oral administration remains intact from mouth to caecum. The in-vivo disintegration of the device will be triggered by a natural characteristic of the large bowel so as to guarantee the selectivity of the system, ie pre-programmed release. In the case of peptide delivery, it is highly likely that additional performance modifiers (critical components) will have to be added to the formulation in order that satisfactory oral bioavailability can be achieved. Following the successful completion of the defined research programme, the partners will locate suitable large companies, preferably European, for the commercial exploitation of the final prototype formulations.

KEYWORDS

Biomaterials; Pharmaceuticals; Polymers; Medicine/Health; Peptides; Drug delivery.

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Proposal no: BE-4055

DEVELOPMENT OF A COLLAGEN BINDING POLYMER SURFACE FOR INTRAOCULAR LENSES

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

To improve long term results of polymer lenses for intraocular use (Intraocular Lens, IOL) a reduction of secondary opacifications of the implants is a prime problem in ophthalmic surgery today. This project aims to solve the problem by developing a surface modified implant that builds up a stable connection to the surrounding lens capsule.

Disc shaped lenses made of poly(dimethylsiloxane) can be treated with gas plasma to bring functional groups to the surface. In further steps of reaction these groups allow covalent bonding of molecules that have a specific affinity to collagen found in the lens capsule.

The realization of a stable connection between an implantable polymer and collagen of the human body can also lead to new concepts for other medical implants e.g. in gynaecology, urology, orthopaedics.

KEYWORDS

Biomaterials; Research/Development; Polymers; Optical; Biomedical; Materials science

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DEVELOPMENT OF A NEW GENERATION OF ARTIFICIAL HIP JOINTS CONTAINING COMPLIANT LAYERS

Starting date: September 1991 ***Duration:*** 48 months

OBJECTIVES

It has been demonstrated that the incorporation of impervious elastomeric layers onto the surface of the acetabular cups of model artificial hip joints generates fluid film lubrication conditions. Friction levels comparable to those of healthy human joints have been observed and the surfaces of the joint remain separated under a wide range of simulated human activities. Long term wear resistance should therefore be good, however, to date poor adhesion between (fully dense) stainless steel substrate and the elastomer has prevented exploitation of this system.

The major objective of the proposed research programme is to investigate, using a multispecimen hip function simulator specifically designed for this project, the long term friction and wear behaviour of joints containing compliant surfaces produced by a variety of novel routes. These will include the fixation of biocompatible elastomers to porous metal substrates produced by powder metallurgy and the development of heterogeneous polymeric systems with compliant surfaces. Powders of approved biocompatible metals will be processed to give prototype porous components to enhance adhesion by interlocking of the elastomeric layers. Effective combinations will be used to produce prototype joints containing compliant surfaces on the acetabular cup and/or femoral head for long term friction and wear testing.

KEYWORDS

Biomedical engineering; Friction/Wear; Adhesives/Bonding; Biomaterials; Powder metallurgy; Polymers

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Proposal no: BE-4249

IMPROVEMENT OF THE MECHANICAL AND CORROSION PROPERTIES OF TITANIUM ALLOYS ESPECIALLY FOR SURGICAL PROSTHESES BY ION IMPLANTATION AND CHEMICAL POLISHING

Starting date: June 1989 ***Duration:*** 36 months

OBJECTIVES

The main objectives of the project consist in the assessment of new surface treatment processes based on ion implantation and chemical polishing, to improve the mechanical and corrosion properties of Titanium alloys and to realize new, long lasting and biocompatible protheses.

ACHIEVEMENTS TO DATE:

The experimental activities on flat samples, defined in order to optimise the sets of process parameters for the treatments of the protheses have been almost concluded. In particular the chemical polishing treatments have been performed and the samples have been characterised by wear tests and surface analysis. Treated samples showed a better wear behaviour, surface analysis made evident the presence of a mixed Ti-oxide layer with a smaller amount of Ti suboxide in treated samples.

As far as ion implantation is concerned a scheme of parameters has been processed and selected, based on three energies, two doses and two temperatures of the samples, in order to optimise the process parameters for applications to the protheses. Low temperature implantations have been performed and wear tests and microstructural analysis are almost concluded.

An unconventional sample heating system for high temperature implantation has been designed and built whereas the design of the system available for the industrial applicatations, in terms of samples manipulation, ion sources, temperature is in advanced phase of realisation.

Methodologies for biocompatibility tests have been selected and the experiments are running on untreated samples.

KEYWORDS

Medical/Biomedical equipment; Processing (minerals & metals); Biomaterials; Surface treatment technologies; Materials science; Research/ Development.

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Contract no: MA1E-0079
Proposal no: P-0570

INORGANIC SURFACE COATING OF TITANIUM ALLOY FOR ORTHOPAEDIC JOINT PROSTHESES

Starting date: November 1988 ***Duration:*** 48 months

OBJECTIVES

First, new metallic and/or ceramic porous coatings on orthopaedic prostheses have to be studied as alternatives to conventional cement. Biological fixation by bone in-growth may be obtained by combining porous metallic coatings with sprayed hydroxylapatite (calcium phosphate; Ca/P=1.67).

Mechanical and biological tests have to be done and corrosion resistance of this porous material has to be looked at.

The second main objective of the contract is to improve the wear rubbing properties of the titanium alloy TA6V on the polyethylene. TA6V parts will be coated with atmospheric plasma sprayed alumina. Joining the mechanical properties of TA6V and the wear rubbing properties of the pair polyethylene/alumina will promote a new highly effective articulating system. Optimised coatings will be placed on knee prostheses for simulation testing.

ACHIEVEMENTS TO DATE

Porous metallic coating: The process for porous bead cakes to be manufactured is now perfected; these porous cakes will be joined to solid parts using silver brazing technology or laser depending on fatigue tests still in progress.

Ceramic powders and coatings: Hydroxylapatite coatings implanted on sheep have given the expected results, i.e. a greater increase in base/implant shear resistance compared to that reached with titanium implants.

Biological results have pointed out that no significant difference was observed between plasma-sprayed calcium phosphate and recovered pure HAP by means of heat treatment.

Physical vapour deposited alumina coated knees are being tested on wear rubbing machines at the moment.

KEYWORDS

Assembly/Joining; Coatings/Thin films; Titanium; Engineering (biomedical); Multilayers/Multimaterials; Hydroxylapatite; Biomedical.

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Contract no: RI1B-261
Proposal no: P-2052

SURFACE COATINGS FOR BIOMATERIALS

Starting date: October 1990 ***Duration:*** 36 months

OBJECTIVES

- To prepare and evaluate new coatings, biomaterials, providing a) increased corrosion resistance; b) improved surface wear; c) biocompatibility.
- To investigate the technology of the process required to optimise mechanical, physical and biological properties.
- To evaluate coatings by SEM, XRD, XPS, SIMS, Auger electrochemical corrosion methods and fatigue studies.
- To investigate biocompatibility by in vitro and in vivo methods.
- To examine the effect of the material on lymphoid cell functions and the influence of lymphoid cell derived molecules on the processes studied, particularly corrosion.
- To produce a specific implant for commercialisation.

ACHIEVEMENTS TO DATE

The first six months have seen good progress. Coatings of hydroxyapatite ceramic have been applied by thermal spray methods to substrates of titanium and stainless steel. Dissolution studies of coatings.immersed in NaCl solution to which metal ions have been added show that cation release from substrates may be inhibited by the coating. Physical methods used to examine coatings have been set up and early results show effects of pre-treatment on substrate, e.g. Al enrichment of Ti. A modular prototype implant is to be coated and tested.

KEYWORDS

Biomaterials; Ceramics/Glasses; Coatings/Thin films; Composites (ceramic matrix); Biomedical; Research/Develpment.

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Contract no: BREU-0172
Proposal no: BE-3048

CERAMIC PART PREPARATION PROCESS TO ENHANCE TISSUE INGROWTH ON ORTHOPAEDIC DEVICES

Starting date: January 1992 ***Duration:*** 48 months

OBJECTIVES

The project objective is the study of the interface behaviour of bony tissue and porous bodies. The controlled porosity is achieved on the surface of dense ceramic bodies by the application of a coating.

This project will demonstrate the feasibility of this new method of orientation of surface behaviour by manufacturing a prototypical series of ceramic acetabular sockets with controlled external surface, coupling the good characteristics of wear resistance, good mechanical performance and biocompatibility of high dense nearly inert ceramic, to a low dense, porous external surface allowing bone ingrowth.

This kind of surface will ensure cementless fixation, replacing the screw-like external surface that ensures the stability of the bioceramic acetabular sockets now in use.

The acetabular socket will be made of Partially Stabilized Zirconia (PSZ). The external coating will be of the same material of dense ceramic - i.e. PSZ on PSZ bulk - followed by a coating of a different material - i.e. Hydroxylapatite (HAP).

KEYWORDS

Manufacturing; Biomaterials; Coatings/Thin films

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Contract no:
Proposal no: BE-4635

DEVELOPMENT OF BIOCOMPATIBLE MATERIALS THROUGH SURFACE TREATMENTS - USE OF ION IMPLANTATION

Starting date: 1991 ***Duration:*** 36 months

OBJECTIVES

To improve biocompatibility and increase the durability of materials used in the biomedical field. These aspects will be explored:

1. The resistance of stainless steel and CoCrMo orthopeadic implants in biological environments with an improvement of the superficial properties relative to fretting and to corrosion. Ion implantation will be performed with species acting on the tribological behaviour (Ti, C, N, Si) and on the surface electrochemical properties (Ti, Mo, Si, Pd).

2. The tolerance of the tissues to the materials, using implantation of elements which make up the tissues and are suspected of inhibiting the biological reactions. Two types of ions will be implanted: Ca, P, Si to link ions enhancing the calcification in the case of orthopeadic implants, ions modifying hydrophilic/hydrophobic characteristics of the polymers surfaces: C, N, O, Si. These implantations will be followed by coatings of constituents such as bioglasses for the bone implants and proteins grafting for flexible materials.

ACHIEVEMENTS TO DATE

1. Improvement of materials resistance to degradation metal/metal interaction: improvement in the tribological properties of metallic materials by nitrogen implantation is one of the first applications of this technique; it has been applied to titanium alloys and stainless steel in the biomedical field as well as in other fields. Moreover, significant improvements in corrosion resistance can be achieved by the implantation of other elements (Cr, Ti, Mo, Si, Pd) used one by one or in combination, possibly including nitrogen.

2. Insertion of the materials in biological medium metal/bone interaction: *(i)* a biodegradable osteoconductive bioglass has been developed; *(ii)* polymer/blood interaction; *(iii)* a feasibility study is under way.

KEYWORDS

Medical/Biomedical Equipment; Biomaterials; Ceramics/Glasses; Coatings/Thin films; Polymers

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Contract no: BREU-0278
Proposal no: BE-3208

COMPARISON OF SURFACE MODIFICATIONS BY ION IMPLANTATION AND COLD PLASMA ASSISTED TREATMENTS AS AN ALTERNATIVE TO OTHER COATING TECHNIQUES

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

The future of a surgical implant depends upon the stability of the tissue-material interface both for tolerance and function in a physiological environment.

To improve fatigue, corrosion-degradation, wear properties and biocompatibility of bearing surfaces in osteoarticular prostheses 3 ways are commonly used :

(i) development of new materials specifically designed for biological use;

(ii) protection with a coating of the metallic materials used in orthopedic surgery (stainless steels, cobalt based alloys, titanium alloys);

(iii) surface modification by diffusion treatment and ion implantation.

We propose a new approach with the following objectives :

- to perform surface modifications and to optimize surface properties by means of cold plasma, advanced implantation techniques, and combination of these 2 methods
- to characterize the treated surfaces in order to understand the fine mechanisms of corrosion-degradation occurring at the bone-biomaterial interface
- to obtain information concerning the important physical and chemical properties of the implant surface and how they are affected by manufacturing techniques, placement and the in vivo solicitations;
- to evaluate their biocompatibility and biofunctionality by in vitro and in vivo tests
- to choose the most suitable surface treatment contributing thus to develop more reliable and rational implant designs.

KEYWORDS

Materials processing; Machining; Databases; Machine tools; Sensors; Signal processing; Expert systems; Mechanical engineering

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Contract no: BREU-0477
Proposal no: BE-4375

RESORBABLE CONTINUOUS FIBRE-REINFORCED POLYMERS FOR THE OSTEOSYNTHESIS

Starting date: September 1991 ***Duration:*** 42 months

OBJECTIVES

The aim of the project is to develop a new form of processing for resorbable osteosynthesis devices, using continuous fibre-reinforced polymeric materials. Taking the main degradable polymers known as a basis, a material has to be chosen which meets the requirements regarding processability, mechanical behaviour and degredation kinetics.

After fibre processing, the embedding of the fibres in the matrix has to be performed with good fibre-matrix adhesion and a high fibre alignment. The intention is to prevent the diffusion of tissue fluids at the fibre-matrix interface, and to obtain maximum strength of the device over an accountable period of time.

The product properties will be tested in vitro. To this end samples are to be prepared both with a rectangular and a circular cross-section, which are subjected to bending and torsional stresses respectively. Degradation will be achieved by immersing the devices in buffered saline at elevated temperatures. Animal tests are unavoidable to test the tissue reaction during the resorption process as well as to substantiate the data of degradation collected in the in vitro tests.

The progress beyond the state of the art is to modify a pultrusion for processing resorbable biomaterials and to develop long-term resorbable fibre materials, which are not so far available, but which are needed for osteosynthesis.

KEYWORDS

Medical/Biomedical equipment; Processing (rubber & plastic); Biomaterials; Composites (polymer matrix); Fibres/Reinforcing materials; Reinforcement technology; Research/Development

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Contract no: BREU-0446
Proposal no: P-4230

DEVELOPMENT OF NOVEL RESEARCH AND FABRICATION TECHNIQUES FOR MATERIALS WITH BIOCOMPATIBLE AND BIOELECTRONIC PROPERTIES

Starting date: 1990 ***Duration:*** 36 months

OBJECTIVES

A system of fabrication and non-destructive analysis for materials with biocompatible/bioelectronic properties is to be developed. This encompassed the novel technique of scanning tunnelling microscopy (STM) and the still developing technique of atomic force microscopy (AFM). Use of both techniques for biomaterials will be an essential feature in competitive product development. The project will use commercial STM and develop an AFM. The possibility of submicron imaging of biomaterials reveals that few real methods of controlling biological molecule deposition on/in polymers exist. Filling this gap would have a wide range of implications for biocompatible and bioelectronic materials. Semiconductor photolithography and electron beam lithography are to be used to pattern molecular attachment. Surface images will be obtained by conventional SEM and optical techniques and compared with the new STM and AFM techniques. Encapsulation of biological molecules in stable materials is also critical and enzymes will be deposited within conducting polymers for conventional electronic characterisation and submicron imaging.

ACHIEVEMENTS TO DATE

The STM has been installed and tested satisfactorily on surfaces of known topography such as pyrolitic graphite and gold-coated, holographic gratings. Biological molecules have also been imaged including biotin, avidin, ferritin, troponic-c and DNA. New immobilisation methods are being developed to overcome the difficulties of binding these molecules to graphite for imaging. A prototype AFM has been built and tested and design refinements are currently in progress.

Photolithographic patterning techniques for cleanroom preparation of micrometre-scale patterns of proteins are complete and nanolithography techniques are in development. Conducting polymer imaging in STM is being carried out and the polymers are also being deposited on microelectrode arrays in the presence of proteins to provide multi-analyte, miniaturised biosensors.

KEYWORDS

Electronic industry; Engineering (Biomedical); Biomaterials; Pharmaceuticals; Micro-engineering; Nanotechnology; Sensors

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Contract no: BREU-0145
Proposal no: BE-3506

MULTIPARAMETER CHEMICAL SENSORS FOR ON-LINE DATA AQUISITION OF BLOOD PHYSIOLOGICAL DATA

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

The proposal aims at developing a single-use multiparameter sterisable ex-vivo chemical sensor. Suitable sensor principles have to be selected which fulfil the specifications of the potential applications,i.e. the performance of the sensors should be comparable to that of laboratory analysers with respect to measurement range and accuracy. The response time has to be enhanced drastically to fulfil the requirements of the potential application. Materials have to be compatible with the ethylenoxide sterilization process, especially since most available polymers for sensor purposes are not stable during sterilization.

These specifications can be fulfilled by the development of sensor materials with better sensitivity, selectivity, faster response time and sufficient lifetime. These new materials consist of metallic or carbon electrodes in combination with new polymers acting as membranes.

The sensors should be at least sensitive to blood gases O_2, CO_2 and pH and optional to electrolytes such as K^+, Ca^{++}, Na^+, Cl^- and HCO_3. One type of the respective sensing mechanism depends on the surface properties of electrodes, other mechanisms depend on the bulk or surface properties of polymers, which have to be deposited directly onto an electrode or the gate of a chemical sensitive fieldeffect transistor (ChemFET).

A pressure transducer should also be integrated in the sensor cell.The complete cell shall be mounted by hybrid and monolithic integration techniques.

ACHIEVEMENTS TO DATE

A series of single parameter chemical sensors for different blood parameters has been developed. A sample-taking system which can be connected to a measuring cell outside of the patient and therefore overcomes the problem of integrating different sensors at the tip of a catheter has been developed by one of the partners.

KEYWORDS

Medical/Biomedical equipment; Biomedical; Biomaterials; Medicine/Health; Polymers; Sensors

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Contract no: BREU-0486
Proposal no: BE-4163

IMPLANT MONITORING PROJECT USING ACTIVE TELEMETRY (IMPACT)

Starting date: December 1990 ***Duration:*** 48 months

OBJECTIVES

The implantation of transducers in the human body leads to technological constraints which are difficult to solve since biological tissues constitute an extremely hostile environment. The project invisages the realisation of new "intelligent" orthopaedic implants sensitive to deformation and using a telemetric link. The transmitted information is of great value to judge the degree of rehabilitation of a fracture, and will assist the standard x-rays which in most cases proved to be unreliable. This project is an original approach to the problem of mechanical failure of orthopaedic implants. The success of the implantation of miniaturised electronics on orthopaedic implants is the availability of biocompatible materials for encapsulation (packaging). The objectives of the project are:

- to significantly reduce the failure rate of high risk osteosyntheses and to decrease the severe complications resulting from such failure e.g. social and financial impacts;
- to develop a tool for assessing new orthopaedic implants including joint replacement;
- to develop implantable miniaturised telemetry system.

ACHIEVEMENTS TO DATE

- preliminary design of the "intelligent implant";
- development of a software for clinical assessment of the patient;
- feasibility study of different telemetry systems and of different packaging alternatives.

KEYWORDS

Medical/Biomedical equipment; Engineering (biomedical); Biomaterials; Biomedical; Instrumentation/Measuring systems; Sensors/Signal processing; Orthopaedic implants

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Contract no: BREU-0323
Proposal no: BE-3500

COMPACT MRI BODY SCANNERS USING STATE-OF-THE-ART PERMANENT MAGNETS

Starting date: July/September 1991 ***Duration:*** 30 months

OBJECTIVES

This proposal is primarily an engineering project, and the direct outcome of a successful industrial specific feasibility study by the prime proposer financed under a BRITE/EURAM programme.

The object is to develop and optimize prototypes of an innovative "compact" MRI scanner.

The important area of medicine, for which this device is aimed, ensures a large potential worldwide market. To date no equivalent permanent magnet MRI scanner has been built, bringing together as it does the theoretical ideas developed in the feasibility study and the new imaging process developed by the other major partner. The use of the term "compact" MRI scanner implies here a new device with the ability to be used in a wide variety of medical diagnostic situations, not previously (or in some cases perhaps very expensive) available from MRI whole-body scanners.

The key to the market potential is this ability now to reduce costs to such a degree as to enable such units to be used in routine hospital and clinic situations. The key technology is in place to achieve this goal. Hundreds of thousands of such units of potential sales, worldwide, makes this growth area worth of the order of 30 billion ECU by the end of the century.

Partners consisting of manufacturers, image processing laboratories and hospital diagnostic departments, have been assembled to ensure through continuous collaboration a successful proposal.

Evaluation includes the following medical areas as well as comparative studies of imaging methods.

- Cranial and craniofacial, non-invasive evaluation of bone morphology in edentulous patients.
- Similar diagnosis and monitoring of treatment of limbs, joints etc.
- Since the compact scanner will permit full body scans of the newborn, the potential for non-invasive neo-natal diagnosis of congenital anomalies affecting all the major systems is immense.

KEYWORDS

Medical/Biomedical equipment; Engineering (biomedical); Magnetic; Biomedical; Computer science/Software; Imaging/Image processing; Medicine/Health

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Contract no: BREU-0481
Proposal no: BE-4121

DEVELOPMENT OF LOW COST, TRANSPARENT BARRIER FILMS FOR FLEXIBLE PACKAGING

Starting date: July 1991 ***Duration:*** 36 months

OBJECTIVES

Research by Camvac (Europe) Ltd indicates that by reacting aluminium vapour with oxygen in a conventional film vacuum metalliser, it is possible to apply transparent barrier coatings of aluminium oxide to plastic films at high rate. Process costs are potentially an order of magnitude less than competitive systems developed in Japan and the USA for coating films with other transparent barrier materials such as SiOx, and subject to development of suitable substrates, should be viable for production of films for packaging.

The project comprises 4 tasks.

1. Background investigation of the interdependence between process conditions and raw materials, composition of the aluminium oxide coating conversion technologies for the films and final product performance properties such as barrier, adhesion and flexibility, together with fundamental research into the barrier and adhesion mechanisms.

2. Development of control techniques for the process and products.

3. Development of polyester and polypropylene film substrates to give the combination of cost, adhesion, moisture resistance and handling properties required for packaging applications.

4. Combination of results of the above tasks, and the development and verification of practical, economic, transparent barrier packaging films materials.

KEYWORDS

Packaging; Flexible materials; Vacuum metallising; Clear barrier films

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Contract no: BREU-0512
Proposal no: BE-4607

SUBSTITUTION OF PVC-FOILS BY RESOURCES AND ENVIRONMENT PRESERVING MATERIALS (SUPREMAT)

Starting date: August 1991 ***Duration:*** 36 months

OBJECTIVES

The development will be undertaken by 5 European SMEs situated in Germany, France and Italy.

Production, manufacturing and disposal of PVC constitute a wear factor on resources and is pollutive because:

- a high volume of non regrowing resources is required
- a high volume of energy is required
- toxic emissions emerge which cannot be eliminated or only at enormous expense
- they demand toxic waste dumps.

The project SUPREMAT will develop new procedures with which the previous PVC foils will be substituted, the effects being:

- re-growing resources
- energy saving
- non-polluting.

The basic material will be similar to paper, with its consistence, structure, surface, etc., modified by various techniques, to come close to the previous material in its utilization and easy waste disposal.

KEYWORDS

Wood/Paper; Wood/Paper/Furniture

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Proposal no: BE-4200

AREA 2

Design methodology and assurance for products and processes

ADVANCED DESIGN OF CRASH FAIL-SAFE TRAIN STRUCTURES UNDER SERVICE AND IMPACT CONDITIONS

Starting date: March 1991 ***Duration:*** 48 months

OBJECTIVES

The aims of the project are

- Understanding of the crash phenomena as applied to trains
- use of advanced methods of structural and dynamic analysis of train crash and impact situations
- development and application of modern design methodologies of train cars
- design and production of lightweight and anti-crash fail-safe train structures.

ACHIEVEMENTS TO DATE

- Review of train accident data, based on the experience of train operators in France, Spain and Portugal
- real size single vehicle dynamic crash test against another vehicle
- reduced model dynamic crash test of a new anti-crash train extremity
- anti-crash initial design of a train was initiated
- dynamic analysis of train crash and non-linear structural analysis software was initiated
- design sensitivity and optimization of linear and non-linear structural software was initiated.

KEYWORDS

Railways; Prototyping; Metallic structural materials; Mathematical modelling; Fail-Safe; Impact; Crash

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Contract no: BREU-0362
Proposal no: BE-3385

NOVEL INTELLIGENT METHOD FOR THE RATIONAL QUALIFICATION AND SELECTION OF RELIABLE SUBSEA HYDROCARBON PRODUCTION EQUIPMENT

Starting date: July 1988 ***Duration:*** 20 months

OBJECTIVES

In the oil and gas industry, quality and reliability are major criteria for ensuring human safety, environmental protection and economic exploitation. With offshore facilities installed on the seabed, the marine environment not only increases risk, but also creates new constraints for maintenance and intervention.

The main objective of the project is to develop a comprehensive and rational method able to measure the suitability of given subsea equipment to perform a specific duty. With very little data about the equipment and limited testing possibilities, the Method will help the Engineer in making a positive decision as to which type of equipment to select. Phase 1 consists of the development of the method and a first stage of practical evaluation by applying it to different valves up to the definition of physical testing programmes required.

ACHIEVEMENTS TO DATE

The METHOD documentation was completed in October 1989. The Partners decided then to carry out a comprehensive assessment of the METHOD by applying it to one single gate valve.

Using a purpose made validation procedure, this work quantified the weaknesses of the METHOD, brought to light the reasons for these weaknesses and recommended improvements.

The validation concluded that a complete application of the METHOD was not practical. Its present state, the METHOD could not provide the expected useful results and, in particular, did not indicate the tests required on this valve.

At this time, which was scheduled end of Phase 1,it was evident that the project could not continue into the planned Phase 2.

Moreover the Partners had diverging opinions about the chances of success in developing an enhanced version. Therefore, they decided by mutual agreement to terminate their joint research at this point , allowing the Commission to continue the project with Entreprises who might be interested.

KEYWORDS

Oil and Gas production; Engineering; Hydrocarbons; Databases; Mathematical modelling; Reliability; Qualification

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Contract no: RI1B-0229
Proposal no: P-2121

OPTIMIZED FIRE SAFETY OF OFFSHORE STRUCTURES.

Starting date: January 1992 ***Duration:*** 36 months

OBJECTIVES

The overall objectives of this project are to rationalize the approach to fire-safety of offshore structures and to integrate this with overall safety management.

These objectives are to be reached through an integrated and multi-disciplinary approach composed of the following steps:

- application of the consequence analysis and risk assment methodologies to topside structures and system layout, in particular for steel fixed platforms, to identify dominant hazard scenarios
- application of the existing analytical tools (fire propagation modelling, finite element aproaches, structural reliability methods), developed for offshore and other industries (nuclear, chemical, building) topside integrity;
- development of ad-hoc methodologies to quantify the system reliability and to optimize cost parameters at acceptable levels of safety
- combination of the above with conventional techniques of topside design and/or reassessment, to develop simplified procedures.

KEYWORDS

Engineering/Software/Technical services; Design; Civil engineering; Safety management; Fire safety; Offshore engineering

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Contract no:
Proposal no: BE-4359

RATIONAL PROCEDURE FOR ADVANCED NON-LINEAR ANALYSIS OF FLOATING STRUCTURES

Starting date: January 1989 ***Duration:*** 33 months

OBJECTIVES

Floating structures such as moored tankers, tension leg platforms and semisubmersibles are characterized by non-linear dynamic behaviour. Today`s existing design procedures relevant to these systems require substantial improvement of:

- the fluid/structure interaction models in order to describe correctly the non-linear wave forces
- the statistical methods allowing the prediction of the extreme values of both the motions and mooring forces
- computer procedures for the evaluation of both high and low frequency second order hydrodynamic forces on floating body of arbituary shape
- new methods for the statistical analysis of single and multi degrees of freedom non-linear systems
- guidelines for the correct simulation of the fluid-structure interaction in the model basins.

ACHIEVEMENTS TO DATE

A computer procedure for the evaluation of the wave force Quadratic Transfer Functions has been developed. A computer programme to simulate the model basin conditions has been improved to include non-linear effects. New methods for the statistical analysis of non-linear systems have been identified and found suitable for several typical offshore structures. Guidelines for the dynamic analysis of large floating structures have been prepared.

KEYWORDS

Mathematical modelling; Software; Statistics; Hydrodynamics; Model tests.

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Contract no: RI1B-288
Proposal no: P-2146

STRUCTURED DESIGN AND VERIFICATION OF SYSTEMS FOR USE ON SHIPS AND MARINE PLATFORMS

Starting date: August 1990 ***Duration:*** 42 months

OBJECTIVES

Marine system designers have identified shortfalls and high design risks resulting from conventional design methodologies such as non-optimisation, ambiguities and inconsistencies. These result in time consuming and costly development programmes, considerable out-of-commission time to rectify faults and increased operational costs.

The structured design methodology used in the aerospace industry results in optimised, complete and much more accurate system/software specifications thus minimising development and commissioning timescales and reducing overall costs.

The main objectives of the project are to evaluate this structured design methodology and demonstrate its effectiveness when transferred to the marine industry. This process will be applied to a representative marine system incorporating an integrated data network for the command and control of selected subsystems. Validation will be assessed experimentally using a data network/distributed processor configuration exercised by simulators representing typical marine subsystems. This methodology should also demonstrate the effectiveness of including testing as part of the overall design/verification process.

ACHIEVEMENTS TO DATE

The initial phase of the project has centered on the analysis of the requirements of the marine industry, especially in the area of equipment functionality and inter-dependency. CASE tools have been identified as suitable for demonstrating the benefits to the marine industry of a top-down design methodology for subsystem integration. Networking systems have been assessed for suitability within the marine environment

KEYWORDS

Shipbuilding; CAE/CAD/CAM systems; Electrical/Electronic industry; Computer/Computer systems; Design; Promotion/Technology transfer

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Contract no: BREU-0202
Proposal no: BE-3324

A STRUCTURAL METHOLOGY FOR THE SHIP PREDESIGN PROCESS

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

The main objectives of the project are the improvement of ship predesign technical quality and the reduction of time for preparing tenders. These will be achieved by the development of a new approach (methodology) and by the implementation on computer of a prototype of the developed methodolgy.

KEYWORDS

Shipbuilding; Design; CAE/CAD/CAM systems

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Contract no: BREU-0489
Proposal no: BE-4227

SHIPREL-RELIABILITY METHODS FOR SHIP STRUCTURAL DESIGN

Starting date: October 1991 ***Duration:*** 42 months

OBJECTIVES

The goal of this project is to develop a set of design rules which are derived from the application of reliability analysis to ship structural design. The specific objectives of this project are :

- The development of reliability based tools to provide a more rational basis for the structural design through explicit quantification and trade-off between safety and economy, leading to consistent decisions on the allocation of safety margins in all components of the structure;
- the development of reliability based tools to make for an assessment of the integrity of existing ship structures, allowing decisions on the possibility of extending their lifetime
- the development of reliability based guidelines in a semiprobabilistic format for ship structural design which will be a proposal, on a pre-normative basis, for unified European regulations on ship structural design.

This project will explore a new way of formulating the rules for ship structural design. The project will develop the methodology for rule development plus the methods to quantify the uncertainty in the variables, to perform a reliability analysis of a ship structure and to derive partial safety factors for the design of the primary structure. The methods will be applied to typical cases of containerships and tankers, indicating how a coherent set of rules can be developed.

The research project will lead to a set of simplified procedures and formulae to be used in design for the prediction of design loads and for the assessment of the strength of structural components. Software packages will also be developed to quantify loading, response and strength for specific ships and components. A methodology for code development and guidance notes for ship structural design will be produced.

KEYWORDS

Shipbuilding; Reliability; Structural design; Ocean engineering; Safety management; Naval architecture; Codes/Standards

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Contract no: BREU-0501
Proposal no: BE-4554

REPAIR POLICY DETERMINATION BASED ON AI LEARNING METHODS (REPAY)

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

The goal of REPAY is to create a system for the determination of the best repair policy of large and complex equipment.

Systems used at present rely on an ad hoc combination of stored data, experience, heuristic rules and analytic assessments. They provide some guidance for the production of estimates but not enough to serve the needs of the repairer who has to be specific as to costs, timescales and workshop schedules and who, most times, works with a requirement from the owner which is not detailed nor can it be made more detailed until inspection and repair have actually started.

The present project aims at developing a comprehensive approach based on recent advances in AI learning methods. The system will make the best use of existing historical data, of applicable analytical approaches, of heuristic rules and of AI, in assessing the implications of a requirement in terms of the possible resulting repair policies and in evaluating the impact on costs and schedules. At the same time the system will not be static and circumscribed by the rules and values input: it will have in itself the capability to learn from experience and improve its policies.

It is expected that the utilization of the system will lead to a reduction in the time needed to prepare tenders, an increase in the success rate of tenders, a rise in turnover and utilization rate, and an increase in profit margins.

KEYWORDS

Ship building; Repair/Maintenance; Quality control/Inspection; Engineering/ Software/Technical services

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Contract no: BREU-0455
Proposal no: BE-4139

CONCERTED ACTION - LIFE ASSESSMENT OF INDUSTRIAL COMPONENTS AND STRUCTURES

Starting date: 1991 ***Duration:*** 24 months

OBJECTIVES

The Concerted Action is aimed at interaction and integration of activities within BRITE/EURAM projects in the field of life assessment of industrial components and structures and focuses on the power, process and offshore industries. It will embrace life-limiting/ degredation phenomena and diagnostic/ surveillance systems relevant to elevated temperature and low/ ambient temperature applications. The specific objectives are:

- to enhance technical progress within individual projects through inter-project exchange of information
- to ensure project developments are complementary by clear identification of project interaction areas and to signal multilateral project integration agreements
- to identify key areas and critical issues for future study and in particular to explore ideas for integrated projects spanning several different industrial sectors, types of organisation (e.g. manufacturers, utilities) and types of plant/ structures
- to review strategic issues and priorities in the life assessment field, and their implications for current and future projects
- to provide a basis for interaction and integration with other European Research Actions, and for promoting the diffusion and exploitation of the BRITE/EURAM projects at workshops and conferences
- to encourage the exploitation of R & D results by recommending host industry demonstrations
- to publish a newsletter to update on the progress of the Action and to disseminate the results arising therefrom
- to identify areas requiring the formulation of standards/codes of practice.

KEYWORDS

Life assessment; Repair/Maintenance; Reliability; Design; Energy/Power generation; Process/Petrochemical plant; Offshore structures

PRIME PARTNER

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Contract no:
Proposal no: BE-4657

DESIGN METHODOLOGY FOR DURABILITY OF MECHANICAL COMPONENTS BASED ON RELIABILITY APPROACHES

Starting date: March 1990 ***Duration:*** 48 months

OBJECTIVES

The objective of this project is to develop a reliable methodology for the design for durability of mass produced mechanical components which are subject to part-to-part statistical variations. The scope of this investigation is limited to the development of probabalistic lifetime prediction methods relevant to forged and cast structural componets typically used in the automotive industry. Also to be examined is the role of Knowledge-Based software techniques for the development of the above design support tools.

ACHIEVEMENTS TO DATE

- Completion of Sub-tasks1&2 which are aimed at an appraisal of uniaxis and multiaxis fatigue prediction methods
- Selection of materials and components for the experimental investigations, specimen manufacture, near completion of a round-robin specimen test exercise, initiation of the componet and specimen test programmes
- tentative analytical models for handling probabalistic inputs, reliability, multiaxis fatigue and surface effects
- A PC based prototype KB system for fatigue assessment.

KEYWORDS

Automotive/Components/Parts; Engineering/Software/Technical service; Design; Metallic structural materials; CAE/CAD/CAM systems; Reliabilty

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Contract no: BREU-0099
Proposal no: BE-3051

INTEGRATED COMPUTER-AIDED RELIABILITY ANALYSIS AND REAL-TIME FAULT LOCATION USING COMPONENT AND SYSTEM MODELLING

Starting date: ***Duration:*** 36 months

OBJECTIVES

The aim of this project is to develop fast and reliable tools for the reliability and risk analsis of, and Real-Time Fault location (RTFL), in complex systems as they are encountered in industry. These tools should be easy to use and economical thus encouraging SMEs to perform reliability analyses on their products. To date Fault Time Tree Analysis, FMEA (Failure Mode Effect Analysis) and RFTL studies have mostly been considered independent. All these algorithms require knowledge about fault imitation within the system and fault propagation through the system. Computerized path development could speed up reliability and risk analyses substantially, but although several attempts have been made, their benefits have been limited by inadequate modelling. Some shortcomings of these modelling procedures are that:

- models described fault propagation in one direction only which made the models dependent on the system variable being analysed
- they complicate the automatic detection of control loops which is essential for automatic analysis.

When the modelling strategy is available these studies can be integrated into two reliability analysis systems:

- a consistent and compact modelling procedure suitable for computer-aided component and system model development
- an expert system (IRAS: Integrated Relibility Analysis System) which allows the convenient and rapid creation of compact component and system models and is able to perform FMEA and RTFL virtually automatically.

KEYWORDS

Repair/Maintenance; Processing (minerals & metals); Mechanical engineering/Machinery; Vibration analysis/Acoustics; Design; Electrical; Machine tools.

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Contract no:
Proposal no: BE-4250

A TOOL FOR DISSEMINATING PRODUCT ASSURANCE IN THE MECHANICAL INDUSTRIES

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

This project aims at progressing the way mechanical reliability estimation is currently handled in industry. Based on proven time intensive methods used in advanced sectors (space, nuclear, weapons), the objective is to :

- provide mechanical designers with an easy to use methodology (and supporting tool) for addressing reliability in their design, particularly regarding identification of main functions and dependencies
- derive reliability evaluation models, for a range of usual parts and components, that allow quantitative assessment. Such models are, in general, non existing at present and must be based on a careful analysis of failure modes, their effects and physical behaviour
- integrate new evaluation models as well as more conventional tools and data into a comprehensive toolkit targeted at mechanical designers.

Exploitable results should comprise:

- a set of validated reliability assessment models of common mechanical parts
- a prototype software package to support designers in design analysis
- a prototype software toolkit featuring a toolkit manager.

KEYWORDS

Mechanical engineering/ Machinery; Design; CAE/CAD/CAM Systems; Reliability; Analysis/Auditing/Consulting; Knowledge-Based system; Integrated toolkit

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Contract no: BREU-0482
Proposal no: BE-4424

AVAILABILITY, MAINTAINABILITY AND RELIABILITY OPTIMIZATION IN ELECTRICAL SUBSTATIONS BY THE INTEGRATION OF PROTECTION AND CONTROL FUNCTIONS

Starting date: ***Duration:*** 36 months

OBJECTIVES

Increasing the availability and reliability in Electrical Power Transmission and Distribution Substations while keeping low maintenance and operation costs, and improving maintainability and usability have become important goals of electric utility companies for the nineties.

In this project, we will create the methods and strategies to analyse the reliability of electrical substations, and to enhance it on the basis of the obtained information.

Until now, the emerging new technologies have been applied in Electrical Substations, with timidity and without any coordinated policy. In this project we will thoroughly change this direction by developing a fully integrated Protection and Control System. This will include new digital protection devices which integrate control functions, and will be able to communicate through fibre optic links within new and existing Electrical Substations.

With the use of expert systems technology the system will be able to process Electrical Substation data and to communicate real time conditions to the Supervisory Control.

The improvement that the results of this project will make to the design and implementation of Electrical Substations will serve to lower the costs for the Electrical Power Utility Companies and to better the services offered to Electrical Energy Distribution Networks users.

KEYWORDS

Energy/Power generation; Prototyping; Electrical; Computer science/ Software; Control systems; Mathematical modelling; Sensors/Signal processing.

PRIME PARTNER

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Contract no: BREU-0459
Proposal no: BE-4049

RESEARCH AND DEVELOPMENT ON A HIGH SPEED OIL FREE INTELLIGENT MOTOCOMPRESSOR (HOFIM)

Starting date: June 1990 ***Duration:*** 30 months

OBJECTIVES

A new concept of oil free machine combining the most advanced research in different spheres. A variable frequency converter raises the frequency of the industrrial network and supplies a high speed induction machine directly coupled to a compressor. Both shafts are levitated by magnetic bearings. The whole system is controlled by digital information used to converse with the central computer. Intelligent software helps to monitor the machine behaviour and to optimize the process.

The major benefits are:

- An improvement in efficiency of 5%
- a drastic drop in maintenance costs
- a mean time between failure of 40 000 hours
- an amelioration in safety and a reduction of risk to the environment.

ACHIEVEMENTS TO DATE

A variable frequency converter and high speed induction machine have been matched from an electrical angle. Power electronics, reactors and snubber circuits have been developed. High speed motors and Barrel compressors have been designed using active magnetic bearings. Rotor dynamics calculation for each machine has been done, whole train calculation is in progress.

KEYWORDS

Chemical/Petrochemical; Other manufacturing industries; Process/Product monitoring; Hydrocarbons/Petrochemical; Oil free compressor; High speed induction motor; Active magnetic bearings

PRIME PARTNER

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Contract no: BREU-0158
Proposal no: BE-3138

DESIGN METHODOLOGIES FOR ENGINEERING COMPONENT PROPERTIES - PRECEPT

Starting date: March 1990 ***Duration:*** 48 months

OBJECTIVES

This project is intended to improve the quality of design and specification of mechanical components used typically in the aerospace, automotive, electrical, electronic and textile engineering industries. The aim is to gather together the state-of-the-art design rules that take into account plastic deformation, fatigue, wear and corrosion, develop a methodology that makes full use of them based on a comprehensive set of case studies and encapsulate the result in a knowledge-based system to assist design engineers in both SMEs and large companies and thereby improve the quality, reliability and maintainability of components and tools produced by industry within the European Community.

ACHIEVEMENTS TO DATE

From a worldwide study of design methodolgies, a general model of the new product design and introduction process has been proposed. Within this systematic design process, the role of an expert system for the selection of materials, treatments and coatings has been identified. Anaysis of the working practices of designers within the two industrial partners has produced a user-based specification for the system.

An initial, top level, design architecture has been developed which has identified the essential components of the proposed system.

Materials databases of the two industrial partners are currently being rationalized with the objective of producing a standardized list of materials. A rationalized classification of materials is being developed based on the characteristic properties of each class, taking account of the influence of composition. A list of material properties that need to be included within this project is also under development.

KEYWORDS

Aeronautics/Aerospace; Automotive/Components & Parts; Design; Coatings/Thin Films; Metallic structural materials; Databases/Expert systems; Evaluation/Selection

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Contract no: BREU-0073
Proposal no: BE-3413

RELIABILITY-BASED OPTIMAL DESIGN METHODOLOGY WITH APPLICATIONS TO ADVANCED AEROSPACE STRUCTURES

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

The overall objective of the project is to create an integrated design methodology that combines the latest developments in the field of database systems, continuum design sensitivity analysis, reliability analysis for both time-invariant and time-variant problems (e.g. crack growth and ageing) and reliability-oriented structural optimization.

The secondary objective is to develop software modules for data management, numerical analysis and interpretation of results, the latter including graphics facilities to display important information on a computer screen.

A further objective is to provide designers in the aerospace industry with a convincing demonstration of the capabilities of reliability-oriented optimal design.

KEYWORDS

Aeronautics/Aerospace; Design; High strength alloys; Composites; Fatigue; Reliability; Optimisation

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Contract no: BREU-0456
Proposal no: BE-4194

PREDICTION OF FATIGUE CRACK INITIATION FROM DEFECTS IN WELDED AND CAST COMPONENTS USED IN POWER PLANTS

Starting date: October 1986 ***Duration:*** 48 months

OBJECTIVES

At the present time fatigue life assessments or structural integrity analyses of critical power station components that contain defects or sharp geometrical discontinuities only take into account the lifetime under crack propagation conditions. However, a significant fraction of operational lifetime is spent under conditions of crack initiation. The principal objective of the project is to develop an engineering methods capable of accurately predicting fatigue crack initiation from defects or sharp geometrical discontinuities in welded and cast components used in power plants. This predictive method will enable decisions to be taken during the operation of a power plant on whether or not a defect discovered during service requires repairing and, if not, how much remnent lifetime exists before such an unrepaired defect would become critical.

ACHIEVEMENTS TO DATE

FRAMATOME and UNIREC have developed a methodology for predicting crack initiation from the stand point of fracture mechanics. The criterion is the stress calculated at a characteristic distance "d" from the tip of the defects. The methodology has been successfully applied to the cases of defects like blow holes or shrinkages in austentic or ferritic castings or weld discontinuities like inclusions, lack of fusion or cracks in welded components. It appears that the case of large defects could be treated by this methodology. The case of coalescence within a cluster of defects can also be analysed. LBF has developed a method where the defects are defined as notches and the local stress concentrations are related by a reduction factor of the fatigue resistance to S-N curves of the sound materials.

KEYWORDS

Energy/Power generation; Nuclear engineering; Metallic structural materials; Research & development; Fatigue; Crack initiation; Metallurgical defects

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Contract no: RI1B-134F
Proposal no: BE-1145

THE INITIATION AND GROWTH OF THERMAL-MECHANICAL FATIGUE CRACKS IN COATED TURBINE BLADE MATERIALS

Starting date: January 1991 ***Duration:*** 48 months

OBJECTIVES

1. To understand the thermomechanical fatigue behaviour of coated single crystal turbine blade materials with particular reference to the effects of:

(a) material variables - alloy and coating composition and microstructure

(b) thermomechanical variables - strain-tempreature cycle, strain range, strain rate, min. and max. temperature, R ratio.

2. To characterize the thermomechanical fatigue behaviour of coated blade materials in terms of the initiation and growth stages of cracking and to determine their dependence upon the material and thermomechanical variables.

3. To formulate and validate a model to accurately predict the thermomechanical fatigue behaviour of coated turbine blade alloys.

ACHIEVEMENTS TO DATE

1. First meeting held in February 1991 and the work plan, deliverables and timescales agreed.

2. Commencement of the study of techniques available for the detection of crack initiation - scheduled for completion.

3. Determination of the 2-D strain-temperature loops at various locations on a particular engine's high pressure turbine blade completed. This provides TMF test parameters.

4. Literature survey on fatigue models and their applicability to TMF ongoing.

5. Temperature distribution on TMF machine optimized at sub-contractors JRC Petten.

KEYWORDS

Thermomechanical fatigue; Modelling; Aeronautics/Aerospace; Metallic structural materials; Coatings/Thin films; Superalloys/Special alloys; Materials characterization/Testing

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Contract no: BREU-0338
Proposal no: BE-3338

LIFE PREDICTION ALGORITHMS FOR AERO-ENGINE DISKS BASED ON CRACK INITIATION AND CRACK PROPAGATION MODELS

Starting date: July 1990 ***Duration:*** 42 months

OBJECTIVES

The aim of the project is to provide a basis for extended use of the life potential of existing and future advanced aero-engine fracture critical parts (e.g. disks). This aim shall be achieved by means of algorithms for life prediction and usage monitoring. Those algorithms shall be based on models for crack initiation and crack propagation. They will be able to predict the behaviour of cracks under variable amplitude loading and transient temperatures such as aero-engine disks experience due to real operating conditions.

The algorithms shall make use of parametric models which allow for a cycle by cycle crack initiation and propagation prediction in order to support the extent of usage by in-flight real time engine usage monitoring. The parameters will be determined by experiments on Corner Crack Specimen (plain), Notched Specimen (plain), Notched Specimen (round with circumferential notch) and biaxial loading specimen (cruciform shaped). The predictions of the algorithms will be verified by component tests (disk spinning tests).

ACHIEVEMENTS TO DATE

The material has been ordered and is scheduled to arrive in Autumn 1991. The governing parameters (loading, temperature, etc.) for the specimen and disk tests have been fixed. The disk design is being completed and an initial survey of existing methods for the description of crack initiation and propagation is being made.

KEYWORDS

Aeronautics/Aerospace; Quality control/Inspection; Super alloys/Special alloys; Materials characterization/Testing; Mathematical Modelling

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Contract no: BREU-130
Proposal no: BE-3379

DAMAGE TOLERANCE OF HELICOPTER METAL PARTS

Starting date: June 1990 ***Duration:*** 24 months

OBJECTIVES

Damage tolerance requirements for helicopters have to be treated separately from their fixed wing counterparts since life requirements and vibration/manoeuvre related load spectra are rather different. Up to now there are no guidelines available for a systematic approach to an improvement of helicopter component life assessment or improved safety level at less or equal maintenance costs, taking into account all aspects of a damage tolerant design philosophy;e.g. systematic approach for the calculation of crack growth by means of fracture mechanics, systematic design, systematic choice or improvement of materials, etc. Therefore, the assessment of a 'Helicopter Damage Tolerant Design Guide' is essential. This Design Guide has to be planned as a compilation of all the knowledge needed to achieve a damage tolerant design of a modern civil helicopter. These efforts are also required in the light of the newly proposed FAR 29.571 which is calling for the approval of damage tolerance as a certification requirement.

ACHIEVEMENTS TO DATE

- Selection of critical parts and their operating conditions
- selection of analysis tools and start of modifications
- development of a load spectra preprocessor
- establishment of material data bank
- "Round Robin" exercise to establish degree of confidence and reliability of each test lab. involved
- start of material tests and analytical verification.

KEYWORDS

Aeronautics; Mechanical engineering; Quality control/Inspection; Materials characterization/Testing; Mechanics; Reliability; Safety management

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Contract no: BREU-0123
Proposal no: BE-3386

IMPROVEMENT OF THE CONTACT CORROSION BEHAVIOUR OF ADVANCED MECHANICAL STRUCTURES MADE FROM HIGH-GRADE ALLOYS

Starting date: October 1988 ***Duration:*** 36 months

OBJECTIVES

To develop an experimental methodology and mechanical model of fretting and its relationship with fatigue resistance and to rationalize the selection of materials and surface conditions according to the contact parameters. This proposal is based on mechanics/materials cooperation which has been very productive in the past.

ACHIEVEMENTS TO DATE

- Identification and selection, by the industrial partners, of critical parts life-limited by fretting, and their operating condition
- development of a mechanical model of crack propogation in fretting-fatigue for one and multiple , perpendicular or inclined, cracks, parametric study of interactions between cracks, numerical simulation for multilayered structures
- manufacture of fretting and fretting-fatigue testing adaptations and machining of test specimens
- fretting, fatigue and fatigue-fretting tests (95%) on different materials (Ti alloys, Ni alloys, high strength steels), with and without different coatings (self-lubricating varnishes, plasma spray or electrolytic deposits), and associated metallurgical analyses
- beginning of the sysnthesis of all the results: mechanisms, influence of load, displacement, fretting frequency, materials coatings, influence of fretting on low cycle or high cycle fatigue strength.

KEYWORDS

Tribology; Solid mechanics; Fretting; Metallic materials; Coatings; Solid lubricants.

PRIME PARTNER

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Contract no: RI1B-249
Proposal no: P-2418

PREDICTION OF EROSION DUE TO CAVITATION IN HYDRAULIC MACHINERY

Starting date: January 1992 ***Duration:*** 45 months

OBJECTIVES

Cavitation is a major phenomenon generating irreversible damage on the blades of hydraulic machinery and causing failure of the machines, but it is still unpredictable. The goal of this proposal is to derive a new methodology which will detect aggressive forms of cavitation and predict the life duration of machinery subject to this cavitation.

The methodology will bring three new advantages:

- It will be applicable to all kinds of hydraulic machinery
- The predictions given by the method will be quantitative and will give access to life and residual life durations
- The predictions given by the method will be obtained rapidly (in a few weeks) under economical laboratory conditions without the need to control and analyse many years of working on prototypes as it is often done nowadays.

As part of the project the methodology will be completely defined on high speed cavitation tunnels and extensively checked on small scale and real industrial machines (turbines, pumps, propellers) put at the disposal by the partners for the project. When it is proved valid, the methodology will be used by manufacturers to control the life duration of machines under design, and by users to choose the best operating conditions and optimize the maintenance operations.

KEYWORDS

Machinery; Prototyping; Reliability; Fluid dynamics; Material testing; Erosion; Lifetime prediction

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Contract no:
Proposal no: BE-4158

NEW TYPES OF CORROSION IMPAIRING THE RELIABILITY OF COPPER IN POTABLE WATER CAUSED BY MICRO-ORGANISMS

Starting date: September 1991 ***Duration:*** 42 months

OBJECTIVES

Pitting corrosion damage occurred in the water distribution systems of copper pipes in the cold and warm water installations of a large building shortly after opening and in the meantime also in older installations. This damage occurring worldwide represents an enormous risk to supply for the citizens of the affected houses because of the pollution of the potable water by corrosion products and organic products leading to serious hygiene problems.

The failure analysis of the copper pipes revealed films of microbial origin on the copper surfaces consisting of organic material. This polymeric biofilm has membrane properties and is able to support the formation and stabilization of occluded corrosion cells, if inhomogeneities are established within the structure of this film. Corrosion cells are responsible for pitting corrosion damages.

The origin and type of this corrosion process caused by micro-organisms is by no means clear and cannot be attributed to known corrosion mechanisms. Our approach will lead to a detection of the corrosion mechanism by verifying structure and membrane behavior of the biofilm, modifying its structure and membrane properties by biological and chemical methods and subsequently simulating of new types of corrosion cells in the laboratory.

KEYWORDS

Food/Drink/Water; Engineering (chemical); Repair/Maintenace; Non ferrous; Reliability; Microbial influenced corrosion.

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Proposal no: P-4088

USE OF CERAMIC MATERIALS FOR ADVANCED TRIBOLOGICAL SYSTEMS INVOLVING FLUIDS WITH ADVERSE LUBRICATING PROPERTIES

Starting date: March 1989 ***Duration:*** 36 months

OBJECTIVES

The proposed research aims to use ceramic materials in the area of components and critical systems running in fluids having no or adverse lubricating properties. Preliminary work has indicated that some silicon based ceramics were able to show quite unexpected tribological performances providing solutions to previously difficult problems but also opening up areas which could not be considered with conventional materials: those of mechanical parts 'lubricated' with water. On the basis of the initial results achieved, it is proposed:

a) to study tribological mechanisms of silicon based ceramics in fluids with adverse lubricating properties
b) to establish a model to define such materials criteria with regard to friction conditions, nature of fluids, etc
c) to undertake an evaluation of the proposed model in the area of pumps components.

ACHIEVEMENTS TO DATE

- A numerical solution has been proposed for calculation of pressure and film thickness in the case of fluid film lubrication of ceramics by water
- tribological evaluation performed on SiC ceramic in homogeneous friction couples has indicated that performance, is due to a low roughness generated through tribochemical reaction of fluid with surface
- results obtained have enabled us to determine, among the possible couples of materials, the most adequate depending on mechanical sollicitations, geometry of contact and ambiance
- an optimized version of SiC with regard to the knowledge gained on tribological behaviour of Si-based ceramics is under evaluation in industrial conditions.

KEYWORDS

Mechanical engineering; Waste/Effluents; Ceramic; Tribology; Materials characterization; Materials science; Research/Development

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Contract no: RI1B-295
Proposal no: P-2231

ANALYTICAL AND EXPERIMENTAL APPROACH TO CUMULATIVE DAMAGE AND RESIDUAL STRENGTH PREDICTION FOR CFRE COMPOSITES

Starting date: September 1990 ***Duration:*** 42 months

OBJECTIVES

The overall objective is to develop a predictive system for the residual life and residual strength of carbon fibre reinforced epoxy (CFRE) composite materials subjected to cumulative service type damage. The methodology is based on an understanding of defects and defect growth. It has two levels of focus with respect to damage type: (a) delamination, (b) matrix cracking.

Deterministic predictive models are being developed incorporating existing models and data: (a) based on a full volume element approach, (b) a beam lattice model which provides a simplified method for modelling damage growth. A computer model is being developed and tested for the probabilistic analysis of fatigue failure and reliability of the composite laminate.

New capability in NDE and opto-mechanics is under development. This will provide: (a) input to the development of the predictive models, (b) test data to permit evaluation of the predictive models by comparison with measured parameters, (c) measurement methods to support the practical application of the models.Experimental data is also being generated from a fatigue test programme.

ACHIEVEMENTS TO DATE

Significant progress has been made in the development of the predictive models. Detailed test planning has been carried out and the main test programme is under way. The first tasks in the development of NDE for damage characterization at the matrix crack level and the furhter development of opto-mechanics methods for the measurement of energy release rate have been completed.

KEYWORDS

Carbon fibres; Composites (polymer matrix); Mathematical modelling; Probabilistic analysis; Fatigue; Optomechanics

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Contract no: BREU-0183
Proposal no: BE-3444

DAMAGE TOLERANCE AND FATIGUE DESIGN METHODOLOGY FOR PRIMARY COMPOSITE STRUCTURES

Starting date: 1990 ***Duration:*** 48 months

OBJECTIVES

To establish a design tool whichcan predict life to failure and residual strength of impact damaged composite structure,requiring only minimal experimental work to obtain the necessary input data to be introduced in a computerized prediction model. This model will use the laminate plate theory, the stability theory , the stability theory and fracture mechanics method, and needs an itterative process. The necessary input data would be obtained from standard compression after impact test samples.

ACHIEVEMENTS TO DATE

- Shape, number and conditions of impact of the samples for extensive materials testing have been fixed
- first material evaluation is already finishing
- microscopy studies of relations between laminate lay-up and shape of delaminations after impact.

KEYWORDS

Aeronautics; Manufacturing; Composites (polymer matrix); Materials testing; Design evaluation; Fatigue testing; Damage tolerance.

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Proposal no: BE-3038

PREDICTIVE TECHNIQUES FOR THE ANALYSIS AND DESIGN OF FIBRE-REINFORCED COMPOSITE MATERIALS AND STRUCTURES CAPABLE OF WITHSTANDING IMPULSIVE LOADINGS

Starting date: July 1988 ***Duration:*** 42 months

OBJECTIVES

The objective of research is to develop methods of predicting the behaviour of fibre-reinforced composites when subjected to high velocity impacts. One or more constitutive models that account for impact damage, including delamination matrix and fibre cracking, spalling and penetration will be developed and incorporated within a FE computer code suitable for use on an engineering work station. To assure wide applicability the numerical tools are to be general purpose to extent that the user can specify arbitary structural geometries. To assist application in the design of structures fabricated from composite materials the tool will be structured so that it can readily interface with CAD software.

ACHIEVEMENTS TO DATE

Activities within the first 18 months included development of a material database, performance of impact tests on plates and beams of selected materials with varying impact velocities, and the selection of a FE computer code suited to incorporation of the proposed constitutive models . During the last 18 months the proposed constitutive models have been developed and incorperated into FE computer code for both the shell and solid elements. The FE computer code has been used to simulate the initial and post impact response recorded during impact testing. Full scale tests have been performed on portions of the fuselage of the Seastar plane.

KEYWORDS

Mathematical modelling; Mechanics/Solid mechanics; Materials science; Engineering (mechanical); Composites (polymer matrix); Finite element

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Contract no: RI1B-215
Proposal no: P-2369

PREDICTIVE FAILURE MODEL FOR DESIGNING TRUCK TYRES WITH IMPROVED SAFETY AND DURABILITY

Starting date: March 1989 ***Duration:*** 36 months

OBJECTIVES

The practice of retreading has increased the service life of radial truck tyres, giving great economic benefits, but also problems in terms of reliability and safety arising from the greater probability of failure of the retreaded tyre. The key factor for the solution of these problems is the ability to control the rate of chemical degradation of the rubber and at the same time the rate of propagation of cracks at certain critical points. The objectives of this research are:

- To appraise the relative contribution of chemical and mechanical processes in the failure mechanism of truck tyres due to belt-edge plies separation
- to design and build a prototype instrument for laboratory simulation of tyre failure
- to build a predictive model.

ACHIEVEMENTS TO DATE

Experimental methods for the characterization of mechanical properties, chemical composition and morphological structure of rubber samples, taken from critical failure regions were developed. Changes induced on rubber compounds by service life in high severity conditions were determined. Changes were found to be moderate with no evidence of oxidations. Tridimensional Finite Element Code was used to calculate the stress-strain field at the belt edge. Fracture Mechanics concepts were introduced in order to compare the results of laboratory experiments with the tyre performance . The predictive power of the known fatigue tests was found to be poor. A new testing rig which submit the specimens to a stress-strain field similar to that calculated for tyre was designed and built.

KEYWORDS

Tyres; Design; Rubbers; Materials characterization; Mathematical modelling; Fracture; Testing

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Contract no: RI1B-274
Proposal no: P-2001

FATIGUE MECHANISMS AND FAILURE CRITERIA IN ROLLING LOBE AIR SPRINGS

Starting date: June 1990 ***Duration:*** 48 months

OBJECTIVES

For the design and optimization of products based on rubber-cord composites the knowledge of internal micromechanics and related fatigue mechanisms under application loadings is of fundamental importance. Several Finite Element programmes (e.g. ADINA, MARC, ABACUS) offer methods for a realistic simulation of deformations and some internal stresses and strains. Composite structures though are usually modelled using transverse isotropic elemental formulations, which only allow a macroscopic description of the internal deformation states. These methods do not take into account the helical geometry and the nonlinear behaviour of the cords. Also, most interactions between the cords and the surrounding rubber are ignored.

Within the project new experimental techniques and numerical tools are to be developed to enable a better modelling of stress and deformation states of thin walled rubber cord composites (e.g. air bellows).

ACHIEVEMENTS TO DATE

- New fatigue testers for rubber-cord-composites have been designed and (partly) built
- testing apparatus for multiaxial measurements on rubber materiazls has been constructed (based on transputer technology for control and data acquisition)
- deformation tests on various cord rubber composites were carried out for comparison with later FE-calculations
- FE-modules (to be used with MARC) for the micromechanical treatment of cod and rubber materials have been written and are currently being tested.

KEYWORDS

Composites (polymer matrix); Fibres/Reinforcing materials; Flexible/Non-rigid materials; CAE/CAD/CAM systems; Materials characterization/Testing; Mathematical modelling; Mechanics/Solid mechanics

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Proposal no: P-3270

POST-BUCKLING BEHAVIOUR OF CFC STRUCTURES

Starting date: February 1991 ***Duration:*** 30 months

OBJECTIVES

- To investigate the cost and weight saving potential of allowing CFC structures to operate in the post-buckling condition
- to instill greater confidence in the use of CFC in the post-buckled mode, which should stimulate CFC technology in general
- to produce a methodology for the post-buckled design of CFC identifying the type of structures most suitable to post-buckled operations and requiring the achievement of the folowing sub-objective
- to evolve reliable failure criteria for the through-thickness (z-direction) modes such as 'ILSS', interlaminar normal stress and delamination
- to investigate scale (thickness dependent) effects and to develop an appropriate criterion
- to develop methods for the estimtion of the through-thickness force levels required to induce panel-stiffener separation
- to develop finite element and other coding as appropriate for the prediction of failure using stress, strain and energy release rate criteria
- to define and perform the testing necessary to validate the methodology being developed.

ACHIEVEMENTS TO DATE

Drawings showing initial sizing of test panels for optimization supplied to partner companies. First results of this optimization process have now been obtained.

KEYWORDS

Aeronatics/Aerospace; Engineering (mechanical); Composites (polymer matrix); Mathematical modelling; Panel and box testing; New failure Criteria; Through-thickness stresses

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Contract no: BREU-0330
Proposal no: BE-3160

PREDICTION OF NONLINEAR MATERIALS AND STRUCTURAL BEHAVIOUR USING PARALLEL COMPUTING METHODS

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

The goal of this type 2 project is the design, analysis and implementation of numerical algorithms on parallel computers for predicting nonlinear material and structural behaviour. The physical problems under concern, namely: thermo-elasto-viscoelastic material behaviour, geometrically nonlinear behaviour of composite structures, polymeric materials (viscoelastic fluids), steel-elastomer composite structures, powder materials, have been selected according of the partners' experience and the expressed industrial needs. They raise computational problems of a generic nature which justify an integrated approach.

Optimum implementation of simulation methods on parallel computers requires the development of an appropriate methodology and the use of adapted numerical algorithms. It will allow the full potential of the simulation methods existing nowadays to be tapped.

The fulfilment of this objective implies close collaboration between research teams specialized in structural and material behaviour, on the one hand, and in parallel computing, on the other.

The research will address following issues: mathematical models, numerical discretization methods, nonlinear parallel algorithms, implementation on parallel computers, solution of demonstrative application cases.

KEYWORDS

Materials processing; Engineering (mechanical); Forming/Shaping/Casting; Computer science/Software; Mathematical modelling; Mechanics/Solid mechanics

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Proposal no: BE-4564

PERFORMANCE AND RELIABILITY EVALUATION OF WELDING IN ELEVATED TEMPERATURE SERVICE

Starting date: March 1988 ***Duration:*** 48 months

OBJECTIVES

The project addresses the optimization of weld procedures to achieve reliable, long-term performance at elevated temperatures in advanced 9%Cr ('grade 91') steel and the implication for remnant life assessment of repair welding in two common low alloy ferritic steels ($^1/_2$Cr$^1/_4$Mo$^1/_2$V, 2$^1/_4$Cr1Mo). The key objectives are: (1) to develop a procedural specification to optimize welding performance by control of microstructural factors, (2) to establish an advanced methodology to predict the remnant life of repaired welds, (3) to optimize new NDE techniques for pre-crack damage assessment and (4) to validate the methodologies on a full size laboratory test vessel and a 'live' service component.

ACHIEVEMENTS TO DATE

Thick section 9% Cr ('grade 91') pipe and bar has been successfully fabricated and weld procedures for the sections developed. Repair welds have been produced in new, aged, and ex-service 1Cr$^1/_4$Mo$^1/_4$V and 2$^1/_4$Cr1Mo pipe sections and an in-service component. The high temperature mechanical properties of these weldings have been determined and results used to (1) calibrate a four material finite element model developed to describe creep deformation in a welding and (2) to develop a mechanistic creep model to define the life extension capability after weld repair.

A novel ultrasonic inspection technique to quantify pre-crack creep damage has been developed and is currently undergoing validaton on a simulated full-size welded 'grade 91' pressure vessel.

KEYWORDS

Energy/Power generation; Repair/Maintenance; Materials characterization/ Testing; Reliability; Creep; Welding; Ultrasonic techniques.

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Proposal no: P-2341

LSM DEVELOPMENT OF AN ADVANCED LIFETIME MONITORING SYSTEM FOR COMPONENTS OF PIPING SYSTEMS IN THE CREEP RANGE

Starting date: 1990 ***Duration:*** 48 months

OBJECTIVES

Project aim is to develop calculation methods, instrumentation/measurement systems and computer algorithms to solve the major problems associated with the lifetime monitoring of piping components operating in the creep range in highly loaded power plants. The advanced lifetime monitoring system will be capable of automatic, real-time estimation of the remnant lifetime taking into account external loads.

ACHIEVEMENTS TO DATE

The German partner group has developed software modules for calculating creep relevant stresses and strains in typical piping components loaded by internal pressure and external forces and moments. For straight pipes, bends, spherical fittings, reducers and wallthickness transitions the modules were evaluated using linear elastic and inelastic Finite Element calculation methods.

The British partner has developed software modules for prediction and monitoring of fatigue strains due to thermal transients by non intrusive temperature measurements on the outer surfaces of components. On line calculations of rapid changing thermal loadings requires effective algorithms. The reverse Fast Fourier Transformation method has shown significant advantages and will be used in the further project.

The Spanish partner group has focused its work on calculation and monitoring of lifetime relevant dynamic loadings in high temperature piping systems. Improved methods based on the response analysis were used. A software programme has been developed to aid the selection of optimum measuring points in piping system for on line monitoring of the dynamic behaviour.

German and Spanish partners have started development of advanced techniques for built determination of pipework (e.g. photogrammetry, tachymetry).

KEYWORDS

Energy/Power generation; Reliability; High temperature piping systems; Monitoring; Life term measurements; Creep/Fatigue; Life extension

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Proposal no: BE-3080

CREEP BEHAVIOUR OF FULL SIZE WELD JOINTS - DESIGN IMPROVEMENTS AND DEFECT ACCEPTANCE CRITERIA

Starting date: November 1988 ***Duration***: 48 months

OBJECTIVES

The project consists of the evaluation of the experimental creep behaviour of large specimens and the theoretical analysis of the same geometries to derive proposals for new more accurate design methods, of welded structures subject to creep. The studies will be performed on an austenitic stainless steel type 316L and on a ferritic steel type $2^1/_4$Cr-1Mo. The project includes the following steps:

- Experimental determination of the dependence of the weld stress reduction factors on geometry
- development of a criteria for small defects acceptance
- utilization and improvement of calculation codes
- derivation of criteria for weld metal specifications.

KEYWORDS

Energy/Power generation; Quality assurance; Metallic structural materials; Solders/Brazes/Welding; Codes/Standards; Validation/Certification

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Proposal no: P-2147

LIFETIME MANAGEMENT OF ELEVATED TEMPERATURE WELDED HEAVY SECTION INDUSTRIAL PLANT OPERATING UNDER VARIABLE THERMOMECHANICAL LOADING

Starting date: March 1990 ***Duration:*** 48 months

OBJECTIVES

The aim is to develop a 'user oriented' condition ananlysis system to accurately evaluate the effect of thermo-mechanical loading cycles on structural integrity and operational reliability of elevated temperature, welded heavy section pressure parts of industrial process and power plant. The system will comprise a validated computer-based lifetime monitoring system with integrated on-line and off-line analytical/NDE features utilising sophisticated inelastic modelling schemes to address crack initiation and propogation at component weldings.

ACHIEVEMENTS TO DATE

In this first year of the project, procurement and evaluation of ex-service component/samples of an internally and externally cracked header hgave been performed successfully. Measurements on an operating header are being carried out on two vessel/tube intersection geometries. Development of a residual stress mapping system using Barkhausen Noise Analysis and Ultrasonic Testing to evaluate high thermal stress locations and determination and modelling of creep and growth behaviour and thermo-mechanical finite element analysis of operating components have started. Development of an 'on-line' crack detection and 'off-line' NDE method for linear surface crack detection and sizing have also started and some promising results have also started and some promising results have been obtained.

KEYWORDS

Electrical/Electronic industry; Repairs/Maintenance; Metallic structural mazterials; Materials characterization/Testing; Research/Development; Non-destructive testing.

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Proposal no: BE-3090

ENHANCEMENT OF INSPECTION AND MAINTENANCE OF INDUSTRIAL STRUCTURES USING RELIABILITY BASED METHODS AND EXPERT SYSTEMS

Starting date: February 1988 ***Duration:*** 39 months

OBJECTIVES

In some industries, probabilistic methods have been applied at the design stage to determine the life expectancy of a structure . Prior to this project however, no tool was available to take into account the new information (measurements, degradation data ...) gathered during the operating phase of the structure in the context of this probabilistic approach. An analytical method and the associated computer tool capable of taking this information into account would lead to an optimization of the maintenance schemes for complex structures by developing time varient probability computation methods and a reliability oriented approach . A Knowledge Based System (KBS) will be designed providing an interface between the numerical implementation and expert knowledge on the aspects of maintenance.

ACHIEVEMENTS TO DATE

The technical development of the project has now ended.Four steps were taken to reach the objectives of the project. The first three steps covered the numerical implementation leading to the optimization scheme . A data base used for the reliabilty calculation and for the KBS was first assembled. An original method, capable of handling time-variant reliability problems, was then implemented numerically. An optimization module taking into account new information and data on inspection costs was created. It yields an inspection plan for a given element. The method and numerical tool was successfully tested and RAMINO was designed. RAMINO provides a rational frame for the collected data and the numerical methods developed, complemented with the knowledge obtained from elicitations of field experts and from the collection of non-numerical data. The different facets of this work are presented in four publications of the proceedings of OMAE 91 held in Stavangoer.

KEYWORDS

Chemical/Petrochemical; Construction/Building/Civil Engineering ; Energy/ Power generation; Databases/Expert systems; Reliability

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Contract no: RI1B-181
Proposal no: P-2124

VERIFIED APPROACHES TO LIFE ASSESSMENT AND IMPROVED DESIGN OF ELEVATED TEMPERATURE TURBINE EQUIPMENT (VALID)

Starting date: July 1991 ***Duration:*** 48 months

OBJECTIVES

Life assessment procedures which incorporate improved material damage modelling methods are necessary to meet the increasing demands for higher performance and optimized maintenance of elevated temperature turbine equipment.

The development of such procedures using validated techniques with improved transferability to meet design and predictive maintenance requirements for components operation under complex multiaxial loads is the primary goal of this project.

The project addresses materials specific to integrity-critical items of steam and gas turbine plant and is timely in view of the current upsurge in worldwide interest in combined cycle power generation. The potential financial benefit to European industry arising from increased industrial competitiveness and efficiency is shown to be 150-200 M ECU per annum.

The major objectives which represent significant advances on current and foreseen practices are to:

- facilitate computer based schemes for improved accuracy lifetime prediction of critical steam and gas turbine equipment
- provide a validated practical methodology for determination of the multiaxial stress criteria for failure initiation
- establish an extrapolation procedure to predict multiaxial failure by accelerated tests
- improve the accuracy of cyclic failure initiation prediction by up to an order of magnitude by means of a diagnostic micro-strain monitoring technique integrated with analytical codes
- validate the predictive codes and techniques, through laboratory simulation tests and field studies, to within +/- 20% on life.

KEYWORDS

Energy/Power generation; Engineering (mechanical); Metallic structural materials

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Proposal no: BE-4285

LIFETIME PREDICTION AND WEAR CONTROL OF MACHINE ELEMENTS USING EXPERT SYSTEMS

Starting date: February 1990 ***Duration:*** 36 months

OBJECTIVES

- to incorporate tribological theory, test data, shop floor experience and monitoring measurements into a practical expert system for the control of specific machines, which will serve as a model for machines in general.
- to establish and understand the relationships between monitoring measurements and the state of critical components in an industrial machine.
- to upgrade the tribological performance of the selected machine elements by design of lubricants and surface condition of the contacting materials.
- to understand the tribological performance of the selected machine elements in industrial service and the interrelationships with laboratory test rig behaviour.

ACHIEVEMENTS TO DATE

- knowledge of the tribological behaviour of bevel gears, needle and axial cylindrical roller bearings and flat guideways used in lathes. Basic laboratory tests, simulated tests and tests on isolated elements have been carried out
- Software to calculate, in the selected elements "lambda" parameter, dynamic load ratings, rating life, contact and scuffing temperature, tooth root strength, surface durability, and loads and deformations
- Prototypes, with the same critical functionality as the final working system, have been prepared. These prototypes carry out the following:
  - select suitable lubricants for rolling bearings, guideways and gears
  - determine the deterioration grade of the lubricant and propose appropriate measures
  - predict the qualitative risk of failure of rolling bearings, gears and guideways.

KEYWORDS

Tribology; Data bases/Expert systems; Lubricants; Machine tools; Vibration analysis/Acoustics

PRIME PARTNER

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Contract no: BREU-0111
Proposal no: BE-3122

MACHINE MANAGEMENT FOR INCREASING RELIABILITY, AVAILABILITY AND MAINTAINABILITY - MIRAM

Starting date: August 1991 ***Duration:*** 36 months

OBJECTIVES

The main goal of the project is the development of a new methodology for condition monitoring and predictive maintenance of machine tools. This methodology will describe applicable techniques to predict and evaluate the evolution of failures and the degradation of machine tool components (eg. ballscrews, axis drives, coolant system, hydraulics), in order to find out the causes of malfunctions, to suggest corrective and preventive actions and to provide support in the operation mode. The proposed methodology is expected to help improve the availability, reliability and maintainability of machine tools as well as other types of machines or processes. The methods will be based on modelling of the machine and its subsystems with physical as well as qualitative models.

The results of the project will enhance fault diagnosis of newly designed machines, make predictive maintenance more applicable and improve scheduled maintenance.

In order to demonstrate the feasibility of this approach the machine management prototype will be fitted to and tested on a field machine tool. The basic ideas, however, which will be detailed below, are thought to be general enough to be applied to other types of industrial equipment and processes.

A low cost system is targeted, and thus the requisite software will be developed for a 386 type computer.

KEYWORDS

Mechanical engineering/Machinery; Machining; Repair/Maintenance; Data bases/Expert systems; Machine tools; Sensors/Signal processing

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Contract no: BREU-0463
Proposal no: BE-4302

PRISMA - PREDICTIVE INTEGRATED SYSTEM FOR THE MAINTENACE OF ROTATING MACHINERY

Staring date: 1990 ***Duration:*** 36 months

OBJECTIVES

The PRISMA Project deals with the demonstration. of the feasibility of an integrated predictive maintenance system on rotating machinery.

To achieve this objective, a compressor supplied by THERMODYN, a subsidiary of FRAMATOME, is chosen as the demonstration equipment.

Experience in reliability and predictive analysis, gained in the nuclear field, is to be applied to this piece of industrial equipment.

ACHIEVEMENTS TO DATE

A first important step aimed at defining and specifying additional instrumentation needed for correct monitoring of the machine has been carried out.

Task 1, Environmental Analysis, has also been completed.

Task 2, Failure Modes and Reliability Analysis, is near completion. A failure modes effects and criticity analysis has been performed on compressor and lube oil system. After validation, this is to form the basis for selection of a restricted number of possible events and faults that will be taken into account in the following tasks of the ptoject.

The overall architecture of the maintenance system, yet to be developed, has also come in for a good deal of thought and discussion and agreement over a common design is now near.

KEYWORDS

Maintenance; Machinery; Expert systems; Mechanical engineering; Prediction

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Contract no: BREU-0148
Proposal no: BE-3371

GAS TURBINE HEALTH MONITORING DEMONSTRATOR (GASTEM)

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

The objective of this project is to develop a gas turbine health monitoring demonstrator which will be able to identify faults in more detail than other systems currently available, enabling better fault diagnosis, improved maintenance planning, higher plant reliability and reduced operating costs.

The demonstrator will be able to identify and process the following classes of fault: blade vibrations (at extreme ambient conditions or unusual speeds), compressor faults (blade erosion, mechanical damage), combustor faults, performance loss (with identification of the parts of the engine causing the loss).

To achieve this goal, the demonstrator will :

- use multisensors acquisition
- use new sensors technologies (for high temperatures)
- use advanced data processing, namely acoustical imaging and gas path analysis method
- use an expertise to be acquired theoretically and experimentally on a large range of faults
- integrate in a high level expert software the acquired expertise and data handling capability to improve monitoring efficiency and decision making quality for both designers and operators.

KEYWORDS

Vibration analysis/Acoustical; Energy/Power generation; Monitoring; Expert system; Imaging; Thermodynamics

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Contract no: BREU-0506
Proposal no: BE-4192

POWER TRAIN NOISE/VIBRATION PREDICTION

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

The goal of the project is to develop and define new and more accurate methods of analysis for use at the power train (engine to road-wheel) design stage to avoid tiresome and costly rectification programmes during prototype development.

The project will address two main vibration and noise generating areas:

- engine structure (Subproject 1 Engine FEM, Subproject 2 Engine SEA)
- drive train (Subproject 3 Gear Rattle).

1. ENGINE FEM: To develop an innovative software package, relying on Finite Element Modelling, capable of predicting the vibrations and noise radiation of the structures up to 2000Hz.

The focus will be on a more accurate prediction of the excitation forces.

2. ENGINE SEA: To develop a methodology, based on Statistical Energy Analysis techniques, suitable for analysis and prediction of vibration and noise above 500 Hz.
3. GEAR RATTLE: To develop a dynamic model of the drive train capab of predicting the gear rattle phenomenon (audible impact of gear meshes) under transient drive and steady state idle conditions.

An objective performance index of gear rattle will also be defined by correlating subjective responses to a wide range of objective measures.

The generated predictive tools will be the object of a thorough stepwise experimental validation.

KEYWORDS

Vibration analysis/Acoustics; Automotive, Components & Parts; CAE/CAD/CAM systems; Mathematical modelling;

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OPTIMIZATION OF NOISE CONTROL MEASURES IN COMPLEX LIGHTWEIGHT SHEET METAL STRUCTURES USING ENERGY FLOW ANALYSIS

Starting date: May 1988 ***Duration:*** 36 months

OBJECTIVES

A CAE tool for modelling of the acoustic design diagnostics has been developed based on energy flow analysis. Car body structures can be optimized for acoustical performance and weight in the frequency range 250Hz to 2KHz. Optimization starts at the concept phase of the body development giving the designers founded information on the quantity of secondary noise control measures required for a particular design. Variation of structural parameters such as base material, thickness and areas can readily be investigated. Geometrical data from sketches or drawings is required for this stage.

Optimization continues based on measurements made on a complete body in white or a trimmed body. Here the sound insulation and damping of the components are measured, revealing their relevant in-situ performance. In the case of the white body the inherent sound insulation and damping is found and the secondary noise control measures designed complentary to this. Based on an experimental or drawing-board model, predictions are made for various sources of noise (e.g. various powered engines in a single body). Diagnostics and 'what if' calculations are available to get the utmost out of the models. Further to this the sound energy flow paths are determined which can augment the acoustical design.

The tools developed have been validated on two different bodies both in trimmed and body in white conditions.

KEYWORDS

Automotive; Engineering/Software/Technical/Services; Mathematical modelling; Vibration analysis/Acoustics; Sound insulation; Damping; Medium frequency.

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Contract no: RI1B-194
Proposal no: P-2319

DEVELOPMENT AND INTEGRATION OF AN ADVANCED UNIFIED APPROACH TO STRUCTURE BORNE NOISE ANALYSIS

Starting date: January 1992 ***Duration:*** 36 months

OBJECTIVES

The principle and overall scope of the project is to develop, implement, evaluate and validate an integrated approach to the problem of structure borne noise transfer in cars. This is achieved through two major subtasks: firstly, to build experience so as to define the practical behaviour of validity of each of the techniques involved, secondly, to integrate the methods in a single approach to the problem of structure borne noise in cars.

The projet aims at evaluating the limitations and assets of techniques such as transfer path analysis, partial coherences and noise analysis by principle components. The evaluation will be based on theoretical and scientific elements in order to identify the complementary parts as well as the eventual overlaps. Strong emphasis will, however, be put to the applicability in an industrial environment by investigating the consequences of the theoretical developments upon the practical use; the effect of practical simplifications upon the accuracy of the results will be considered to be very important.

Through the evaluation of those techniques, the project aims at integration of the analysis results, and the formulation of an interpretation scheme.

From result integration, the project focuses on the integration of the methods themselves, so that not several measurement sessions but only one integrated session has to be carried out. The definition and implementation of the integrated approach will adhere to an open system architecture as well as to current standards for user interaction and develop pre-competitive data processing and handling techniques so as to allow automation of the approach.

KEYWORDS

Automotive, Components & Parts; Sensors/Signal processing; Vibration analysis/Acoustics

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DEVELOPMENT OF ACOUSTIC EMISSION (AE) TESTING METHODS FOR ANALYSIS AND ON - LINE MONITORING OF STRESS CORROSION CRACKING (SCC) UNDER OPERATING CONDITIONS IN THE CHEMICAL INDUSTRY

Starting date: May 1989 ***Duration:*** 48 months

OBJECTIVES

Corrosion is a very costly problem in the chemical industry, and one of the main damage mechanisms is stress corrosion cracking (SCC). The objective is to study the ability of acoustic emission (AE) testing to detect SCC damage on large chemical structures and to conceive an on-line monitoring system. The following aspects will be investigated:

- basic relationship between SCC and AE for different corrosion systems in laboratory experiments
- practical tests on small vessels as an intermediate step for studying other signficant parameters for transferability
- conception of an on-line monitoring system for large vessels and demonstration of the efficiency of the system in practical service conditions.

ACHIEVEMENTS TO DATE

In laboratory experiments, it has been possible to characterize signals from extraneous sources, e.g. solution boiling and recrystallization, and to distinguish these from real AE activity from SCC crack growth, allowing detection and location of SCC. A good qualitative correlation between AE activity and SCC damage has been achieved.

The need was clarified for small scale vessels to be as representative as reasonably practicable of full-scale, but it was recognized that some compromise will be necessary between the desire to reproduce the operating environment and the need for accelerated tests to provide useful results. Positive results have been obtained on small vessels confirming the capability for detection and location of AE from SCC, within the limitations of size and geometry so far investigated. Detection and monitoring capabilities now require a quantative correlation of the AE data with the extent of SCC damage.

KEYWORDS

Quality control/Inspection; Ferrous; Metallic structural materials; Corrosion science; Reliability; Sensors/Signal processing; Acoustic emission

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Contract no: RI1B-306
Proposal no: P-2032

ACOUSTIC EMISSION FOR PROCESS MONITORING DURING TURNING AND DRILLING

Starting date: March 1987 ***Duration:*** 36 months

OBJECTIVES

The objective is to apply acoustic emission (AE) techniques to the automatic tool monitoring for turning, drilling and grinding. Moreover, the new AE-system has to be integrated in a computer aided testing system. Steps are:

- to develop AE as a testing method which is able to gain on-line information on the extent of tool wear, chip-formation and micro-fracture on the cutting edge
- to separate these three parameters: 1) turning, 2) drilling, 3) grinding
- to demonstrate and to prove the capability of the developed AE system through experiments under real industrial conditions.

ACHIEVEMENTS TO DATE

Within the scope of this project, a new approach for tool-wear monitoring during turning was tested successfully. It was demonstrated, that the beginnings of tool wear can be detected with relative sensitivity using a broadband AE-detection, short transmission paths and the extraction of disturbance signals caused by collisions between the chips and the tool.

An essential result of this project concerns the sources of the AE during the turning process. The examination of the signal transmission from the workpiece to the tool suggests that the interactions at the contact area between the workpiece and the tool are the most important AE-sources, i.e. the sources within the workpiece itself can be neglected. Furthermore, a new theoretical approach to the generation of AE during turning has been evolved. This approach starts from the assumption that the essential AE-sources during turning result from the friction at the contact area between the workpiece and the tool. The present experimental results prove this model, i.e. the model makes correct predictions on the AE-behaviour, where other theories fail (e.g. independence of AE from the feed per revolution f).

In the examined case, tool-wear monitoring during drilling could be performed relatively simply by an evaluation of the average signal level (ASL-value). It has to ascertained, if this result can be generalized.

KEYWORDS

Automotive, components & parts; Handling/Transportation; Packaging

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Proposal no: P-1300

DEVELOPMENT OF AN EXPERT SYSTEM FOR TOOL WEAR MONITORING IN MILLING, DRILLING AND BLANKING USING MULTISENSOR SYSTEM AND MACHINABILITY STUDIES USING ACOUSTIC EMISSION

Starting date: January 1989 ***Duration:*** 48 months

OBJECTIVES

One of the main aims of an FMS is to permit unmanned operation for considerable periods of time. This requires sensing systems which can monitor tool wear and breakage to ensure that tools are changed before there is a deterioration in workpiece quality, or a danger of damage to the machine itself. The major aim of this project is to develop the specifications and implement a prototype expert system for tool wear monitoring in milling, drilling and blanking operations. The effect of tool wear on Force, Torque, Power or current and Acoustic Emission parameters in milling and drilling operations will be investigated, and a tool-life prediction model is to be derived. New investigations will result in the improved control of blanking operations. A machinability test based on Acoustic Emission will be defined. Novel multiparameter sensors which are suitably compact, robust and non-invasive for use in the monitoring of machining and metalworking operations in the industrial environment will be developed. They will be based on fibre-optic and laser techniques which will be incorporated into the expert system.

ACHIEVEMENTS TO DATE

Milling, blanking and drilling test stations were built and instrumented, AE fibre optic interferometers, force and thrust optical sensors were designed and tested both in laboratory and industrial conditions.

Analysis of preliminary tests enabled us to estimate the main parameters influencing AE and other measurements in milling, blanking and drilling. A new classifying test of machinability steel batches has been defined.

Development and organization of the knowledge base progressed as work on control strategy.

KEYWORDS

Manufacturing; Instrumentation; Quality; Expert Systems

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Contract no: RI1B-264
Proposal no: P-2049

MODULAR, SENSOR-BASED SYSTEM FOR KNOWLEDGE-BASED ANALYSIS AND OPTIMIZATION OF THE GRINDING AND DRESSING PROCESS

Starting date: January 1990 ***Duration:*** 48 months

OBJECTIVES

The intention is to develop a modular, sensor-based monitoring system for the grinding action, combining intelligent diagnosis of the dressing/conditioning and grinding processes with automatic process optimization (grinding and dressing).

The ability of the individual sensor components to function in the machine space under process conditions will be demonstrated by applying the system to a cylindrical grinding machine of one of the partners, which is capable of producing cylindrical parts with a maximum diameter of d_w=200mm and a maximum length of l_w=500mm.

A realistic production test of the innovative sensors and evaluation of the monitoring strategies can be achieved only through a series of representative tests with all the sensors acting together within the machine cycles.

The optical surface analysis system, the structure-borne sound sensors used to monitor grinding wheel dressing and tool life and the non-tactile diameter measuring sytem will therefore all be fully integrated in the machine. Extensive machine modifications will be necessary for this purpose.

KEYWORDS

Machine/Grinding; Process/Product monitoring; Quality control/Inspection; Automation/CIM; Instrumentation/Measuring; Sensors/Signal processng.

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Contract no: BREU-0078
Proposal no: BE-3014

MACHINE: MONITORING AND CONTROL OF HOIST TECHNOLOGY IN INDUSTRIAL ENVIRONMENTS

Starting date: September 1990 ***Duration:*** 36 months

OBJECTIVES

Hoists are the most versatile and widely used mechanical handling technology in industry, yet control of the hoist and its end effector (the hook) remains unsophisticated. MACHINE will create models of hoist and crane structures and from there develop monitoring and control techniques for application in the construction and manufacturing industries.

Objectives include; reduction of swing on pick up by 90%; an increase in the accuracy of load delivery by a ratio of between 100:1 and 10:1 (depending on hoist size), and automatic coupling to specified loads, with a 2% rate of failure to couple first time. MACHINE will also build a crane performance record system so that data provided by the sensor system may be used for more efficient crane development decisions making and activity planning.

ACHIEVEMENTS TO DATE

MACHINE has completed its system design phase, the following elements have been finalised.

- four level dynamic crane model suitable to describe the motion of gantry and tower cranes
- distributed control and monitoring system utilizing FIELDBUS interconnection
- comprehensive sensor 'set' including ratio data links
- evaluation of motor performances for advanced cranes
- versatile grab for coupling difficult objects.

KEYWORDS

Construction/Building/Civil engineering; Building/Construction; Automation/CIM; Electrical/Electronic industry; Manufacturing; Mathematical modelling; Quality assurance

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DEVELOPMENT OF EXPERIMENTALLY TESTED 3-D COMPUTER CODES FOR FUNDAMENTAL DESIGN OF PROCESS EQUIPMENT INVOLVING NON-NEWTONIAN MULTI-PHASE TURBULENT FLUIDS

Starting date: February 1986 ***Duration:*** 48 months

OBJECTIVES

This project sets out to devise, implement and verify computational methods for the prediction of non-Newtonian multi-phase turbulent flow and the consequent effects thereof in process equipment. Predictions are to be based on the fundamental physics of local phenomena and not the suspect global empirical correlations currently used in the chemical industry. The verified predictions will provide a capability for better diagnosis of existing equipment and optimal design of new equipment without excessive intermediate experimental scale-up. Faster, cheaper and more efficient development of new processes will result.

ACHIEVEMENTS TO DATE

The progress has been very significant. Computer programmes for flow prediction incorporating new two-phase turbulence models for flows containing suspended bubbles, droplets or particles and non-Newtonian effects on the boundary flows, drag and tubulence are now operating and in use for industrial problems. They have been tested againsy experimental data obtained in pipe-flow and in mixing vessels, using flow visualisation, anemometry and various two-phase measurement techniques. Other significant new features of the computer programmes include the local modelling of dispersed phase break-up and coalescence (without surfactant effects) within the flow, a new discretisation technique which saves computing time and improves accuracy, and the calculation of progress of tracer and reactions in the flows. The programmes have now been largely de-bugged and made reasonably user-friendly, and are being appropriately spread acoross ICI and Unilever for use by competent process engineers. The new break-up and coalescence modelling is also in use independently. Application to the improvement of large fermenters, suspension polymerisers and food and detergent manufacture is in progress, and new scientific insights into these processes is emerging. Publications from the work are appearing, and further collaboration between the partners is in progress.

KEYWORDS Engineering (chemical); Processing (food, non-rigid materials); Hydrocarbons/Petrochemicals; Paints; Computer science/Software; Dynamics/Fluid dynamics; Mathematical modelling

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EXPERIMENTAL, THEORETICAL AND COMPUTATIONAL ANALYSIS OF GAS AND PARTICLE BEHAVIOUR INSIDE A CYCLONE PROVIDING THE BASIS FOR IMPROVED PERFORMANCE OF CYCLONES AND SIMILAR SEPARATORS

Starting date: March 1989 ***Duration:*** 36 months

OBJECTIVES

The flow of gas and particles inside a cyclone is being studied. On the one hand, a computer code is being developed, taking into account the high swirl tridimensional flow of gas and the main phenomena which control the behaviour of particles: inertia, drag (which can be affected by shape, concentration of dust and by turbulence), and particle-particle interaction (collisions leading to agglomeration).

At the same time, experiments are performed in order to calibrate the computer code. The velocity field is studied inside a small scale cyclone using a laser anemometer.

Pressure drop and collection efficiency are being measured on various sizes of cyclone and in various operating conditions (gas flow, dust concentation, gas temperature, nature of dust).

The code, once validated, will be applicable to other problems of gas particle flow with high swirl as in centrifugal classifier's or cyclone burners.

ACHIEVEMENTS TO DATE

Many experimental data have been obtained: LDA measurements have provided a map of the velocity field (3 components and their fluctuations) in a small cyclone. Efficiency has been measured for various conditions on a full-scale cyclone. Various parameters have been measured on a cyclone mounted on a coal-fired fluidized bed. These data are being used to validate the first version of the code, now available. This code has a Navier-Stokes 3D aerodynamic solver, using a new collocated approach with boundary fitted non-orthogonal grids, and 3 different turbulence models. Particular improvements have been found in the collocated approach and in a new k-ε model extended to swirling flows. This code is fully interactive and includes graphics capabilities, grid generation and calculation of collection efficiency by particle tracking.

KEYWORDS Engineering/Software/Technical services; Mechanical engineering/ Machinery; Recovery/Recycling; Computer science/Software; Mathematical modelling; Particle technology; Dynamics/Fluid dynamics

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Proposal no: P-2317

DEVELOPMENT OF A GENERAL COMPUTER - AIDED TECHNIQUE FOR THE CHARACTERIZATION OF THE MICROPORE STRUCTURE OF INDUSTRIAL POROUS MEDIA AND DEVELOPMENT OF GENERAL NETWORK SIMULATORS FOR PREDICTION OF MULTIPHASE FLOW AND TRANSPORT PHENOMENA IN SUCH POROUS MEDIA

Starting date: December 1988 ***Duration:*** 48 months

OBJECTIVES

Experimental methods are to be developed to characterize industrial porous media and to obtain parameters needed for construction of geometrical network models decribing such media. The experimental studies are to be used in the development of a mathematical network model of porous media. oreover, a computer-aided three-dimensional network simulator of two phase viscous flow and diffusion in porous media is to be developed. 2-D and 3-D experiments are to be conducted in order to assess the reliability of the prototype simulators.

ACHIEVEMENTS TO DATE

Porous media have been studied and characterized in two- and in three dimensions at the pore- and macroscopic levels. The characterization methods used involve scanning electron microscopy, image analysis and X-ray diffraction measurements. The computer models developed in the course of the project include a simulator of mercury porosimetry in a three-dimensional network of pores and a three-dimensional general network simulator describing single- and two-phase flow through in porous media. Physical- and physicochemical mechanisms in noncircular capillary tubes have been studied both experimentally and by using mathematical models. Finally, an original experimental set-up for studies of two-phase flow in three-dimensions involving the use of an ultra sonic method has been developed.

KEYWORDS

Mathematical modelling; Materials characterization/Testing; Catalysts/ Zeolites; Porous media; Network models; Two-phase flow;Micropore structure

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Contract no: RI1B-290
Proposal no: P-2289

THE STUDY OF NON-EQUILIBRIUM TWO PHASE FLOWS IN STEAM TURBINES

Starting date: March 1989 ***Duration:*** 36 months

OBJECTIVES

Two phase wet steam flows introduce important losses over and above those of a purely aerodynamic nature in the last stages of steam turbines and much of the power plant for water cooled nuclear reactors. It is intended to adapt the wealth of experience and progress in gas turbine aerodynamics to encompass the field of non-equilibrium condensing flows, by introducing mathematical models which will be validated against experimental data collected using purpose built instrumentation. The resulting computer codes will enable parametric studies to be undertaken of two-phase condensing flow phenomena, thus paving the way for the ultimate aim of improvements in the design and efficiency of steam turbine design.

ACHIEVEMENTS TO DATE

Achievements to date are:

(1) Fundamental conservation equations of mass, momentum and energy for a two phase flow in both through flow and blade to blade calculations have been rewritten.

(2) Models for nucleation, droplet growth and drag have been developed.

(3) Experiments on non-equilibrium flow in the blade to blade plane have been completed.

(4) Design of an optical probe for measurements in the meridional plane has been completed.

KEYWORDS

Non-equilibrium; Nucleation; Droplet growth; Wet steam flow in turbines

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Contract no: RI1B-271
Proposal no: P-2156

THREE DIMENSIONAL COMPUTER SIMULATION OF IN - CYLINDER FLOWS IN LARGE ENGINES

Starting date: November 1988 ***Duration:*** 36 months

OBJECTIVES

Objectives of the project include:

- definition of a design tool reciprocating engine modelling turbulent flows occurring in cylinders and ports with moving valves
- initiation or methodolgy for its production
- construction and validation of the tool with measurements performed on real cylinder and on transport cylinder (LDV measurements).

ACHIEVEMENTS TO DATE

- at BERTIN:

The following computations have been successfully performed using CALIFE:

  - a steady 3D inlet port with a gas valve and two air valves
  - an unsteady opening exhaust valve from closed position to full lift.

- at CHAM:

  PHEONICS code has been used to compute:

  - a steady 3D inlet port with a gas valve and two air valves
  - an unsteady opening exhaust valve from closed position to full lift.

- at RUSTON DIESELS:

  Overall measurements for one piston head geometry have been made. New piston heads are designed.

- at UNIVERSITA DELLA CALABRIA:

  Flow visualization in the vicinity of the valves has been performed and LDV measurements are now feasible in the engine.

- all partners:

  Technical information exchanges and preliminary specifications are going on for use of design tool with experimental engines as part of the project.

KEYWORDS

Automotive, Components & Parts; Energy/Power generation; Engineering/ Software/Technical services; Design; Dynamics/Fluid dynamics; Instrumentation/Measuring systems; Mathematical modelling

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Contract no: RI1B-247
Proposal no: P-2315

IDENTIFICATION OF FLUID/STRUCTURE INTERACTION FOR THE DEVELOPMENT AND DESIGN OF BOILERFEED PUMPS (BFP)

Starting date: March 1990 ***Duration:*** 36 months

OBJECTIVES

The fluid/structure interaction forces of annular clearance seals and impellers are the dominating factors in the dynamic (vibration) characteristics developed by large multistage boilerfeed pumps (BFP). These fluid/structure interaction forces must clearly be defined prior to the product development of a new generation High Speed Boilerfeed pump. Furthermore, these unknown interaction forces are today the leading cause of unscheduled feed pump outages in power plants worldwide. It is now recognized that centrifugal pump rotor dynamic behaviour is influenced tremendously by fluid/structure interaction forces generated at annular seals and impellers. These forces can be divided into two groups: a) motion dependent forces, b) pure hydraulic excitation forces.

The main aim of the project is to generate sufficient data to quantify both motion dependent and pure excitational forces developed by fluid/structure interactions of specific boiler feed pump components.

ACHIEVEMENTS TO DATE

Presently two experimental testrigs are operational radially and axially suspended in active magnetic bearings. Both testrigs allow identification of motion dependent fluid/structure forces and moments related to five D.O.F. Also excitation forces can be measured.

A new indirect identification technique is developed and built into a data acquisition sytem for both testrigs. Theoretical fluid flow models are developed for long grooved and smooth annular seals and for the impeller shroud based on bulk flow models. Currently, finite difference fluid flow models are developed for the impeller shroud leakage path.

KEYWORDS

Mechanical engineering/Machinery; Energy/Power generation; Dynamics/Fluid dynamics; Vibration analysis/Acoustics; Fluid/Structure interactions; Identification

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Contract no: BREU-0102
Proposal no: BE-3472

DECISION SUPPORT ENVIRONMENT FOR THE DESIGN OF PIPING AND FLOW SYSTEMS

Starting date: March 1990 ***Duration:*** 36 months

OBJECTIVES

The major cause of failures in many processes, oil and gas, power, chemical and manufacturing plants, is poorly designed piping and internal flow systems that cause undesirable flow conditions, noise and vibration. This project will specify integrated computer aids to:

- specify and select flow system components for reliability performance and safety
- avoid adverse fluid-structure interactions, noise and vibrations.

ACHIEVEMENTS TO DATE

So far, it has laid down the technical basis for both the individual modules and the overall software environment, including:

- pulling together the physics of fluid-structure interactions
- determining practical approaches to mathematical modelling of noise and vibration propagation
- setting up and now getting results from test rigs to validate the models
- determining a usable selection strategy for equipment specification modules
- designing practical software structures, including for complex data handling and knowledge representations
- designing a software module for automatic transformation from registration to a simplified model for mathematical analysis
- intelligent graphical editor already built and currently being tested in industry
- in-depth analysis of industrial requirements for integrated design software.

KEYWORDS

Data bases/Expert systems; Dynamics/Fluid dynamics; Mathematical modelling; Vibration analysis/Acoustics; Design; Engineering (process); Engineering/Software/Technical services

PRIME PARTNER

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Contract no: BREU-0109
Proposal no: BE-3394

EXPERIMENTAL AND NUMERICAL ANALYSIS OF SLOSHING AND IMPACT LOADS

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

The main objective of this project is to develop a fully integrated software for the numerical modelling of the fluid/structure interaction, in terms of free surface motions and impact loads, validated through ad-hoc experiments and applied into innovative design guidelines and procedures.

The following types of problems will be considered:

- for the shipbuilding industry-large amplitude imposed motions, harmonic or irregular (stochastic), large prismatic (steel) tanks with internal baffles and antiwash bulkheads, or quasi-spherical tanks
- for the automotive industry-tanks for automobiles and road transport
- for the aerospace-tanks in low gravity environment low amplitude excitations, liquid fuel free surface reorientations, surface tension
- for the civil engineering industry-large tanks for liquid storage, stochastic earthquake excitations, concrete (rigid) and (flexible) steel walls.

For the specific problems under examination, the values of free surface orientations and impact loads depend on the modelling of a number of fluid and structural parameters (such as viscosity, compressibility, gas cushioning, structural flexibility, gravity, etc.), which will be properly specified.

KEYWORDS

Aeronautic/Aerospace; Automotive, Components & parts; Construction/ Building/Civil engineering; Shipbuilding; Design; Dynamics/Fluid dynamics; Codes/Standard

PRIME PARTNER

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Contract no: BREU-0499
Proposal no: BE-4354

DEVELOPMENT OF BASIC FABRICATION TECHNOLOGIES AND SIMULATION TOOLS FOR MICROMECHANICAL DEVICES

Starting date: October 1990 ***Duration:*** 36 months

OBJECTIVES

The aim of the project is to further advance the technological and theoretical basis of Si micromechanics in order to fully exploit its potential for new applications, thereby creating the foundation for a new industry. This project sets out to investigate specific areas that will contribute to the building blocks necessary for the development of Si based sensors for monitoring pressure, acceleration, etc. The project will provide the elements needed for:

1. fabricating micromechanical structures with high aspect ratios and compensated for stress. The experiment will determine the best masking material for etching. Various techniques for the stress compensation in dielectric and semiconductor layers will be studied;
2. developing devices with freely movable silicon parts, which can be used for the realization of micromechanical sensors and actuators;
3. allowing the prediction of the behaviour of micromechanical devices using the software packages and simulations. The static and dynamic behaviour of cantilevers, bridges and plates and the influence of temperature on such structures will be cosidered.

ACHIEVEMENTS TO DATE

A number of achievements obtained after six months can be listed:

1. Experiments with dry and wet chemistries show that the required deliverable etching depths can be obtained.
2. Some microstructures stress compensation techniques have been determined.
3. Development of sensor stimulation packages is in progress.

KEYWORDS

Instruments/Sensors/Precision equipments; Quality assurance; Mechanics/Solid mechanics; Micro engineering; Sensors/Signal processing

PRIME PARTNER

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Proposal no: BREU-0264
Contract no: BE-3364

INNOVATIVE TRANSDUCERS FOR ADVANCED SIGNAL PROCESSING

Starting date: March 1989 ***Duration:*** 36 months

OBJECTIVES

The use of acoustical inspection techniques is limited by (1) scanning possibilities to insonify the material and (2) by evaluation and interpretation of the results, for which highly sophisticated specialists work is required. New transducers for systems using signal processing both for data evaluation and for measuring would be able to provide automated data evaluation even for complex shaped surfaces using suitable acoustical sensors with broadband characteristics and beam steering. The development of these new transducers is based on the present available Piezoelectric Polymer technology, which already proved its advantages in comparison with existing tranducers. This technology has to be fitted to the needs for non-destructive testing with special consideration of the imaging techniques. The expected advances for future inspection systems are:

(1) to improve the inspectability of complex shaped geometries.

(2) to avoid the use of expensive manipulators.

(3) to reduce inspection time.

(4) automate data evaluation.

ACHIEVEMENTS TO DATE

1. Specifications for single element transducers and linear arrays for standard and advanced ultrasonic techniques were drawn up.
2. The design and fabrication technologies for single element and linear array transducers was developed.
3. The first transducer prototypes were manufactured. Preliminary tests showed satisfactory results.
4. Signal evaluation algorithms for PVDF transducers were developed.

KEYWORDS

Sensors; Imaging; Inspection; Analysis

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Contract no: RI1B-190
Proposal no: P-2172

DEVELOPMENT OF FABRICATION TECHNIQUES FOR THE PRODUCTION OF METAL-OXIDE BASED SENSORS

Starting date: February 1990 ***Duration:*** 48 months

OBJECTIVES

The aim is to provide Europe with production techniques and a production source, now monopolised by one Japanese manufacturer,for reliable and fast responding sensing devices which are selective and sensitive towards various gaseous species.

Therefore the project objectives are:

- to investigate the potential of engineering of SnO_2, In_2O_3, ITO or sandwiches of these materials as reliable and selective gas sensing materials
- to investigate the suitability of thin and thick films produced with these materials as reliable and selective gas sensing films
- to investigate the films and related solid state structures for the detection of gases in terms of fabrication processes, process-parameters, and the resulting gas sensitivity
- to demonstrate the use of the most successful structures as gas detectors for a number of gases on lab scale
- to demonstrate the most promising sensor with the required mechanics and electronics in a prototype apparatus by field tests in such a way that a European production source for these devices can be established.

KEYWORDS

Sensors; Signal processing; Gases; Research/Development; Multilayers/ Multimaterials; Materials characterisation

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Proposal no: BE-3142

NOVEL SEMICONDUCTOR GAS DETECTORS IN MULTI-SENSOR SYSTEMS FOR SAFETY, EFFICIENCY AND THE ENVIRONMENT

Starting date: 1991-1992 ***Duration:*** -

OBJECTIVES

This project is driven by the desire to avoid increasing Japanese dominance of the low cost gas sensor market, and to ensure that Europe benefits from exploitation of the world-leading gas sensor knowledge of the participants. The user partners have strong and complementary horizontal interests, typical of the wide spread applications of gas sensors. An SME working with a national laboratory provides the leading edge technology and ensures a vertical relationship with the other partners. Society is increasingly demanding improved safety, reduced emission of pollutants and higher efficiency of fuel use. The applications addressed in this project make it possible to satisfy these three goals simultaneously. Technically, the work concerns gas sensing systems employing novel materials. Multi-sensor arrays will be investigated to facilitate the use of improved signal processing algorithms. The objective is to develop these concepts to the point where realistic long-term laboratory tests can be undertaken.

KEYWORDS

Sensors; Engineering(chemical); Engineering (electrical); Ecology/ Environment; Safety management.

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Contract no: BREU-0502
Proposal no: BE-4033

A FUNDAMENTAL STUDY OF ELECTROCHEMICAL SENSORS FOR THE ALUMINIUM INDUSTRY

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

In this project a detailed investigation of electrochemical sensing principles for the detection of certain elements in molten aluminium is proposed. With respect to the development of a sodium sensor, emphasis will be put on the development and characterization of a suitable reference system and the production of the solid electrolyte. A prototype sensor will be constructed and tested in the laboratory as well as in an industrial environment.

With respect to strontium, magnesium and hydrogen as elements to be monitored, appropriate sensing systems will be investigated in detail. For strontium and magnesium, the focus will be on a system of recently developed ceramic proton conductors protected by a hydrogen permeable material. The final aim of this basic research is to characterize the appropriate materials and to investigate the feasibility of these materials in electrochemical sensors. If successful, these sensors can be developed into a prototype sensor (cf. sodium sensor).

KEYWORDS

Instruments/Sensors/Precision equipment; Materials processing; Quality assurance; Non ferrous; Materials science; Sensors/Signal processing; Chemistry

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Contract no: BREU-0500
Proposal no: BE-4512

CONTROL OF FLOCCULATION OF CELLULOSE FIBRE AND MINERAL SOLIDS IN PAPERMAKING STOCKS

Starting date: August 1990 ***Duration:*** 48 months

OBJECTIVES

Flocculation of a papermaking stock is subject to continuous change during its passage through the papermaking system. It will be increased by raising the concentration of fibres and by the addition of chemicals usually suppplied in the fan pump, the approach to the flowbox and in the flowbox itself; Once leaving the flowbox, flocs will form during formation and drainage. These flocs result in micro or macro variation in grammage. Their distribution is commonly referred to as formation. This project aims ultimately to control formation by controlling the flocculation characteristics of the stock.

ACHIEVEMENTS TO DATE

In the first year the project has concentrated on:

- process modelling: papermachine steady state and dynamic models have been refined using industrial data from participating companies
- sensor selection: ultrasonic, optical and imaging techniques have been assessed for onward development
- fundamental studies of the flocculation behaviour of papermaking stocks have been investigated and used to develop models of floc behaviour.

Compilation of this information will be used to develop and refine sensors for use in a feed forward control system for paper formation.

KEYWORDS

Control systems; Flocculation; Sensors; Cellulose fibres; Paper; Mineral fillers

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Contract no: BREU- 0159
Proposal no: BE-3135

LASER MASS SPECTROMETRY FOR IN-LINE INDUSTRIAL MICROANALYSIS

Note: updated information was not provided in time for publication

Starting date: February 1989 ***Duration:*** 36 months

OBJECTIVES

The primary objective of this project is the adaptation of Laser based Mass Spectrometric techniques for in-stream diagnostics of ores, slurries and solutions. A Laser Mass Spectrometer prototype is to be designed, installed and pilot tested on site at an enrichment plant. The use of currently available high-repetition rate pulsed laser systems (Nd, YAG, Excimer or Dye) allows the in-line and on-site representative sampling together with sensitive and selective monitoring of the target compounds of interest. Implementation of this technology is expected to increase production efficiency, product quality and employee safety together with lower capital investment requirements than the technology currently available.

KEYWORDS

Instruments/Sensors/Precision equipments; Mining/Extraction; Processing (minerals & metals); Instrumentation/Measuring systems; Laser technology/ Power beams

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Proposal no: P-2449

IN-PROCESS MONITORING OF ELEMENT COMPOSITION AND DERIVED PROPERTIES OF POLYMERIC MATERIALS BY REMOTE LASER MICROANALYSIS (RELMA)

Starting date: March 1990 ***Duration:*** 40 months

OBJECTIVES

The strategic purposes of RELMA are to improve product quality and to reduce manufacturing time and costs during the compounding and mixing of polymers like rubber. This will be achieved by application of a new technique called laser-induced emission spectral analysis (LIESA®) recently developed by Krupp for direct liquid steel elemental analysis in a steel plant.

For industrial rubber mixing processes, for example , it is highly desirable to evaluate on-line the dispersion of the different ingredients in the polymer matrix (i.e. compound homogeneity). Therefore the main objective of the project is the development of a laboratory system capable of in-process monitoring of the homogeneity of rubber slabs in the open mill and other locations in the early stage of a tyre production line.

By scanning the focused beam of pulsed laser across the surface of rubber slabs in a rubbers mixing line, spatial element distributions will be measured and evaluated on-line. The optical emission of the plasmas which are created at the focal spot (spot size up to $10mm^2$) of the laser beam during scanning, is detected for spectral microanalysis of the polymeric material.

ACHIEVEMENTS TO DATE

- construction of experimental set-ups for the elemental analysis of rubber
- identificaton and assignment of all observed spectral features
- measurement of calibration curves for variety of interesting elements
- development of software for data evaluation and measurement control
- specification of material properties to be measured via element distributions.

KEYWORDS

Rubber mixing plant; Process/Product monitoring; Quality control/Inspection; Plastics/Rubbers; Laser technologies/Power beams.

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Proposal no: BE-3102

NON-DESTRUCTIVE CHARACTERIZATION OF DAMAGE IN PARTICLE REINFORCED ALUMINIUM MATRIX COMPOSITES

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

The aim of the project is to provide a nondestructive technique to characterize damage in aluminium matrix composites, which may negatively influence their fitness for use. Mechanical and thermo-mechanical behaviour depends strongly on the microstructural situation (e.g. volume fraction, defects introduced by fabrication, size distribution, etc.), the damage of the materials and the residual stress state. In addition to this, damage accumulation during service life restricts the lifetime. At present there is some empirical evidence of correlation between the results of ultrasonic tests, the microstructure and the progress of fatigue damage in metal matrix composites. Further progress requires understanding of the physical processes underlaying this correlation. This project aims at providing such an analysis, leading to a multiparameter approach for the ultrasonic characterization of metal matrix composites.

ACHIEVEMENTS TO DATE

From tests on undamaged specimens the most promising techniques were selected: acoustic-elastic constants; thermo-elastic constants; phase velocity and backscattering as a function of frequency. Absolute velocity and second order constants measurements were judged unsuitable. The first comparisons between measured and modelled data showed good agreement. Starting the next phase of the project is considered justified.

KEYWORDS

Composites (metal matrix); Research/Development; Materials characterization/Testing; Mathematical modelling

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Contract no: BREU-0146
Proposal no: BE-3495

ON-LINE QUALITY CONTROL OF STRIP CAST ALUMINIUM ALLOYS

Starting date: July 1991 ***Duration:*** 36 months

OBJECTIVES

The aim of the project is to achieve significant improvement in stripcast quality through an integrated control system and its use in process driving.

The production process chosen, continuous casting of Al alloy strip, shows characteristics particularly suitable for the development / assessment of the control system.

To achieve this target the following actions are necessary :

- continuous assessment of the strip temperature distribution immediately after solification
- thickness profile measurement of the strip both longitudinal and transversely
- detection of defects and identification of the type, importance and dimension of same. All the above mentioned measurements must be taken non destructructively and by non contact method techniques in hostile industrial environments.

The detection of the surface defects has to be fulfilled in real time while manufacturing the aluminium strip.

The data obtained will be used in a further stage for:

- development of the data management system for the collection of data from various measurement devices and for their integration as quality report of the strip
- analysis of correlations between the process parameters and the collected measurements
- development of an expert system able to drive the casting operation using processed data
- final in-field test of the prototype system and evaluation of the improvements achieved.

KEYWORDS

Forming/Shaping/Casting; Process/Product monitoring: Quality control/ Inspection; Non ferrous; Control systems; Imaging/Image processing; Instrumentation/Measuring systems

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Contract no: BREU-393
Proposal no: BE-4336

SYSTEM FOR ON-LINE INSPECTION, CLASSIFICATION, QUALITY CONTROL AND RESCHEDULING OF FLAT ROLLED PRODUCTS MOVING AT HIGH SPEED

Starting date: July 1991 ***Duration:*** 36 months

OBJECTIVES

The main aim of the project is the development of a system for inspection and diagnosis, which carries out the quality control and classification of flat products obtained in different industries (e.g. steel, aluminium, copper, paper, plastics, glass, coated materials).

The system will detect visual defects of a size up to 2 mm^2 at a speed of 1200 m.p.m. The detected defects will be compared to the established quality standards in order to determine the quality of the products and the reason for its possible rejection.

The system will consequently allow the product to be delivered, plan the production of an alternative product or sort the outgoing product into a lower quality category.

The project is split into the following main tasks:

1) Methodology of work, specifications, preliminary measurements and optimal strategies for inspection and quality control
2) High lighting level system and CCD camera
3) Signal preprocessing and object definition
4) Classification of objects
5) Data base management unit
6) Diagnostics of the vision system
7) Expert and products
8) Integration of the subsystems and test on the prototype
9) Final report.

KEYWORDS

Databases/Expert systems; Electronics; Sensors/Signal processing; Quality control/Inspection; Multimaterials/Multilayers; Vision/Optical systems.

PRIME PARTNER

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DEVELOPMENT OF MICROWAVE TECHNIQUES FOR NON DESTRUCTIVE EVALUATION OF ADVANCED CERAMICS

Starting date: April 1989 ***Duration:*** 36 months

OBJECTIVES

The detection of critical defects in advanced ceramics, i.e. defects which are likely to bring on rupture of pieces in service, is of prime importance. Sophisticated non destructive testing methods (high frequencies ultrasounds, X-ray, tomography) already exist, but are not well suited to industrial use because of their price and of some technical requirements (test duration, coupling medium). An alternative could be microwave techniques with frequencies higher than 25-30 GH_z, provided they allow the detection of small defects (size: some microns to a few hundred microns) in complex shapes.

The first objective of this project is to assess the capability of microwave techniques in terms of sensitivity and resolution. The range of application, i.e. types of microstructures which can be easily investigated by microwaves must be defined. To achieve this objective, some samples will be prepared using various raw materials and elaboration processes and first characterized, in green and sintered states, by means of classical methods.

In a second stage, the dielectric properties of the materials will be determined. Thereafter, the samples will be tested using an experimental microwave NDE device. The second objective of the project is to design and build a microwave device for industrial application.

ACHIEVEMENTS TO DATE

The contract had been stopped the 30/09/1990. At the end of the phase 1 'feasibility' results are not sufficient.

With microwave techniques it appears that is not possible to detect in industrial conditions defects smaller than 100µm.

KEYWORDS

Aeronautics/Aerospace; Automotive, Components & Parts; Quality control/ Inspection; Ceramics/Glasses; Instrumentation/Measuring systems.

PRIME PARTNER

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Contract no: RI1B-301
Proposal no: P-2396

ON-LINE MULTI SENSOR INSPECTION SYSTEM FOR COMPOSITES AND CERAMIC COATED MATERIAL

Starting date: November 1991 ***Duration:*** 48 months

OBJECTIVES

The objectives of this project is to provide a demonstration device with the basic functions and capabilities of an on-line modular multi sensor inspection system for carbon fibre composites (CFC) and ceramic coated material (CCM).

The on-line modular multi sensor inspection system (OMMSIS) will be realized with optronic, electromagnetic and ultrasonic sensor techniques including an appropriate scanning device, on-line signal processing, automatic or menu-driven operation, correlation and assessment of defects as well as a powerful graphic presentation of the results.

The project is defined as follows:

(i) definition, production/selection and preparation of test specimens with and without defects;

(ii) development and adaptation of optronic, electromagnetic (ED, DC, MMW) and ultrasonic (SAFT) methods for surface and volumetric inspection of CFC (including anisotropic layered material) and CCM;

(iii) integration of the inspecting systems by a data system and control unit for defect correlation and assessment;

(iv) demonstration of trials with the demonstration device OMMSIS.

ACHIEVEMENTS TO DATE

The achievements to date after six months of project running time are an infrared inspection system working in principle; adapted MMW- and DC-sensors, first mathematical solutions for anisotropic layered material, the design of a test bench for the test specimens and the production of several test specimens.

KEYWORDS

Aeronautics/Aerospace; Automotive, components & parts; Quality assurance; Quality control/Inspection: Fibres/Reinforced materials; Composites (polymer/metal matrix)

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Contract no: BREU-269
Proposal no: BE-3607

X-RAY VOLUDENSITOMETRY APPLICATION TO THE TESTING OF TECHNICAL CERAMICS AND ADVANCED MATERIALS

Starting date: February 1989 ***Duration:*** 48 months

OBJECTIVES

Development of a new non-destructive testing (NDT) method for inspection of small, light industrial parts. The aim is to provide the NDT staff a 3-dimensional image of the volume of the object to be tested. The equipment , called EVA, processes the captured X-ray transmission measurements along a series of projection planes surrounding the object. A special algorithm is used to reconstruct, from these data, a 3D density cartography. A high spatial resolution can be achieved by this method which allows detection of small critical defects in ceramics or advanced materials.

ACHIEVEMENTS TO DATE

Acquisition equipment was specifically designed for the project and put into operation. It is composed of an accurate computer-controlled manipulator, incorporating a 160 kV microfocus X-ray tube and an image intensifier tube. The measuring bench automatically generates a full acquisition and calibration cycle with storage of data for the next processing step: the reconstruction stage.

A prototype version of the reconstruction software, including Feldkampf and Grangeat algorithms as options, has been applied on real data: the results are rather encouraging. However, the final version will run on a vectorial processor. An important optimization phase is under way in order to reduce the testing time; significant improvements could be achieved.

Display software under implementation is intended to facilitate the interpretaion of the resulting imges by offering a friendly, interactive human interface: display functions have been selected and designed to ease characterization of defects in materials.

A methodological study was performed to supply reference ceramics parts with and without calibrated defects. The next step, now in progress , consists in the production of a more complex part: a prototype precombustion chamber. These parts are dedicated to the evaluation of the NDT perfomances of EVA.

KEYWORDS

Materials characterization; Quality control; Non-destrustive testing; Imaging instrument; Research and development; Ceramics; Advanced materials.

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Contract no: RI1B-285
Proposal no: P-2051

NON CONTACTING SURFACE CHARACTERIZATION OF CERAMICS AND COATINGS WITH MICRO ACOUSTIC WAVES (C - MAW)

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

The goal of this project is to demonstrate a novel laser generated ultrasonic inspection technique for surfaces and interfaces of ceramic components and thin film ceramc coatings. This technique will provide accuracy and resolution up to 2 orders of magnitude better than techniques now in use for identifying residual stresses and defects in thin surface regions (3-10 μm).

The specific objectives of this project are as follows:

(i) create a technique for very accurate measurement of residual stress, microstructure, and defects in ceramic components and coating systems

(ii) demonstrate application of the technique to optimisation of selected manufacturing processes. This will involve surface acoustic wave measurements on a range of industrial samples followed by mechanical or thermal testing

(iii) demostrate capability for in-process control, a second prototye measurement apparatus with in-process monitoring capability will also be assembled.

KEYWORDS

Ceramics; Coatings; Non destructive testing; Machining; Reliability; Quality control; Instruments

PRIME PARTNER

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Contract no:
Proposal no: BE-4398

ATTAIN: APPLICATION OF TRANSIENT THERMOGRAPHY TO ADVANCE INDUSTRIAL NDT

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

The mission of the ATTAIN project is to demonstrate the industrial potential of an advanced non-contacting NDT technique-advanced transient-illumination thermography. It is anticipated that this technique should prove applicable in a wide range of industrial situations where the type of measurement to be made (such as defect type, speed or resolution), or environmental and access requirements, make other techniques inappropriate. The seven partners, together with additional industrial sponsors, represent both system and user interests across a representative range of industries - some of which have wished to apply suitable on-line NDT inspection techniques for some time. Major cost savings are identified in the Proposal, should the proposed research and feasibility trials prove successful. Technical goals include detection of:

- cracks of width 0.1mm and length 1 mm in ceramic coated turbine blades, and measurement of coating thicknesses in the range 0.2-0.6mm to accuracy of ± 5%
- areas of disbonding (> 100 cm^2) of thin (20-200 μm) metallic and organic (paint) coatings on steel strip
- wear-related thickness variation and >10 μm surface cracks on ceramic bearing components
- high-resolution (< 10 μm) defect detection in thin films on ceramic substrates
- quantitative determination of thermal properties of ceramic substrates for thin films.

KEYWORDS

Transient thermography; Coatings/Thin films; Composites (polymer matrix); Databases/Expert systems; Image/Image processing; Materials characterization/Testing; Mathematical modelling

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Proposal no: BE-4334

DEVELOPMENT OF NON-INVASIVE METHODS FOR MEASUREMENT OF STRESS IN WELDED STEEL STRUCTURES

Starting date: February 1989 ***Duration:*** 48 months

OBJECTIVES

The nondestructive measurement of stress in welded steel structures has been identified as a key element in the evaluation of their fitness-for-purpose. The objective of this four-year project is the research and development of non-invasive methods capable of measuring stress in such structures. Particular attention is being paid to offshore constructional steels, but it is intended that the techniques under development will have a wider application within electricity supply and manufacturing industries. The approach is first to study a wide range of magnetic and ultrasonic methods and then to focus on those with the best practical potentential for determining (in increasing order of difficulty) relative surface stresses, absolute surface stresses, relative bulf stresses, and absolute bulk stresses.

ACHIEVEMENTS TO DATE

The project has just successfully completed its Mid-Term Review. After a wide-ranging Phase I programme of experimental and theoretical studies, a combination of magnetic techniques has been identified with the best balance of technical performance and practical potential for biaxial stress determination in ferritics weldments. The work has included some seminal theoretical modelling of the interaction of magnetic fields with depth-dependent tensor stresses. In addition to further background research relating to calibration and optimization, the Phase II work programme aims to develop a demonstrator system for testing on a range of industrial problems.

KEYWORDS

Chemical/Petro-chemical; Energy/Power generation; Reliability; Quality control/Inspection; Materials characterization/Testing.

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Proposal no: P-2082

RESIDUAL STRESSES AND HARDENING DEPTH MEASUREMENTS - AN ON LINE APPROACH TO MECHANICAL PART 100% PRODUCTION TESTING

Starting date: July 1991 ***Duration:*** 48 months

OBJECTIVES

The continued effort towards product quality improvement in the automotive industry has identified the need for reliable on-line non-destructive testing techniques that enable evaluation according to product specifications, the execution of local heat and/or mechanical treatments on critical components such as crankshafts, camshafts and gears. Required performances include characterization of surface hardness and residual stress states, independent of initial charge variability (Priority themes 2.2.1, 2.2.2, 2.2.3, 4.1.1).

The objective of the project is to develop solutions based on non-conventional electromagnetic techniques (controlled-signal pulsed eddy currents, anisotropic magnetic permeability, Barkhausen noise), which are the most favourable to on-line implementation. These solutions will be based on parameter combinations of proven diagnostic reliability and on measuring procedures applicable to on-line testing. A prototype system with automated evaluation capabilities will be assembled and used for experimental validation in shop environment. A user-orientated flexible design will allow operation by non specialist personnel and enable different industrial end users to address their own specific problems. On-line feedback information to the process will thus become possible, with further benefits in terms of reduction in finished product scraps and in related costs.

KEYWORDS

Automotive, Components & Parts; Quality control/Inspection; Ferrous; Instrumentation measuring systems; Cold working processes; Residual stress; Hardening depth profile

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Contract no: BREU-0507
Proposal no: BE-4108

HIGH RESOLUTION NON-DESTRUCTIVE X-RAY EQUIPMENT FOR INDUSTRIAL PRODUCTION LINE MONITORING WITH ON-LINE COMPUTER EVALUATION

Starting date: September 1990 ***Duration:*** 36 months

OBJECTIVES

The aim of the proposal is the investigation and the development of an automatic X-ray NDT analysis using a new sensor concept with customised integrated pulse handling and readout together with special multichannel image processing. This approach makes use of energy selective X-ray sensors associated with a low noise linear integrated electronics as well as an integrated image processing system. The main tasks are:

- research and development of cadmium telluride energy selective sensors built together in blocks of up to 1500 elements
- specification and design of a suitable integrated preamplifier followed by other integrated pulse handling electronics adapted to these sensors
- design and development of a flexible X-ray generator adapted to both sensor and scanning technologies
- concept and prototype development of special image processing hard- and software to handle the multidimensional data delivered by the material discriminating NDT system
- integration of the components to a prototype system to verify the functionality.

ACHIEVEMENTS TO DATE

Final specifications have been worked out.

KEYWORDS

Materials processing; Process/Product monitoring; Quality control/Inspection; Image/Image processing; Sensors/Signal processing

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Contract no: BREU-0274
Proposal no: BE-3036

VISION BASED INTERNAL AND EXTERNAL AUTOMATIC INSPECTION SYSTEM FOR METAL PRODUCTS

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

In the project a novel multisensorial-data supported industrial inspection system for metal parts is proposed. It involves new X-ray sensors and conventional light based computer vision modules, for simultaneous detection and correlation of internal and surface quality defects of metal parts, giving non invasevely in realtime, a total quality assessment.

The system will be suitable for unattended, as well as for manned operations, in dense factory environments. It will be based on advanced image processing algorithms and multi-sensorial data fusion methodologies, effectively combining image features and high level artifacts derived from them, in order to compile an accurate defect modelling and localization and to fast validate the produced parts, according to their overall quality specifications.

The project aims at a directly exploitable multi-sensorial inspection workstation, to be actively marketed by the consortium members soon after the projects conclusion, both in EEC countries and abroad.

The system will bring high-tech quality inspection tools to a hostile and difficult to operate environment (such as metal parts manufacturing, casting and machining), thus offering a tremendous potential for quality improvement and productivity acceleration.

KEYWORDS

Quality control/Inspection; Processing (minerals & metals); Imaging/Image processing; Sensors/Signal processing; X-ray imaging; X-ray sensors; X-ray sources

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Contract no: BREU-0478
Proposal no: BE-4602

THE DEVELOPMENT OF A NEW NMR MICROSCOPE FOR STRUCTURAL AND DYNAMIC STUDIES OF CHEMICAL AND BIOLOGICAL PROCESSES

Starting date: January 1989 ***Duration:*** 36 months

OBJECTIVES

- to develop an NMR microscope with resolution in the order of 10 microns.
- to provide spatially localised NMR spectroscopy (at lower resolution).
- to provide the ability to carry out a range of experiments in the second half of the 3 year programme.
- to study spatial reaction between flowing reacting fluids; diffusion studies in gels and porous materials; microflows velocities; the dynamic structural changes occurring during polymerization, isomerization and solidification.
- this will lead to improved knowledge of fine chemicals and materially improve methods of analysis and on-line inspection.
- to establish the potential industrial uses of these processes.

ACHIEVEMENTS TO DATE

The project has been delayed by one year because the magnet ordered for the project was a year late from the suppliers, owing to technical problems that they encountered. Now that the magnet is operational all parts prepared by SMIS have worked well, resulting in initial images with 20 micron resolution. Final tests are underway before shipping the complete system to RUCA. Additional hardware will be added to improve image resolution below 10 microns. Parallel studies have continued at both RUCA and PGS.

KEYWORDS

Imaging/Image processing; Instruments/Sensors/Precision equipments.

PRIME PARTNER

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Contract no: RI1B-001
Proposal no: P-1545

DEVELOPMENT OF NOVEL INTELLIGENT MONITORING TECHNIQUES AND OPTIMAL ADAPTIVE CONTROL FOR FED-BATCH PENICILLIN FERMENTATION

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

The main goal of this project is the development of new monitoring techniques and advanced control methodologies to be applied on industrial fermentation processes. The case in study in the project will be the penicillin fed-batch fermentation.

Specific objectives on this project are:

- Extension of the enzyme thermistor system previously developed for measurement of penicillin and glucose for monitoring of the penicillin fermentation
- to design a "software sensor", an algorithm used as an adaptive observer, based on a penicillin fermentation model and to test it as a mathematical tool for on-line estimates of non measured parameters and non-measured state variables of penicillin fermentation
- to design and implement model-based adaptive optimal controllers in order to maximise the yield of the penicillin fermentation
- to integrate these achievements on an "on-line" sampling and data acquisition system and run pilot experiments for validation of developed technology.

KEYWORDS

Penicillin fermentation; Dynamic modelling; Sampling devices; Pharmeceuticals; Control systems; Instrumentation/Measuring systems; Sensors/Signal processing

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Contract no:
Proposal no: BE-4522

SUB ANGSTROM STRUCTURE CHARACTERIZATION

Updated information was not provided in time for publication

Starting date: 1990 ***Duration:*** 48 months

OBJECTIVES

Development of methods and instrumentation for structure characterization below the 0.1 nm level. By combining the know-how of European Universities and Industries it is possible to construct a unique electron microscope which can reach beyond the physical limit of characterize the atomic structure and chemical composition will be used for materials where knowledge on structural deviations at an atomic scale is essential for understanding these properties.

A fundamentally new method of phase and structure retrieval by focus variation, developed in the Unvirsity of Antwerp, together with an auto alignment method developed in Delft forms the key issue. A second method-electron holography developed at the University of Tubingen can lead to the sameresullt employing almost the same microscope.

The hardware consists of a special electron microscope designed by Phillips with an image detector designed by University of Tubingen. Also to be designed by Tietz Video and Image processing Systems GmbH is an ultrafast image processing system.

This combination of know how is unique in the world and will make the instrument by far superior to the Japanese competition.

KEYWORDS

Instruments/Sensors/Precision equipments; Imaging/Image processing; Materials science; Micro engineering

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Contract no: BREU-0071
Proposal no: BE-3322

NON-DESTRUCTIVE EVALUATION FOR THE PRE-INSTALLATION ASSESSMENT AND IN SITU INSPECTION OF WOODEN TRANSMISSION POLES

Starting date: May 1988 ***Duration:*** 48 months

OBJECTIVES

The Feasibility Study prior to this project identified the annual costs of inspecting wooden transmission poles in the EEC as 150 million ECU. With the continued use of wooden poles assured, reliable and accurate non-destructive methods to assess the condition and predict the strength properties of poles are essential if unexpected failures are to be prevented and fewer poles are to be prematurely replaced. The objective is to enable significant reductions in the cost of maintaining overhead line systems, by developing prototype devices for the improved strength prediction.

ACHIEVEMENTS TO DATE

1. One 350 poles both new and removed from service, have been destructively tested following assessment by a range of non-destructive testing techniques. Testing continues using the specially developed cantilever test facility at TRADA.
2. A prototype technique for the production of the strength and condition of poles in-situ has been developed and has undergone field trials in both Denmark and the UK.
3. A prototype machine for predicting the strength of new poles at the production stage has been constructed and is undergoing trials.
4. Work is processing on th edevelopment of a ' quick check ' device for use by needing to know whether a pole is safe to climb.

KEYWORDS

Construction/Building/Civil Engineering; Wood/Quality control/Inspection; Materials characterization/Testing; Vibration analysis/Accoustics; Research/Development.

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Proposal no: P-2177

WOOD ANALYSIS BY DIGITAL IMAGE PROCESSING (WOODIP)

Starting date: March 1991 ***Duration:*** 36 months

OBJECTIVES

The project's aim is to create a new intelligent sensor, based on Visionics, initially adapted to the timber and wood industry, but also to cork industries, which face similar problems. The main performance to be attained is: automatic detection of defects as small as 1 square millimetre, with an image contrast factor (signal-noise ratio) aproaching 1 and a rate analysis of 2 image/second.

This work will make it possible to solve the following essential problems:

- qualification of different types of defects (knots, cracks, bluestain and coloured stain, grain and all types of defects) and quantification of their acceptibility
- development of simple systems, based on analysis of a minimum number of discriminatory parameters, and at a cost of less than 70 000 ECU for an integrated system
- definition and identification of human decision criteria and creation of a mathematical model transcription.

KEYWORDS

Image processing; Wood; Cork; Sensors; Machining; Quality control; Automation

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Proposal no: BE-3264

INTEGRATED SIMULATION AND EVALUATION OF ULTRASONIC TESTING DATA

Starting date: October 1991 ***Duration:*** 48 months

OBJECTIVES

The goal of the project is to develop a methodology and a system which allows simulation of ultrasonic testing inspections especially of complicated geometries. Also the comparison of simulated and measured data will be supported by this system. The system will be realized by integration and if necessary modification or further development of the following modules:

- 3-D handling of geometry (CAD, Preprocessing, Postprocessing)
- modelling - Scanning path optimization - Imaging methods as central beam approximation, topography, SAFT
- flaw analysis and interpretation.

The project is based on the result of the PISC III modelling group and on existing techniques of the partners and subcontractors. The results of the project will be a helpful tool for:

- Estimation of inspectability of a specimen to be constructed
- planning of inspection strategy, which means transducer design, scanning path optimization and selection of instrumentation
- inspection demonstration by simulation; - analysis and interpretation of insertion data, especially sizing of defects with respect to fracture mechanics
- documentation of NDT results; - assurance of inspection quality.

Comprehensive tests will be carried out by comparison of simulated UT data with measured ones using mock-ups which cover a wide range of applications.

KEYWORDS

Quality assurance; Inspection; Maintenance; Metallic structural materials; CAE/CAD/CAM Ssystems; Imaging; Mathematical modelling

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Contract no: BREU-0508
Proposal no: BE-4574

DEVELOPMENT OF A NON-DESTRUCTIVE TEST METHOD BASED ON ACOUSTIC MICROSCOPY, FOR PROCESS MONITORING OF POWER SEMICONDUCTOR DEVICE MANUFACTURE

Starting date: November 1988 ***Duration:*** 44 months

OBJECTIVES

The purpose of this project is to use Scanning Acoustic Microscopy (SAM) to identify and characterize defects in power semiconductor devices (p-i-n diodes, BJTs, SCRs, RCTs, GTOs). At various stages of the fabrication process, defects are inevitably introduced in the silicon wafer, like impurities in the crystal, microcracking of silicon wafer, voids at the silicon-contact metallization interface. Such defects may strongly affect the electrical performances and reliability of the finished device. Since high voltage and high current ratings are required from very large area devices, an accurate knowledge of the defects introduced into the silicon is a key factor in manufacturing.

ACHIEVEMENTS TO DATE

This project is logically divided into three main sections as follows:

- calibration of the different SAM equipment available for research and acoustic characterization of materials typically used in semiconductor manufacturing
- assessment of actual defects introduced in the silicon water during the fabrication process, by SAM and other cross-characterization techniques
- image acquisition and processing; development of a system for measurement management.

The first part of the research was completed with important achievements both in terms of measurement protocols and characterization of materials. The investigation of actual defects started during the second year of research. Some kind of defect has been fully characterized and SAM is now used for in-line assessment of commercial devices, while other types of defects are still being studied. Hardware and software for image acquisition and processing have been developed, and a system for automatic management of the measurement of two particularly meaningful defects is now under consideration.

KEYWORDS

Electronics; Power semiconductor devices; Non destructive evaluation; Acoustic microscopy; Process monitoring; Image processing; Materials characterization.

PRIME PARTNER

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Contract no: RI1B-250
Proposal no: P-2318

DEVELOPMENT OF AN AUTOMATED BOND VERIFICATION SYSTEM FOR ADVANCED ELECTRONIC PACKAGES

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

Customers purchasing electronic products are demanding increased product functionality, reduced unit size and higher reliability. The first two factors combined result in an increase in the connection denbsity inside the product. To satisfy this requirement the width of the component leads and pitch of the connections are made finer. In order to provide increased reliability 100% automatic inspection is necessary.

While some systems exist for inspecting fine pitch bonds, no system can inspect all types of defect in both visible and hidden bonds, or inspect very fine pitch bonds in the sub 300μm range.

This project will provide a prototype, non-contact, automated inspection system capable of assessing the integrity of soldered joints and wire bonds, including those of very fine pitch devices (<300μm), at production speeds, on electronic printed circuit boards. The use of 2D vision, 3D high resolution laser and x-ray fine focus techniques will be investigated and a system incorporating a combination of technologies will be developed. The system will be of modular construction to allow appropriate sensors to be used, and include sufficient flexibility to allow for inspection of larger bonds which will continue to be a feature of the mixed interconnection technology boards in the future.

KEYWORDS

Electrical/Electronic industry; Quality control/Inspection; Solders/Brazes/Welding; Automation/CIM; Imaging/Image processing; Laser technology/Power beams; Vision/Optical systems

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Contract no: BREU-0587
Proposal no: BE-4595

CHARACTERIZATION OF POLYMER-LIKE FILMS, FIBRES AND CERAMICS, AND THEIR SURFACE TREATMENTS, BY HIGH RESOLUTION ELECTRON ENERGY LOSS SPECTROSCOPY

Starting date: November 1990 ***Duration:*** 36 months

OBJECTIVES

In order to enhance the qualities of textile materials (synthetic and natural fibres) that, because of their physical shape, are dependent on their surface elemental and chemical composition and morphology, a new generation of HREELS (High Resolution Electron Energy Loss Spectrometer) instrument will be designed and optimized. With the study of case examples, the applicability of this spectroscopy to fibre materials will be demonstrated in three steps:

(1) as (natural and synthetic) fibres have a very heterogeneous complex morphology, first models like flat polymers films will be studied.

(2) then modified (by plasma or laser treatment; coating) polymer surfaces will be prepared and characterized.

(3) finally industrial films and fibres will be studied.

This research is backed up by the use of (more) conventional (FT) Infra-Red, Raman, ESCA,(TOF) SIMS and AFM techniques, and mechanical tests.

ACHIEVEMENTS TO DATE

After six months, the evaluation of the physical performances of the HREEL-prototype developed in Namur has been performed. Consequently, construction of the new spectrometer for the project has been ordered. In the meantime, the surface characterization of clean, or as received, polymer films is undertaken.

KEYWORDS

Instrumentation/Measuring systems; Materials characterization/Testing; Surface treatment technologies; Coatings/Thin films; Polymers; Superconductors; Textile/Clothing

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Contract no: BREU-0267
Proposal no: BE-3494

SURFACE MODELLING AND QUALITY CONTROL SYSTEM FOR MANUAL AND AUTOMATIC COORDINATE MEASURING MACHINES

Starting date: November 1991 ***Duration:*** 36 months

OBJECTIVES

The project's aim is to satisfy the needs of exploiting manual and automatic coordinate measuring machines (CMM) in connection with CAD/CAM systems, at any stage of the manufacturing process and for a wide range of applications, from the geometric modelling of physical workpieces by CMM digitizing, to the set up and inspection of models, dies and moulds. While the field of classical geometric features (planes, cylinders, circles) for mechanical parts inspection has been widely investigated and some excellent solutions exist (i.e. from BCR-project MTR-075), the application of CAD/CAM/CAQ methods to the measurement of complex free-form surfaces is just beginning. The project will develop:

(i) a software package for surface modeling based on digitizing data from a CMM machine and having advanced smoothing and fitting algorithms (e.g. surface to surface fitting, CMM error smoothing, etc.)

(ii) a software package for manual and CNC programmed digitizing and quality inspection, with related printed and graphics reports

(iii) a new concept of coordinate measuring machines, supporting discrete manual and discrete as well as automatic surface digitizing

(iv) a PC-based CNC controller, with specific features for quality control and surface digitizing.

These developments are integrated into an unique application, but are organized in separate modules, that can be used independently, communicating with other CAD systems by means of standard interfaces, mainly DMIS, IGES, VDA-FS, STEP and BM-interface.

KEYWORDS

Aeronautics/Aerospace; Automotive,Components & Parts; Quality control/ Inspection; Automation/CIM; CAE/CAD/CAM systems

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Contract no:
Proposal no: BE-4527

DEVELOPMENT OF NON-DESTRUCTIVE HIGH PRECISION TEST METHOD FOR ASPHERIC COMPONENTS AND TOOLS IN OPTICS

Starting date: August 1987 ***Duration:*** 36 months

OBJECTIVES

Aspheric components are key components in modern opto-electronic domestic appliances like CD-players, projection television systems and video cameras. Using aspheres can make the systems much smaller and lower in weight while retaining or even improving their optical performance. The main objective of this project was to provide techniques for both the absolute measurement and comparison of aspheric surfaces.

From analysis of a great number of aspheric designs it turned that no single test instrument is able to measure every aspheric surface. Emphasis was given to aspheric surfaces for optical recording and projection television lenses. The optical recording lenses are best suited for determining the limits of the test techniques, for their surface accuracies and numerical apertures are the most demanding. The required accuracy for the testing of optical recording lenses should be about 0.01 micron, an order of magnitude greater than the required surfce accuracy.

ACHIEVEMENTS TO DATE

The project has resulted in the assessment of various conventional testing techniques, and the development of several innovative testing techniques, and tools. One of these innovative test techniques showed very promising results : a major part of the relevant aspheric surfaces could be measured with this technique. An industrial version of this testing technique is currently under development at Philips, and it is expected that this will enable the manufacture of aspheric components for various lens systems with the ever increasing accuracy required.

KEYWORDS

Instruments/Sensors/Precision equipments; Optical/engineering; Quality control/Inspection; Measuring systems; Materials characterization/Testing; Nanotechnology.

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Contract no: RI1-0186
Proposal no: P-2103

OPTICAL SENSORS AND FIBRE OPTIC WAVELENGTH DIVISION MULTIPLEXING SYSTEMS FOR PROCESS CONTROL

Starting date: December 1988 ***Duration:*** 36 months

OBJECTIVES

- to develop temperature and pressure sensors using three distinct approaches:
  - development of intensity-modulation sensors with reference and line compensation
  - design of novel optical micro-transducers using silicon micro-engineering (optically powered, optically read sensors)
  - design of fibre optic sensors on luminescence decay.
- to study and design a network and its associated optoelectronics, electronics and software, based on the wavelength division multiplexing principle, using multimode fibres, which accepts simultaneously the three types of sensors mentioned above.

ACHIEVEMENTS TO DATE

- the three types of sensors exist as prototypes and are currently under evaluation and optimization, taking into account the network specifications
- the network associated electronics, optoelectronics and software is nearly achieved and the complete system integration with the various sensors is just starting.

KEYWORDS

Instrumentation/Measuring systems; Optical fibres; Control systems; Sensors /Signal processing; Optics

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Contract no: RI1B-248
Proposal no: P-2167

HYBRID OPTICAL/ELECTRONIC MULTI - CHANNEL SYSTEM FOR INDUSTRIAL INSPECTION

Starting date: February 1989 ***Duration:*** 36 months

OBJECTIVES

The original objective was to develop a hybrid optical/electic vision demonstrater for application in automatic industrial inspection. Following work performed during the first two years of the project, the consortium believe that a hybrid system cannot currently be realized for high resolution inspection applications with available spatial light modulator, SLM, technology. It is also our belief that the general industrial vision architecture that has been developed is valid and that optical technology has a considerable speed advantage over VLSI technology provided suitable SLMs are developed. In order to prove this two functionally linked but separate demonstrators are being developed.

ACHIEVEMENTS TO DATE

An inspection demonstrator consisting of a work handling environment, a digital image processor, an inspection pre-processor, and a process controller is under development. The indidual modules are nearing completion and system integration has started. Theoretical modelling of the image processing algorithms in relation to the inspection task has been completed. Modeling of the effects of optical implementations continues. The implementations of a number of algorithms have been experimentally investigated, including power spectrum analysis, correlation, Sobel filtering, image moments, the logpolar transform, and the Hough transform. The log-polar, power system, and Sobel algorithms are currently being integrated into an optical image processing demonstration system.

KEYWORDS

Vision/Optical systems; Quality control/Inspection; Imaging/Image processing; CAE/CAD/CAM systems; Robotics.

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Contract no: RI1B-294
Proposal no: P-2202

PROJECT 'OFELIA' – OPTICAL FIBRES FOR ELECTRICAL INDUSTRY APPLICATIONS' – DEVELOPMENT OF PASSIVE OPTO-ELECTRONIC SENSORS FOR MEASUREMENTS AND DIAGNOSTICS IN ELECTRICAL POWER SYSTEMS

Starting date: May 1988 ***Duration:*** 48 months

OBJECTIVES

The reserarch foresees the development of opto-electronic devices for measurement of the following quantities in Electrical Systems:

- High Voltages, steady state and transient, up to some MV
- High Currents, steady state and transient up to 100 kA
- Temperatures in electrical machines and components.

The devices are based on the use of passive optical sensors: the transducer, in field, consists of a passive optical elements (optical fibre, crystal), while the active optical components (light emitter and detector) and the electronics for light control and signal processing are placed, out of field, at the "receiving" end. The signal transmission, to and from the field, is made by optical fibres. The main technical features are: high accuracy, high immunity from EMI; minimum invasiveness; full electrical insulation; high resistance to environmental stresses; intrinsic safety. The main economic issue is the independence of the cost of the applied voltage. The device can be used for measurement, protection and control, as well as for on-line diagnostic monitoring.

ACHIEVEMENTS TO DATE

Temperature measuring devices are completed and successfully tested. Their installation inside a power transformer is in progress.

Voltage and current devices, composed of two major subsystems, optical and the electronic, are completely developed and realised. Presently the two subsystems are being assembled together in the final devices. Laboratory tests are planned for the next month, while field tests, in an electrical susbstation, will follow.

KEYWORDS

Sensors; Optical fibres; Measurements; Electrical engineering

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Contract no: RI1B-172
Proposal no: P-2251

INTELLIGENT COMPOSITES CONTAINING MEASURING FIBRE OPTIC NETWORKS FOR CONTINUOUS SELF-DIAGNOSIS

Starting date: May 1988 ***Duration:*** 42 months

OBJECTIVES

The ability to monitor the changes of strain and temperature fields within a composite structure during fabrication and lifetime, is an important means of improving the quality and reliability of composite production. The good mechanical and chemical compatibility between optical fibres and the composite matrix, enables a fibre optic sensing network to be embedded into a composite structure and to check local properties with a suitable interrogation technique. The major objectives of the project are to:

- design the fibre optic sensing elements for measuring strain and temperature, as well as the optimal network
- establish general rules for incorporating fibre optic sensors into the composite and develop manufacturing procedures which avoid the degradation of both sensor and composite
- assess the relevance of the sensing network for representative composite structures, strain and temperature levels.

ACHIEVEMENTS TO DATE

- definition implemenation and test of the sensor
- definition and implemenation of a real time network for up to seven sensors
- simultaneous measurement of strain and temperature when using one sensor
- finding, embedding and utilizing of fibre structure that does not degrade the composite
- strain measurement with a two sensors network inside composite and four sensors bonded on the composite.

KEYWORDS

Aeronautics/Aerospace; Instruments/Sensors/Precision equipment; Quality control/Inspection; Composite (polymer matrix); Sensors/Signal procesing; Research/Development

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Contract no: RI1B-173
Proposal no: P-2361

OPTICAL IN-PROCESS INSPECTION OF ELECTROPLATED CONTACT SURFACES

Starting date: September 1990 ***Duration:*** 36 months

OBJECTIVES

To improve the reliability and the yield of surface-treated components, new methods for the inspection and in-process quality control have to be developed to detect and avoid defects and inhomogeneities at the micrometre level.

Therefore the first main objective is to develop an automatic optical inspection system which should work on-line due to high speed of plating process. The second objective is the investigation of the origin of defects which are detected by inspection system.

The exploitation of results will help to install a process control loop into the plating baths system in order to enhance the throughput and to reduce the costs.

ACHIEVEMENTS TO DATE

Basic optical experiments:

- an optical sensor which detects the direction of light which is scattered by a defect is the most suitable solution for discrimination between typical defects such as pits, protrusions and discolorations.

First concept development:

- the sensor system should consist of a lserscanner, a fast transputer-based image pre- and postprocessor, and a sytem controller.

Development of laboratory set-up:

- the optics and mechanics of the laboratory set-up have been completed.

KEYWORDS

Materials processing; Imaging/Image processing; Process/Product monitoring; Sensors/Signal processing; Quality control/Inspection; Vision/Optical systems; Vision/Optical systems; Coatings.

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Contract no: BREU-0266
Proposal no: BE-3076

PROJECT DEMOS – DISTRIBUTED ENVIRONMENTAL MONITORING WITH OPTICAL FIBRE SENSORS

Starting date: March 1990 ***Duration:*** 48 months

OBJECTIVES

Fibre optic sensors provide a method of reliable, passive monitoring of environmental changes for industrial and civil engineering applications. More recently they gained interest as a sensor technology issue with great promise in measuring various variables such as: temperature, pressure, level, flow and other analogue parameters because of its high data rates, safety in flammable or explosive atmospheres, immunity to electromagnetic-interferences and hence longevity in hostile environments.

The system is based on a network of fibre optic intensity modulated sensors interrogated by a 'time delay frequency multiplexing' tehcnique used for processing the signals of the multiple sensor system.

The major advantage of optical fibres for this sensor system is the possibility of passive sensing, that is, sensing without the use of electrical components in the sensor head. The long term stability of the proposed system is an essential requirement.

ACHIEVEMENTS TO DATE

As the R & D is focusing on referencing and line neutrality measurements, several sensors have been successfully implemented into a prototype netwok, consisting of home sensors and control units.

KEYWORDS

Optical; Fibres; Sensors; Networks.

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Proposal no: BE-3077

COMPUTER VISION BASED IN - PROCESS QUALITY CONTROL (BRIGHTVISION)

Starting date: August1990 ***Duration:*** 36 months

OBJECTIVES

A new generation of computer supported visual inspection systems will be developed, directly applicable to many industrial quality control and assurance environments. Rules and facts as well as multiple design criteria inspection system-design methodology which will enable the fast prototyping and implementation of high performance quality control systems in many different industrial applications. The study will be based on small-scale experimental setups where various visual inspection scenaria and the required knowledge-based systems and soft-decision processes will be tested and validated. The project focuses on 3 test-benches, one for metallic foils, one for linen and the other for wood surface inspection. The consortium consisting of an even mixture of industrial and research establishments will finally aim at a common specification derivation for the development and implementation of a multicriteria in-process quality inspection system.

ACHIEVEMENTS TO DATE

Measurements for the spectral and specular characteristics of the materials to be tested (i.e. linen, wood and galvanised steel) were performed and the best illuminating conditions and camera arrangements weree deduced.

Decisions and choices concerning computer hardware and software were performed and various alternatives were studied for implementaton of the image processing systems. Previous experience and usage of multi-transputer architectured systems led to a viable and efficient solution to the image processing problem.

The measurements of the optical properties of the surfaces provided useful information for the prototype construction of the test benches. Of these test-benches the galvanized steel has been constructed and tested whereas the linen and wood are under construction.

The algorithms to be implemented have been decided and the implementation of them has started evaluating their efficiency and defect detection capability. A Knowledge acquisition tool has been constructed and tested which will lead to the implementation of a knowledge extraction tool where the various material classes will be sorted and classified.

Neural networks have been considered and decided to be used at least in the linen test-bench and neural network software is under evaluation at this moment.

KEYWORDS Quality control/Inspection; Image/Image processing; Vision/ Optical systems; Wood/Paper/Furniture.

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Contract no: BREU-0192
Proposal no: BE-3110

FAST-MOTION-COLOUR TELEVISION CAMERA SYSTEM FOR FAILURE DETECTION AND ANALYSIS ON FAST MOVING PRODUCTION STEPS

Starting date: 1990 ***Duration:*** 36 months

OBJECTIVES

Television cameras with only 1μs exposure time per field for video imaging of fast moving objects without blurring are equipped with pulsed image intensifier tubes as shutters. Up to now such cameras have been available only for black and white pick-ups because image intensifier tubes output screens are always monocromatic and because 3-channel versions for 3 colours (e.g. red, green, blue) would be very expensive.

Electronic shutters are superior to mechanical rotating shutters as they can be triggered by the object. A fast-motion colour camera with only 1 image intensifier and only 1 CCD could become the main component of a low-cost, robust test and measuring system which can precisely pick up the geometry and the colours of fast moving objects, hold them in a frame store or forward the information for automatic image analysis. The basically new step is a high resolution proximity focus image intensifier tube with integrated colour stripe filters coupled to a high resolution CCD by fibre optics.

KEYWORDS

Electrical/Electronic industry; Instruments/Sensors/Precision equipments; Medical/Biomedical equipment; Engineering (optical); Quality assurance; Electronics

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Contract no: BREU-0081
Proposal no: BE-3177

DEVELOPMENT OF ADVANCED NON CONTACT METHODS FOR NON DESTRUCTIVE DETECTION OF DEFECTS AND DAMAGE IN AERONAUTICAL STRUCTURES

Starting date: April 1990 ***Duration:*** 36 months

OBJECTIVES

The aim of this project is to provide more advanced non destructive inspection techniques. To accomplish this the following objectives have to be achieved:

- development of non-contact inspection methods
- evaluation of existing methods curently used in laboratory environment
- evaluation and comparison of different techniques.

ACHIEVEMENTS TO DATE

▪LASER ULTRASONIC

An experimental set-up used for laser ultrasound generation has been achieved. Mode-locked Nd:YAG laser is used to excite the ultrasound waves in an aluminium sample. A set-up based on a Fabry-Perot Interferometer has ben manufactured. A procedure has ben formulated which allows Finite Element modelling of elastic wave propagation to be applied to the prediction of laser generated ultrasounds.

▪OPTICAL MEHODS

The portability of the holographic system was achieved by assembling the double-pulse-laser and the optical components on a breadboard. For the computer-aided fringe evaluation it is necessary to use the double-reference-beam technique for making the holographic double exposure. To generate and manipulate the two reference beams an optical device based on Michelson interferometer is used.

▪THERMOGRAPHY

Several heating sources have been tested. on the base of this evaluation the optimum characteristics of a heating source were pointed out for stationary and quasi-stationary thermographic inspection. Moreover, a prototype thermogaphic workstation has been developed.

KEYWORDS Aeronautics/Aerospace; Quality control/Inspection; Carbon/Graphite; Metallic structural materials; Imaging/Image processing; Materials characterization/Testing; Research/Development

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Contract no: BREU-0100
Proposal no: BE-3209

AUTOMATED IMAGE RECONSTRUCTION USING EXPERT SYSTEMS (AIRES)

Starting date: September 1991 ***Duration:*** 27 months

OBJECTIVES

The AIRES project will integrate electromagnetic and vision sensors to give a system capable of automated, total surface inspection. A fast Expert System will also be integrated with the sensor system to allow characterization of defects and automated image reconstruction. The complete AIRES system will be used for inspection of ground or machined components and will be capable of detecting and visualising defects such as cracks, pitting and changes in material quality. The use of an electromagnetic sensor sytem may also allow the inspection of coated specimens.

The objectives of the project include the development of miniaturised array of elctromagnetic sensors with asssociated electronics and new signal inversion procedures for defect sizing. An integrated vision and lighting system will also be developed along with improved edge detection and other image processing algorithms for detection and characterization of geometrical features and defects. A fast Expert System will be implemented using the blackboard architecture and appropriate Knowledge Sources will be compiled containing the expert knowledge required for the electromagnetic and vision sensors, sensor fusion and defect characterization. The combined sensors and Expert System will be integrated into a compete hardware/software system providing problem definition, execution and graphical facilities.

KEYWORDS

Automotive,Components & Parts; Quality control/Inspection; Ferrous; Databases/Expert systems; Imaging/Image processing; Sensors/Signal processing; Vision/Optical systems

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INTEGRATION OF NON-CONTACT INSPECTION WITH MODELLING OF ENGINEERING COMPONENTS (NIMEC)

Note: Updated information was not provided in time for publication.

Starting date: December 1990 ***Duration:*** 36 months

OBJECTIVES

The project (acronym NIMEC) is aimed at advancing the state of the art in measurement of component geometry by developing and demostrating an integrated system employing non-contact transducers manipulated by a customised multi-axis manipulator and control system. Inspection programmes will be interactively generated within a UNIX based workstation based on a CAD representation of the nominal component geometry. The inspection data generated by the measuring system will be used to generate a CAD model of the actual geometry which can subsequently be used for comparison with the nominal CAD geometry. Methods of comparing measured with nominal geomatries are to be researched and implemented to enable rapid identification of geometric distortion and to allow re-alignment of measured 3-D free-form surfaces to bve carried out without the need for complex mechanical holding fixtures. The result of the project will be a measuring system demonstrating the above features with a nominal measuring volume 500 x 500 x 500mm.

ACHIEVEMENTS TO DATE

The basic logical system design has been completed and the process of specification of the hardware and software platforms is now in its final stages. The design for the laser triangulation probe to be used is now also approaching completion, as is the requirements specification for a laser edge profiling sensor.

KEYWORDS

Aeronautics/Aerospace; Engineering (mechanical); Automation/CIM; Automated inspection; Triangulation probe

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INTERFEROMETRIC CINEHOLOGRAPHY FOR NON DESTRUCTIVE TESTING AND QUANTITATIVE INSPECTION

Starting date: June 1990 ***Duration:*** 36 months

OBJECTIVES

The goal of the BE-project "Interferometric Cinehology For Nondestructive Testing and Quantitative Inspection" is to develop a holographic interferometric inspection system which is capable of recording double-exposed holograms with a repitition rate of 25 frames per second, even under industrial environment conditions. Its purpose is to analyse non-sinusodial vibration, transient deformation and dynamic behaviour of test objects and material samples.

The system uses two frequency-doubled Nd:YAG-lasers with sufficient coherence length and a pulse repetition rate of 25 Hz as a source for illumination. Three recording device alternatives, a siver halide camera and a thermoplastic camera, both including reconstruction units, and a TV-holographic camera, can be integrated. A real-time image analysis system is provided to evaluate the recorded holograms.

ACHIEVEMENTS TO DATE

First results in recording holograms with the Nd:YAG-laser system with 24 Hz have been achieved using silver halide film and the TV-holographic recording device. With the TV-system, the first computerbased realtime image-processing and evaluation ersults have been demonstrated.

KEYWORDS

Quality control/Inspection; Optical; Imaging/Image processing; Instrumentation/Measuring systems; Materials characterization; Testing; Vibration analysis/Acoustics; Holographic non-contact testing

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Proposal no: BE-3599

HOLOGRAPHIC INTERFEROMETRIC ANALYSIS OF VIBRATIONAL ACOUSTICAL BEHAVIOUR OF STRUCTURES BY DETERMINATION OF THE DISPLACEMENT VECTOR

Starting date: January 1990 ***Duration:*** 42 months

OBJECTIVES

The goal of the project is to set up a laboratory equipment to measure vibration patterns of structures in view of the improvement to the vibrational and acoustical comfort of automobiles. The basic innovation is to develop an industrial holographic optical bench, enabling in double pulse, to record the three components of the displacement vector thus givng full and rapid access to the vibration pattern.

As a result of the first phase of the project the following method, using three directions of illumination and one direction of observation, has been retained. This one appeared to be the most convenient: sensitivity, simplicity, accuracy in terms of optical arrangement.

The shape of the object, used as a reference, will be obtained by optical measurement made in situ or by interrogating the CAD database. Finally, an automatic procedure will be industrialized for the quantitative evaluation of the resultant vector of the vibration. Car noise being the result of the coupling between structure vibrations and air vibration, will be reduced by modification of the vibrational pattern (optimized by computer or trial and error method). New trends could be accompanied by these types of developments in holographic metrology for industrial purpose.

KEYWORDS

Automotive, Components & Parts; Vibration analysis/Acoustics; Instrumentation/Measuring systems

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Contract no: BREU-0090
Proposal no: BE-3622

PRE-COMPETITIVE AUTOMATED VISUAL INSPECTION APPLIED TO STONE PROCESS (AVIS)

Starting date: July 1991 ***Duration:*** 36 months

OBJECTIVES

The project addresses the problem of automated visual in-process inspection and mensuration of dimension stones during manufacturing.

The research effort will consider the characterization of dimension, stone colour, texture and physical fractures. The inspection and measurement technique developed will be implemented in software and incorporated in a prototype hardware to carry out on-site extensive evaluation of the novel technological tools.

Inside the project an image archiving database with high compression coding methods will be created. This database will contain stone images of blocks and slabs currently in stock, together with the associated inspection and measurements. Samples of stone (polished slabs) will be also included for reference and training purposes.

The system will play a fundamental role in advancing productivity and quality of dimension stone manufacturing process for maintaining the leadership position of EEC countries, but also an important social benefit by improving the working environment of the personnel employed in the industry (i.e, by avoiding noise and dust aspects).

KEYWORDS

Dimension stone processing; Software; Sensors; Quality control; Databases; Image processing; Safety management.

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Contract no: BREU-0496
Proposal no: BE-4097

AREA 3

Application of manufacturing technologies

DECISION SUPPORT SYSTEMS FOR PRODUCTION ISLAND BASED CIM IN SMES

Starting date: March 1991 ***Duration:*** 36 months

OBJECTIVES

To provide a decision support system for production island based CIM in SMEs. The system is defined as a group of people and computer-based decision support and information tools. It is focused on both improving decision making in, and fostering collaboration between, business, design, planning and manufacturing activities.

The objective is to process sales enquiries and customer orders and to provide customers with accurate and realistic information, thus improving the company's customer responsiveness and busines performance in a dynamic market environment.

ACHIEVEMENTS TO DATE

The first deliverable is due in March 1992.

KEYWORDS

Human-Computer integration; Batch manufacturing industries; Decision suppport systems; CAE/CAD/CAM systems; Software; Reinforcement technology

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Contract no: BREU-0352
Proposal no: BE-3302

A COMPUTER INTEGRATED PROCESS PLANNING AND NC-PROGRAMMING SYSTEM

Starting date: April 1987 ***Duration:*** 59 months

OBJECTIVES

Process planning generated automatically by computer from a description of the part to be produced is a key element to computer integrated manufacturing systems. Since NC-programming and process planning lie at the heart of the activities of many small - and medium-sized enterprises engaged in batch production of metal parts, an integrated stand-alone system would render them a great service and provide an economic and productive alternative to present fully fledged CAD/CAM systems. The system consists of the following modules: the CAM-I Testbed solid modeller, the Macroplanner, the Microplanner, the APT IV Plus, the Postprocessor Generator and the tool and machine database.

ACHIEVEMENTS TO DATE

- A Postprocessor Generator has been developed.
- The macro routines for the Tool Motion Generator have been written.
- A feature coding scheme for the Testbed solid modeller has been devised for part modelling which includes geometrical and form tolerances.
- Machinability experiments have been completed and algorithms have been developed for optimal selection of cutting parameters (eed rate, cutting speed) as well as the calculation of the tool wear.
- Algorithms have been developed whiicch simulate the kinematics of each manufacturing case in milling.
- A database system has been developed which contains all process capabilities of a specific manufacturing environment (machine tools, cutting tools, boundary matrices).
- Programs have been written for process selection logic for machining centres.

KEYWORDS

Mechanical engineering; CAE/CAD/CAM systems, Manufacturing; Machining.

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Contract no: RI1B-150
Proposal no: P-1025

MANUFACTURING CELL OPERATORS EXPERT SYSTEM (MCOES)

Starting date: 1990 ***Duration:*** 36 months

OBJECTIVES

This research will lead to advanced integration of process planning and manufacturing design of one-of-a-kind products. In future, the product designer will take care of process planning while the product sales engineer will be able to make variations to the product and make manufacturing decisions as well. The stages of design, planning and manufacturing will be closely integrated. To reach this objective, methods and tools for design, planning, and manufacturing have to be enhanced to cope with the relevant planning and decision-making steps. Production for the design will be implemented rather than designing for production.

The objectives of the project are:

1) to introduce computerised methods so the part designer is able to analyse the manufacturability of designed parts;

2) to develop a generative process planning system which supports the manufacturing engineer;

3) to develop an interactive expert system that integrates the former objectives. The application will be used in manufacturability analysis, process planning, NC-generation and simulation stages.

KEYWORDS

Engineering/Software/Technical services; Design; Logistics/Management/ Prod. plan.; Computer science/Software

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Contract no: BREU-0317
Proposal no: BE-3528

SIMULTANEOUS ENGINEERING SYSTEM FOR APPLICATIONS IN MECHANICAL ENGINEERING (SESAME)

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

A feature oriented detailed design system allowing the designer to specify both features and explicit feature relationships and a design for manufacturing advice system will be implemented. Techniques will be developed to allow the recognition of implicit feature relations such as proximity and obstruction. A computer aided proces planning (CAPP) system will handle processes related to one workcell including a mixture of cylindrical and prismatic cutting and the addition of surface treatments. A new commercial NC generation, simulation and verification system will be fully interfaced to and driven by the CAPP system. Genetic algorithms will be applied to solve the problem of optimizing the choice of machines, tools, orientations, part movements and ordering of operations.

These objectives will be acheived using the significant advances made by the participants in the development of a new generation of solids modeller, a highly advanced NC programme preparation system based on the solids modeller, a prototype CAPP system and sophisticated genetic algorithms.

Integration of these components and their application in the end users' environment represents progress beyond state of the art. The project's innovative character is enhanced by further new areas of investigation - implicit feature interaction and useful feature heirarchy.

KEYWORDS

Engineering/Software/Technical services; Design; Manufacturing; CAE/CAD/CAM systems; Mechanical engineering/Machinery; Engineering (process)

PRIME PARTNER

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Contract no:
Proposal no: BE-4539

CAD/CAM FOR MARINE ENGINEERING, PIPING AND ACCOMMODATIONS IN SHIPBUILDING

Starting date: June 1988 ***Duration:*** 36 months

OBJECTIVES

The main purpose of the research is to extend the capabilities of existing CAD/CAM systems for shipbuilding in the fields of mechanical engineering, piping and accommodation, with the aim of increasing the industrial productivity and reliability of the use of CAD/CAM techniques for shipbuilding design and manufacture.

This is to be achieved by:

- Selection and customisation or development of an interactive module for layout and design of machinery installations.
- Selection and customisation or development of an interactive module for design and manufacture of piping and ducting systems, including electric cable-ways.
- Development of an interactive module for layout and design of ship outfitting.

These modules are to be implemented and tested on a suitable testbed CAD/CAM system (Schiffko package for shipbuilding design and manufacture).

The project aims are:

- To reduce the project lead-time and drafting resources allocation by 25%.
- To provide uniform quality in the product.
- To build up the framework for development towards CIM, by integration of activities at design and manufacturing levels.

ACHIEVEMENTS TO DATE

1. Definition of 3-D database structure for all 'components' with respect to engine room arrangement, piping and accommodation.
2. Linking of the areas of enquiry room, piping and accommodation to the existing Schiffko 'steel structure' module.
3. Establishing an interactive programme for the generation of pipe diagrams.

KEYWORDS Mechanical engineering/Machinery; Shipbuilding; Design; CAE/CAD/CAM systems

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Proposal no: P-2385

INCREASING PRODUCTION CAPACITY IN THE FURNITURE INDUSTRY, INTEGRATING GROUP TECHNOLOGY, CAD/CAM AND ADVANCED MANUFACTURING APPLICATIONS

Starting date: January 1991 ***Duration:*** 36 months

OBJECTIVES

An integrated system has been identified in an earlier BRITE project (P-1320) as a key element to improving efficiency in the furniture industry. The project is a continuation of this completed BRITE project.

It is the aim of the project to develop a Group Technology System, including a pre-production and detailed process planning system. It is the intended to integrate the system with the CAD/CAM system and the MRP system of the participating companies.

The system will consist of a computer programme, which on the basis of the developed Group Technology classification can create detailed process plans for the components that require manufacturing. By using this computer programme, normally referred to as Computer Aided Process Planning (CAPP) system, a process plan database is built which can be used by the MRP system, the capacity and detailed planning system and the Shop Floor Control System (SFC).

Furthermore, a software model will be developed which, by means of the Group Technology code and the established process plan database, will make it possible to simulate production cycles and re-plan where necessary. The development will comprise an adaptation to an existing detailed planning system or an adaptation to an existing SFC system.

KEYWORDS

Wood/Paper/Furniture; Logistics/Management/Prod. Plan.; Automation/CIM; Databases/Expert Systems; Research/Development; CAPP-systems/Pre-production; Group technology

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Contract no: BREU-0270
Proposal no: BE-3557

THE DESIGN, IMPLEMENTATION AND TEST OF A DESIGN FOR MANUFACTURING ARCHITECTURE AND TOOL SUITE (DEFMAT)

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

New Design For Manufacturing (DFM) tools are required which can be tailored to the needs of individual enterprises.

They should be integrated into the Design/Manufacturing systems of the enterprise, with the possibility for incremental capture of manufacturing rules and information. It should be implemented so as to be accessible from the earliest design stages right up to design engineering.

A generic architecture will be developed for the implementation of DFM methods and the functional requirements of a prototype DFM system will be investigated and specified. The industrial partners, producing both electro-mechanical and electronic parts and products, will provide varied sources of design/manufacturing expertise and DFM knowledge.

This project will result in the implementation at the test-sites of industrial prototypes. Industrial prototype systems will be implemented and tested comprehensively, the results of these implementations will provide methodologies for future implemetations of this architecture as well as showing where further developments are needed.

KEYWORDS

Databases/Expert systems; Design for manufacture; Design for assembly; CAE/CAD/CAM systems; Design; Manufacture

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Contract no: BREU-0492
Proposal no: BE-4661

INTERACTIVE KNOWLEDGE-BASED SHOP FLOOR CONTROL SYSTEM IN A SMALL MANUFACTURING ENTERPRISE ENVIRONMENT

Starting date: May 1987 ***Duration:*** 55 months

OBJECTIVES

Aiming at improving the productivity of Small Manufacturing Enterprises (SME's) an efficient Shop Floor Control system (SFC) software will be developed and installed as a prototype.

This SFC software has to be able to provide a continuous overview of the Shop Floor situation, has to generate realistic schedules and handle the entire information flow in modern workshops including DNC and FDA.

To meet these objectives the software has to rely on the latest software engineering devices such as data bases and graphics in order to become highly modular, extendable and, over all, user friendly for the SFC staff.

ACHIEVEMENTS TO DATE

Problems being investigated by SME's cover:

Increasing demand for flexibility and dynamic adaptation to structural changes. This causes unsolvable problems for SME's with inadequate staff qualification, organisational weaknesses and lack of financial back-up.

- The modular concept provides a kernel with it's own data base and event manager.
- There are defined interfaces for extended functions.
- An analysis of production control philosophies points out that MRP II in combination with short term load oriented order release is the appropriate base for scheduling.
- Decision rules of 10 companies have been collected in order to build up the knowledge based functions.
- Simulation is determined to serve as evaluation module for the proposed schedules.
- A prototype has been implemented and linked to a MRP system. Special features are modules 'problem analyser' and 'schedule simulator' integrated into the MRP system.

Negotiations are taking place with potential pilot users at the moment.

KEYWORDS Automation/CIM; Control systems.

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Proposal no: BE-1381

MODELLING AND AUTOMATIC CONTROL OF THE POLISHING PROCESS (MAC POP)

Starting date: May 1988 ***Duration:*** 36 months

OBJECTIVES

High precision polishing of optical surfaces is an expensive process which requires many working hours by experienced polishers. It appears that a substantial reduction of the manufacturing cost of optical components could be obtained with automatic polishing. Automatic polishing can be performed with a robot able to generate polishing strategies from the specifications of the desired piece and the measurement of the surface topology and to implement these strategies through appropriate actions on the influential parameters of the process.

Such a robot does not exist at the moment and it is proposed to examine the various aspects and requirements for its design, using an original approach based on synergy between several fields: mechanics, optics, electronics, automatic control, artificial intelligence. This project concerns the basic research to be performed prior to the development of a polishing robot. Its objectives are to:

1. Obtain a general model of the polishing process.
2. Design a controller able to derive automatically and to implement optimal polishing strategies.
3. Demonstrate the feasibility of automatic polishing.
4. Define the architecture and the specifications of a robot for automatic polishing. The programme defined to reach these objectives includes seven tasks and several key parts such as model identification from experimental data and the use of modern control theory together with experienced polishers know-how in the controller.

ACHIEVEMENTS TO DATE

- Development of a general model of the polishing process.
- Simulation code to determine tool path kinematics and optimal strategies.
- Control of the reproducibility of polishing experiments.

KEYWORDS Machining; Automation/CIM; Mathematical modelling; Robotics

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Proposal no: P-2362

INTEGRATION OF CAD/CAM AND PRODUCTION CONTROL FOR SHEET METAL COMPONENTS MANUFACTURING

Starting date: May 1988 ***Duration:*** 40 months

OBJECTIVES

To a higher degree than other branches of manufacturing, progress in the sheet metal components industry suffers from an insufficient integration of (1) the design and production preparation process with (2) the production planning and control system. A new approach is needed which replaces the old emphasis on improving the integration of engineering data flow. Instead, a just-in-time delivery of engineering data for automated processing is required, with decentralized intelligent real-time control modules substituting for the past central processing control. The proposed research project will apply this new approach to the design, development and implementation of an order-oriented sheet metal component manufacturing system which will eliminate the critical drawbacks of present systems, in particular their poor utilisation of modern manufacturing equipment and their vulnerability with regard to unpredictable events. Emphasis will be placed on developing heuristics for optimal grouping and regrouping of components for each phase with the help of decentralised intelligence and expert systems.

ACHIEVEMENTS TO DATE

A new highly flexible model for data representation has been developed. It is based on using standard form features and information features. The model is implemented in a SQL-database and serves as interface between departments. A working prototype, integrated in a control database, has been developed consisting of (1) a design module that allows flexible item-design based on form features; (2) a fast module to solve rectangular cutting stock problems; (3) an automatic Ganttchart scheduling module; (4) a generalised module for generating NC-code, using form features; (5) a monitoring system, which monitors the status of each activity to be performed on an order including the status of the operations.

KEYWORDS Design; Manufacturing; Process monitoring; NC code generation; Process planning.

PRIME PARTNER

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Contract no: RI1B-197
Proposal no: P-2406

CONCEPT – INTEGRATED CAD/CAM AND CNC TECHNIQUES FOR AUTOMATIC 5-AXIS MILLING

Starting date: January 1990 ***Duration:*** 32 months

OBJECTIVES

In CAD/CAM applications to automotive design, automatic NC programming for 5-axis machine tools, a crucial area, is not well covered and integrated. The goal of the project is to coordinate the development pursued in this field by Inter-Prog (Italy), specialising in 5-axis NC software, Ford (Germany), IAD (UK), interested in shortening the lead time for style model manufacturing and Jobs (Italy), a leading company in 5-axis machines and CNCs. The automatic 5-axis NC system will be implemented on DEC and SUN workstations, to reduce 5-8 times the time needed to obtain physical models and to minimise the work of skilled programmers. Automatic NC means that complex surface milling does not require an intensive programming work: the only information to be supplied are the math model and the technological specifications, the tools and the finish degree. The NC system will be integrated by a CNC controller with the features required by 5-axis automatic machining: fast block programming, trajectory control, synthetic curve and surface programming, tool shape compensation and non-linear interpolation.

ACHIEVEMENTS TO DATE

- 3-axis automatic isoparametrical and parallel planes milling. The user is not to be expert in CN millings: the data to be assigned are the tool set and the finishing degree.
- 5-axis milling, with gauge collision control and automatic modification of the leading tool angle.
- Data exchange interfaces: IGES, VDAFS, SET,U3, SPAC

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Proposal no: BE-3147

PRODUCTION AND COST ORIENTED MOULD INTEGRATED DESIGN EXPERT SYSTEM (PROMISES)

Starting date: July 1990 ***Duration:*** 36 months

OBJECTIVES

▪Provide functional layout tools to enable initial definition of the fundemental characteristics of a mould.

▪Provide tools to enable estimation of the cost of a mould, especially for quotation purposes.

▪Provide tools to enable the design of a complete mould, and the production of a detailed description of this complete mould design (e.g. workshop drawings).

ACHIEVEMENTS TO DATE

Implementation in LISP of a decision support or expert system. This development allows the representation of knowledge and various inferencing schemes over this knowledge base.

- Implementation of an object oriented hierarchical, feature-based mould model in LISP.
- Implementation of an object oriented drawing environment in LISP.
- Implementation of two aspects of a costing system- the calculation module and the front end.
- Implementation of a variety of user interfaces which use state-of-the-art GUI's.
- Implementation of a neutral database interface using a client server model and inter-process communications.
- Implementation of a client server model of the BM interface.

KEYWORDS

Mechanical engineering; CAP/CAD/CAM systems; Tools/Dies; Manufacturing; Machining; Decision support system

PRIME PARTNER

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Contract no: BREU-0265
Proposal no: BE-3148

DEVELOPMENT OF COMPUTER - AIDED MOULDING AREA RESERVATION AND OPTIMIZATION SYSTEM (CAMARO)

Starting date: 1991-1992 ***Duration:*** 41 months

OBJECTIVES

The "CAMARO" (Computer Aided Moulding Area Reservation and Optimization System) proposal is for improving the use of moulding areas in foundries producing castings which are hand-moulded.

Currently, a foundry computer-aided planning system which often only considers the personnel resource allocation, the stock of orders and the delivery dates demanded by the customer. The possibilities of the plant itself are not considered. Castings being hand-moulded can be produced either in flasks, placed on special areas on the workshop floor or in moulding-pits, where the mould is shaped directly in ground. A major problem in manufacturing castings is not only scheduling in general, but the allocation of an order to appropriate moulding pit or area. In order to achieve an optimal capacity utilization and production time, the planner has to consider an enormous variety of changing constraints, many of them spatial.

The main aim of the proposal is to build scheduling tools which will aid the human planner in optimizing the production schedule. An improvement in the scheduled performance will lead directly to a reduction in costs and this has a direct bearing on the efficiency of the foundry.

KEYWORDS

Materials processing; Forming/Shaping/Casting; Logistics/Management/ Production plan; Ferrous; Automation/CIM; Databases/Expert systems

PRIME PARTNER

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FEMOD – APPLICATION OF FEATURE BASED MODELLING FOR COMPLEX PRODUCT DESIGN AND MANUFACTURE

Starting date: February 1991 ***Duration:*** 30 months

OBJECTIVES

Current computerised design methods have shown their limit, especially in high technology sectors such as the aerospace industry. Areas in which substantial developments need to be made are:

- Integration of design activity with general company management.
- Integration and durability of company know-how.
- Reduction of extra work needed to develop manufacturing data from design data.

The new set of methodologies specifications to be established will allow these problems to be solved; the cornerstone will be a 3-D feature-based modeller which will enable us to: harness the skills and know-how of designers; reduce the time spent going backwards and forwards between design and manufacturing; reduce lead times for the release of new versions of aerospace products.

The aim of the project is to develop specifications for this feature-based modeller in the fields of aerospace sheet metal and milled part.

KEYWORDS

Aeronautics/Aerospace; Design; Machining; CAE/CAD/CAM systems; Mathematical modelling

PRIME PARTNER

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Proposal no: BE-3455, BE-3456; BE-3457

AN INTELLIGENT KNOWLEDGE ASSISTED DESIGN ENVIRONMENT (IKADE)

Starting date: May 1991 ***Duration:*** 36 months

OBJECTIVES

The primary objective of this project is to develop software tools to allow designers to assess the consequences of design choices on the manufacturing or production engineering processes. The aim is to improve the efficiency of the design process by reducing the design cycle time and increasing the level of innovation.

This would require achieving the following sub-objectives:

(a) The development of prototype IKADE support systems to allow manufacturing/production information to be available to engineers at the design stage.

(b) The development of a knowledge based system for:

- converting product and component specification into manufacturing requirements;
- evaluating manufacturing requirements against available manufacturing processes;
- identifying inapropriate product and component design features and providing recommendations for possible product, component and/or manufacturing process changes.

ACHIEVEMENTS TO DATE

Progress to date (1st May '91 - 21st June '91) includes detailed definitions and agreements on project sub-tasks. A detailed Project Plan has been formulated. Hardware and Software tools necessary for development have been selected and purchased.

KEYWORDS

Aeronautics/Aerospace; CAE/CAD/CAM systems; Automotive, components & parts; Databases/Expert systems; Design; Analysis/Auditing/Consultancy; Manufacturing

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Contract no: BREU-0359
Proposal no: BE-3600

DEVELOPMENT AND EVALUATION OF A DESIGN - METHODOLOGY FOR TOOL LOGISTICS IN THE AUTOMOTIVE INDUSTRY'S MANUFACTURING ENVIRONMENT

Starting date: ***Duration:*** 36 months

OBJECTIVES

The objective of the Project is to develop a methodology to design tool logistics (storage, transportation and handling) systems for automated industrial shop-floor. Within the problem of the materials handling, tool logistics calls for a support system to rationalize and speed-up the design phase and to improve the quality of the results. The Project will first focus on identification of a suitable Knowledge base on the basis of the application experience of the industrial Partners involved, and with particular reference to the automotive industry's environment. Secondly, a design methodology will be developed, based on a problem-solving procedure which will combine heuristics and analytical models to handle the relevant design inputs (plant lay-out and strategic, production requirements). Finally, the formulated methodology will be implemented in a prototypical expert-type design support systems, incorporating simulation capabilities. The system will be validated and assessed through full-sale software implementation in the technical design department of the industrial Partners

TLS being an integral part of FMS or FTL, must comply with all the requirements and constraints of the manufacturing system as a whole.

- production
- technology
- physical structure of the system
- economy
- operative reliability;
- flexibility, in the sense that the system can easily shift from a productive situation to another with the minimum set-up time/costs.

These requirements are often contradictory and the trade-off among them, which is the basis for the specification/design of the TLS, is very complex.

In order to address this trade-off problem from a comprehensive point of view, a proper industrial application environment has to be selected; this project will deal with the automotive industry environment,including the following:

- different production strategies;
- high variety of pieces/components to be manufactured,

KEYWORDS Automotive, Components & Parts; Handling/ Transportation; Logistics/Management/Prod. plan.; CAE/CAD/CAM systems; Machine tools

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Contract no: BREU-0493
Proposal no: BE-4113

INTELLIGENT INTEGRATED TOOL MANAGEMENT AND HANDLING SYSTEM

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

The objective of this project is the integration of tool management handling and supply based on the concept of a central tool room. The input to the tool room from the shop floor are tool requests, the output are the demanded tools or plans for rescheduling of the requests. The functional modules of the tool room comprise tool room managing, tool inspection, tool assembly, tool measuring and presetting.

The main task of the tool room manager is the scheduling of the tool flow throughout the whole system according to the tasks to be performed. Stations for assembly, inspection, measuring and presetting will be realised as well as planning functionalities to carry out the needed operations on the supplied tools.

ACHIEVEMENTS TO DATE

The framework of the whole project is given by a common architecture. An agreement for a common hardware and network has been achieved. Protocols have been defined. A common data base for all tool room relevant modules has been developed. It is accessible for every module via a common data interface. All available functions of the interface are defined in common data interface language.

The different stations have been built up. Basic functionalities to carry out tool operations are implemented.

KEYWORDS

Engineering/Software/Technical services; Mechanical engineering/ Machinery; Engineering (mechanical); Repair/Maintenance; Automation/ CIM; Computers/Computer systems; Manufacturing.

PRIME PARTNER

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Contract no: BREU-0066
Proposal no: BE-3127

TOOLS AND METHODS FOR IDEAL FIXTURING OF MECHANICAL WORKPIECES WITH MODULAR SYSTEMS (IDEFIX)

Starting date: April 1990 ***Duration:*** 36 months

OBJECTIVES

The aim of the IDE(al) FIX(turing) project is to develop tools and methods to improve the fixturing of non-rotational workpieces on machine tables (e.g. of machining centres). The major tasks, which represent significant advances on current fixturing and planning methods, will be:

- the development of methods for the selection of workpiece setups and the design of fixtures, based on modular fixturing systems;
- the introduction of these methods in a computer programme, totally integrated with the existing CAD and CAM software of the industrial partners;
- the development of methods for the technical-economic justification of the use of modular fixturing systems in the metalworking industry and especially in SMEs.

ACHIEVEMENTS TO DATE

- Complete functional model of the final system.
- Complete data model of the database of the system.
- Collection, sampling and grouping (group technology based) of workpieces and their complete description.
- Catalogues of technological features for the description of workpiece and modular fixturing elements as well as description methodologies.
- Symbol catalogue for the description of the fixturing functionalities on the workpiece at a conceptual level (virtual fixture).

KEYWORDS

Assembly; Design; Manufacturing; Automation/CIM; CAE/CAD/CAM Systems; Machine tools; Modular fixturing elements

PRIME PARTNER

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Contract no: BREU-0113
Proposal no: BE-3480

COST REDUCTION THROUGH MANUFACTURING PLANNING AND CONTROL USING IMPACT ANALYSIS AND CAPACITY SCHEDULING

Starting date: August 1991 ***Duration:*** 30 months

OBJECTIVES

In order to meet the needs of visibility in the manufacturing process, the Manufacturing Impact Analyser (or MIA) has been defined. This takes data from the shop floor and applies any necessary simulation technique to give predictions as to the future state of the plant. Having done this, the MIA then filters the information in such a way that useable information is given to the right people within a manufacturing organisation.

Having reported problems, a Capacity Scheduler uses the best known techniques and provides a set of tools for the reported problems to be corrected as quickly as possible.

All this is to be done using minimum data from the shop floor and minimum paperwork.

KEYWORDS

Logistics/Management/Prod. plan; Manufacturing; Engineering (electrical)

PRIME PARTNER

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Contract no: BREU-0513
Proposal no: BE-4244

ICADES - INTEGRATED CALCULATION IN A DESIGN SYSTEM

Starting date: 1991 ***Duration:*** 24 months

OBJECTIVES

The main objective of this project is to research methods and develop a prototype software tool which enables the designer, determining about 65% to 80% of the costs of the whole production, to estimate the cost indices and to compare alternatives in every stage of the design process in order to optimize the design to be made.

This shold result in shorter iteration steps during theign process. To achieve such a result, structured methods for designing have to be made. The developed methods will be verified and tested.

KEYWORDS

Mechanical engineering/Machinery; Design; Manufacturing; Prototyping; CAE/CAD/CAM Systems; Engineering (Mechanical)

PRIME PARTNER

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Contract no:
Proposal no: BE-4471

METACOST

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

The main objective of the project is to develop methods for estimating manufacturing costs in mechanical engineering and to create a software tool on the basis of a new methodology. This methodology uses existing cost estimation methodologies as well as combinations of them but also new methodologies derived from existing cost calculation methodologies. By this, small and medium enterprises (SMEs) will be able to answer quickly to tenders with precise and competitive cost estimations. The new methodology will be specialized for special machine and subcontracting manufacturers.

This means:

- Developing a methodology for configuring the estimation system according to the enterprise typologies
- being able to propose different cost estimation models depending on the structures of the enterprises
- developing cost estimation software integratable into the enterprise structures, especially into the engineering and the process planning department.

KEYWORDS

Mechanical engineering/Machinery; Assembly; Manufacturing; Ferrous; Metallic structural materials; CAE/CAD/CAM systems; Machine tools

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Contract no: BREU-0510
Proposal no: BE-4545

REDUCTION OF DESIGN TO PRODUCT LEAD TIME THROUGH INSTANT MANUFACTURING OF MODELS PROTOTYPES AND TOOLS

Starting date: June 1990 ***Duration:*** 36 months

OBJECTIVES

The proposed R&D project aims within a joint research work of industrial partners, universities and research institutes to make Layer Manufacturing Techniques applicable for pattern making shops and companies in which the production of concept models and prototypes forms a major topic in manufacturing. Many of the companies in the European Community, to which this proposal applies, are typical SME's. Furthermore, the area shape study and design, casting, pattern and tool making shops are developed specially. In general the method can be applied in all industries.

ACHIEVEMENTS TO DATE

Presently, a report describing the state-of-the-art in the LMT area, also called DeskTop Manufacturing, is available.

KEYWORDS

Rapid Prototyping; Shape, study & design; CAD; Tools/Dies; Research/ Development

PRIME PARTNER

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Proposal no: BE-3527

FLEXIBOT PROJECT - FLEXIBLE MANUFACTURING SYSTEM INTEGRATING DIFFERENT WELDING TECHNOLOGIES AND OTHERS FOR SMALL-LOT AND VERY DIVERSIFIED PRODUCTION

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

This project starts from Bisiach and Carru's existing Mobile Gantry Robot. Their big, 3 polar-axes, hollow-head robot was originally devised for spot-welding, with a huge structure, a big operating volume (about 600m^3) and many specific features for this process. This is the most complex welding process, because of the high currents, magnetic field and loads of operating welding groups which are involved.

The basic robot already includes an automatic gun-changer and tools-magazine already planned for all necessary fluids (cooling-water, compressed-air, oil, electrics and electronic connections for sensors, secondary current, etc.).

The project aims at integrating other different technologies in the robot, to be used in the same work-station, with the same jigs in line with the total quality concept to transform the robot into a total flexibility poly-technological Universal Robotic Production Centre.

To do this, three possible end-users will collaborate in the project for three years, with their experience in different welding technologies in relatively low and diversified car production-MECEDES ESPANA, PININFARINA and STEYR-DAIMLER-PUCH.

The planned technolgies for the project which are to be integrated in the robot are, among others; spot welding-direct/indirect, with gun (simple and multiple up to 4 guns), with tip (simple and double) in d.c. current, seam-roll welding, projection welding, MIG-welding, bolt-welding, rivetting and other operations with working elements for sheet-metalworking.

The advantages would be:

▪a polytechnological robot system including several technologies in the same cycle and in the same work-station. ▪increase in the quality of the final product. ▪reduction of production time, ▪extension of the client's potential market ▪work ecology ▪off-line programing, increased safety ▪general increase in logistical flexibility.

KEYWORDS Automotive, Components & Parts; Assembly/ Joining; Engineering (process); Manufacturing; Quality assurance; Automation/CIM; CAE/CAD/CAM systems

PRIME PARTNER

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Contract no: BREU-0491
Proposal no: BE-4159

INTEGRATED AND HIERARCHIZED SYSTEM FOR AUTOMATED CONTROL OF GRAVEL PRODUCTION (PETRUS PROJECT)

Starting date: October 1990 ***Duration:*** 36 months

OBJECTIVES

Materials used in the construction of civil engineering works are composed of approximately 90% aggregate. The industrial make-up of aggregate manufacturers consists almost exclusively of small and medium-size enterprises which have no available means for research and development. For the past ten years, only a few basic automated process controls (on/off mode control, safety controls) have been installed in some plants. In most cases, the capacities of such process controls have proven insufficient. Yet, because specifications in this sector are particularly strict, there has been a considerable need for control of aggregate quality. In addition, wear of the crushing components in the crushers introduces a drift in the aggregate quality, which needs to be compensated through automation of the production process. In order to meet such needs, the research will deal simultaneously and interactively with the study of the following sensors and related softwares: a prototype sensor designed to make on-line measurements of the size distribution and shape of manufactured products, a prototype sensor supplying on-line the wear level of crushing components, optimisation software providing for calculation of optimum rated settings for a plant according to production requirements, and a control/command software controlling in real time compliance with production specifications despite any disturbances.

Spin-off from this research will be a 10% decrease in operating expenses and an improvement in aggregate quality.

KEYWORDS

Mining/Quarrying; Mining/Extraction; Minerals/Ores; Automation/CIM; Control Systems

PRIME PARTNER

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Contract no: BREU-0275
Proposal no: BE-3152

RELIABILITY, AVAILABILITY AND MAINTAINABILITY OF BRIDGES

Starting date: February 1989 ***Duration:*** 36 months

OBJECTIVES

The objective of this project is the development of a computerised decision support system on maintenance management of bridges. The programmes will consist of:

A. A reliability submodel for predicting future bridge structure and/or usability deterioration and the likely effects of maintenance interventions, using large Markovian systems combined with uncertainty.

b. A cost submodel for assessing the cost of alternative remedy policies for different bridge designs.

c. An optimisation submodel to provide the best solution according to given parameters.

Aimed at existing bridges and maintenance policies, the programme will support decisions on novel designs and new materials for improving bridge reliability in an optimum way.

ACHIEVEMENTS TO DATE

The partners have completed the design, coding integration and testing of subsytems for prototype Large Markov system and a mergeable Markov system. Work on quantification of uncertainties has been initiated as well as work on final integrated model refinement, testing, consolidation and documentation.

KEYWORDS

Construction/Building/Civil engineering; Repair/Maintenance; Concrete/Building materials; Computer science/Software; Databases/Expert systems; Mathematical modelling; Reliability.

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Contract no: RI1B-300
Proposal no: P-2349

CONDITION ASSESSMENT AND MAINTENANCE STATEGIES FOR BUILDINGS AND BUILDING COMPONENTS

Starting date: August 1991 ***Duration:*** 48 Months

OBJECTIVES

The building maintenance sector in most EEC countries is set to overtake the new building sector by the turn of the century. Research has shown that condition-based maintenance is most efficient and cost effective. However, the current practice of condition monitoring by inspectors suffers from subjective perceptions. The research project aims to increase productivity and introduce high-tech into the maintenance industry through :

- the development of objective condition scales for some 50 major maintenance cost generators in buildings
- the development of a knowledge-based expert system linked to the objective inspection process and capable of developing optimized maintenance strategies
- the reduction of a reliance on building inspectors by specifying measurement techniques which allow the development of instruments capable of dynamic condition monitoring

The new building industry will derive benefits from the henceforth structured feedback information system on the performance and degradation of buildings in use.

KEYWORDS

Construction/Building/Civil engineering; Building/Construction; Maintenance; Condition monitoring; Expert systems; Maintenance-strategy

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Contract no: BREU-0514
Proposal no: BE-4213

CONDITION ASSESSMENT AND MAINTENANCE STATEGIES FOR BUILDINGS AND BUILDING COMPONENTS

Starting date: August 1991 ***Duration:*** 48 Months

OBJECTIVES

The building maintenance sector in most EEC countries is set to overtake the new building sector by the turn of the century. Research has shown that condition-based maintenance is most efficient and cost effective. However, the current practice of condition monitoring by inspectors suffers from subjective perceptions. The research project aims to increase productivity and introduce high-tech into the maintenance industry through :

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The new building industry will derive benefits from the henceforth structured feedback information system on the performance and degradation of buildings in use.

KEYWORDS

Construction/Building/Civil engineering; Building/Construction; Maintenance; Condition monitoring; Expert systems; Maintenance-strategy

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NEURAL NETWORKS INVOLVING NEW SIGNAL PROCESSING PROCEDURES FOR FAULT ASSESSMENT IN CIVIL ENGINEERING STRUCTURES

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

This project is directed toward the development and application of neural networks new signal processing procedures in a novel approach to detecting and characterizing faults and other nonlinear mechanisms related to defects or structural damage. Although the study is directed toward components used in civil engineering structures in order to take advantage of specific competence in these areas, it is fundamental in its nature and therefore is directed at establishing principles that will result in applications to other key sectors of industry. The major difference in this work with respect to existing methodologies is the pre-processing of the raw data to enhance "training" procedures. Complex behaviour as in neurological systems has been successfully treated by using the digital equivalent of the human brain, i.e. neural networks. These can be "trained" to recognise highly complex patterns and therefore should have the capability of recognising behaviour such as stress wave emissions from crack propagation or similar phenomena, hence they have the potential for use in identifying and distinguishing fault conditions. The establishment of the principles will enable a signiciant advance in the technology for detecting and characterizing faults.

Such technologies could gainfully be developed for use in key sectors of the Aerospace industry, Civil Engineering Infrastructural systems (bridges/monumental buildings), and Manufacturing and Automobile industries, by initiating a programme of research involving both theoretical and experimental studies based upon new processing and neural network methodologies.

KEYWORDS

Signal processing; Dynamics; Nonlinear detection; Civil structures; Neural networks

PRIME PARTNER

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Contract no: BREU-0526
Proposal no: BE-4618

QUALITY ASSURANCE OF CONCRETE, BASED ON TESTING OF THE FRESH, STILL PLASTIC MATERIAL

Starting date: March 1991 ***Duration:*** 36 months

OBJECTIVES

Quality Assurance and Quality Control of concrete are today in its advanced form carried out in separate stages:

- Quality verification of the conrete components, ie cement, water, aggregates and additives.
- During batching and mixing it is assured that the composition of concrete is in accordance with the specifications.
- Strength testing of laboratory produced specimens.
- Petrographic analysis of hardened concrete.

Generally it can be stated that the above mentioned methods and procedures are excellent for the control of the hardened concrete and for the documentation of the properties achieved as to durability as well as strength performance. The methods are also excellent to assure that harmful alkali-aggregate reactions will not appear in the concrete structure.

The objective is to develop a system for Quality Assurance of Concrete and to test and verify this system based on petrographical analysis in combination with testing of permeability and diffusivity of the hardened concrete using traditional testing methods.

It is a further goal to produce demoversions of testing equipment and manuals for the testing methods developed.

KEYWORDS

Building/Construction; Engineering (civil);Concrete; Quality assurance.

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Contract no: BREU-0358
Proposal no: BE-3376

IMAGE ANALYSIS FOR MONITORING BUILDING MATERIALS

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

The ultimate target of this project is the development and the introduction of automatic image analysis techniques into the petrographic analysis methods for monitoring and assessing the quality of concrete constructions and cementitious building materials.

The objectives of this project are:

- to prepare guidelines, rules and a sample catalogue for the petrographical assessment of the durability parameters in order to assure the use of uniform procedures and evaluations and to contribute to the pre-normative work in the EC
- to develop, evaluate and standardize methods in order to measure and to quantify parameters which until now are described qualitatively by petrographical means
- to introduce a fractal approach to characterize the microstructure of the cement paste
- to develop methods in order to recognize, to describe and to quantify complex patterns (for example crack patterns) with the aid of mathematical morphology
- to develop the necessary procedures for an automatic image analysis system to measure and evaluate all the parameters resulting from the forementioned methods.

It is expected that this research will result in a fast, objective and uniform method for the quality control of new structures and in a method for the assessments of defects and damge and its causes in already existing structures.

KEYWORDS

Construction/Building/Civil engineering; Concrete/Building materials; Rocks/Stones/Aggregates; Image/Image processing; Materials characterization/Testing; Quality assurance

PRIME PARTNER

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Contract no: BREU-0490
Proposal no: BE-4300

INDUSTRIAL DEVELOPMENT OF REINFORCED MASONRY BUILDINGS

Starting date: 1991 ***Duration:*** 48 months

OBJECTIVES

The proposed project is dealing with the development of Reinforced Masonry (R.M.) as a competitive alternative to low and medium rise reinforced concrete (R.C.) or plain masonry (P.M.) buildings, especially in case of soft foundation soil or under seismic conditions.

Thanks to the improved habitability of masonry structures, R.M. is expected to be more user-friendly than R.C., and more safe than P.M.

The project is intended to cover several aspects such as the design and production of bricks adequate for R.M. construction, investigation of the habitability of R.M. buildings (insulating properties and fire resistance), the development of fundamental behaviour models (allowing for a rational structural design of R.M. buildings), analysis versus settlements or earthquakes and behaviour of full masonry buildings, cracking behaviour or R.M. subassembleges, durability problems of reinforcing bars embedded in lime or cement-lime mortar, as well as construction and economical aspects in order to check both the feasibility of the proposed construction system and its expected lower cost compared to that of similar reinforced concrete structures.

KEYWORDS

Construction/Building/Civil engineering; Engineering (civil); Concrete/ Building materials; Mathematical modelling; Reinforcement technology

PRIME PARTNER

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Contract no:
Proposal no: BE-4001

FAILURE MECHANICS OF FIBRE-REINFORCED CONCRETE AND PRE-DAMAGED STRUCTURES

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

The proposed research project covers a comprehensive programme towards

- the development of rational design rules and reliable predictive methods for progressive failure in fibre-reinforced concrete; and
- the development of computational strategies for (conventionally reinforced) concrete structures which are pre-damaged.

The second objective serves the purpose of assessing the residual load-carrying capacity, the chances of repair and the effectiveness of various alternatives for repair. The envisaged programme covers an integrated spectrum of activities, ranging from experimental investigations to theoretical, numerical and verification studies.

Based on an extensive testing programme, constitutive relations and improved design rules will be established for (i) plain, (ii) pre-damaged and (iii) fibre-reinforced concrete (FRC).

For these models well-documented finite element software will be written and made available to engineering practices. This software will be benchmarked with verification analyses of medium-scale test specimens which will be tested to failure within the proposed project as well as studies on large-scale structures for which in-situ measurements are available at the partners. The verification studies will encompass both FRC structures and existing pre-damaged structures. The two main objectives of the project are (i) the development of constitutive models, general design methodologies and robust software for failure analysis of FRC structures, and (ii) benchmarked software which can be used to assess the residual load-carrying capacity and the effectiveness of repair measures for existing pre-damaged structures.

KEYWORDS Construction/Building/Civil engineering; Building/Construction; Design; Engineering (civil); Concrete/Building materials; Fibres/Reinforcing materials; Codes/Standards

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Contract no: BREU-0070
Proposal no: BE-3275

PERFORMANCE TAILORING OF STRUCTURAL CONCRETE

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

The need for strategic research for the purpose of modelling concrete making, early age structural analysis and durability and combining these models into a comprehensive system for tailoring concrete for specific performance requirements has been identified. The aim of the project is to fill specific gaps in the current state-of-the-art knowledge in particular regarding:

1. efficiency of concrete mixing as dependent upon raw materials, dispersion of cement, mixing sequence and batching and mixing equipment, including innovative machinery;

2. establishment of mathematical models for analysis of stress configuration during early ages of concrete structures combining thermal stresses due to heat of hydration and early age imposed loads;

3. establishment of models for minimising and/or eliminating the two principal deteriorating mechanisms, alkali silica reactions and chloride-induced corrosion for improving durability and prediction of lifetime of structure concrete.

Parallel to these tasks, research will be conducted into how a framework combining existing knowledge and experience and new knowledge generated through 1-3 will be combined into expert system(s) for improved decision making for the purpose of modelling and hence tailoring concrete for specific performance criteria.

KEYWORDS

Concrete; Civil engineering; Export system; Mix design.

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Proposal no: BE-3469

THE DEVELOPMENT OF STANDARDISED PERFORMANCE TESTS AND CRITERIA FOR CONCRETE REPAIR SYSTEMS

Starting date: September 1990 ***Duration:*** 48 months

OBJECTIVES

The repair of concrete damaged by reinforcement corrosion is a worldwide problem costing with estimated costs of $10 billion annually. A large proportion of these repairs are ineffective and fail, requiring further repair. To be durable a repair must adhere to the substrate concrete and protect the underlying steel against corrosion. It must therefore have physical and chemical properties.consistent with the design and use of the structure it is applied to. No co-ordinated standards and methods exist to guide engineers and structure owners in selection and specification of repair materials. This programme will compare the performance of repairs to existing structures; test repairs which have been exposed for 10 years; repairs exposed to accelerated weathering regimes; large scale, repaired members subjected to structural testing and accelerated weathering. The results of these tests will enable direct comparison of natural and accelerated testing. The results of this comparison will assist with formal standardisation of performance tests and criteria.

ACHIEVEMENTS TO DATE

Repaired structures have been identified in the U.K, Spain and Italy. A number of these structures have been inspected in detail and performance of repairs established. Similarly repaired test specimens exposed for ten years have been inspected. Where the repairs were identified as defective, failure mechanisms were identified. Exposure sites have been established in the U.K, Spain and Italy to enable comparative natural exposure testing.

KEYWORDS

Civil Engineering; Repair/Maintenance; Concrete; Codes/Standards; Development; Performance Criteria

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Contract no: BREU-0272
Proposal no: BE-3291

THE RESIDUAL SERVICE LIFE OF CONCRETE STRUCTURES

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

A very high proportion of national construction expenditure is spent on repairs to and maintenance of mature structures (over 40 per cent in the U.K.). It would thus be of very considerable economic benefit to improve the understanding of the effects of the ravages of time upon the performance and safety of reinforced concrete structures, so that the best strategic decisions can be taken about the future use of the structure, with or without remedial work.

The proposal aims to develop a system which will enable the current state and future performance of a structure to be established quantitatively. Three deterioration mechanisms will be considered: corrosion of reinforcement, freeze-thaw damage and alkali-silica reaction. For each mechanism, methods will be developed to establish the aggressivity of the environment, the current state of the materials within the structure and current rates of deterioration. Mathematical models will be used to predict from this information the current and future performance of the structure. This information will permit rational decisions to be made for maintenance and repair strategy.

KEYWORDS

Building/Construction; Concrete/Building materials; Engineering (civil); Research/Development; Residual life

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FIBRE-REINFORCED COMPOSITE WITH MODIFIED CEMENTITIOUS MATRIX

Starting date: October 1988 ***Duration:*** 36 months

OBJECTIVES

The development of new glass fibre-reinforced composites, based on cementitious matrices which will preserve their high mechanical properties over a long period of time, could have a very significant impact on the construction market.

The aim of this project is the development of a practical glass fibre reinforced cement with a flexural strength of 35 MPa and an ultimate strain of minimum 0.7% after ageing process. With age, glass fibre-reinforced cements (i.e. GRC, PGRC) currently available demonstrate a significant reduction in strain capacity. This greatly restricts potential applications. The performance of fibre reinforced composites could be improved if the matrix is modified by the addition of active mineral fillers with or without polymers. This improvement is also applied to mortars and concretes reinforced with amorphous iron ribbons.

ACHIEVEMENTS TO DATE

Glass fibre-reinforced composite with the modified matrix: portland cement with good metakaolinite performs performs better then GRC after curing and after different accelerated ageing tests such as: hot water, wet-dry cycling test, freeze-thaw test, carbonation test. Fly ash, or condensed silica fumes cannot be considered as good pozzolana for GRC . Impact and fatigue tests in bending before and after ageing confirm the good strain capacity of the new composite.

The presence of acrylic polymer in the matrix has a significant positive effect on the water absorption of the composite.

The analysis of the mechanical and acoustic responses of new composite and GRC subjected to increasing amplitude cycles in third-point bending test is performed. These results enhance previous conclusions which confirm the high durability of the new composite.

KEYWORDS Building; Concrete; Fibres; Polymers; Materials characterisation; Interface; Mechanics.

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Contract no: RI1B-226
Proposal no: BE-2370

FIBRE COMPOSITE ELEMENTS AND TECHNIQUES AS NON-METALLIC REINFORCEMENT OF CONCRETE

Starting date: September 1991 ***Duration:*** 48 months

OBJECTIVES

Deterioration of concrete structures due to corrosion of steel reinforcement is a world-wide problem, especially in the case of exposure to aggressive environment (e.g. marine atmosphere, sea water, aggressive chemicals, deicing brine). Alternative reinforcing and pre-stressing materials which do not corrode in such environments due to their nonsusceptability to ionic dissolution may be a valuable expedient. Such materials are unidirectional fibre reinforced plastics (FDP), consisting of endless glass-aramid- and carbon fibres in a polymeric matrix. Most important properties of these FRP materials for the application for civil engineering structures are: very high tensile strength in fibre direction, excellent corrosion resistance and very low density. More durable concrete structures and a range of new kinds of structural elements and of new applications are realizable with FRP reinforcement and/or pre-stressing.

The prime objective of the proposal is to acquire the fundamental knowledge for FRP application in civil engineering structures:

- Adjustemet of material properties of FRP elements and of production technologies to the demands of structural engineering.
- Investigation of load bearing behaviour of concrete members reinforced and/or pre-stressed with FRP.
- Development of application techniques: reinforcing elements, anchorage assemblies, post-tensioning systems, etc.
- Development of criteria for design, detailing and execution of concrete members with FRP.

Based on recent developments, clearly demonstrating the advantages of FRP for many structural applications, this project concentrates on material properties, especially under long term static and fatigue stresses under simultaneous chemical attack, on the load-bearing behaviour of concrete members reinforced and/or pre-stressed with FRP and on development and testing anchorages for FRP tendons. Generation of up to now otherwise unavailable data in the above mentioned areas is a major goal of the project.

KEYWORDS Construction; Engineering (civil); Manufacturing; Composites (polymer matrix); Fibre reinforcing materials; Polymers; Reinforcement technology.

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Proposal no: BE-4142

FREEZE/THAW DURABILITY OF CONCRETE PAVING BLOCKS

Starting date: October 1988 ***Duration:*** 48 months

OBJECTIVES

1. To produce basic models of micro-climates using measured and currently available data on meteorological conditions so that appropriate freeze/thaw regimes may be specified.
2. To investigate the correlation between current standard freeze tests and actual performance in practice.
3. To develop a new test apparatus capable of subjecting specimens to experimental regimes similar to the actual regimes obtained in practice.
4. To investigate the performance of blocks manufactured with new compositions.
5. To advance fundamental knowledge of the processes of freeze/thaw damage.

The results will enable economic block products to be produced of a quality adequate to deal with likely climatic conditions.

ACHIEVEMENTS TO DATE

Five exposure sites have been constructed: two in Germany, two in Italy and one in the UK. Each site has a weather station and blocks have been instrumented to record the effects of ambient conditions on the block paving. Data have been recorded over two winters. Concrete block paving has been manufactured on normal production machinery with 40 different compositions. Twelve 'control' mixes have been laid on all exposure sites and the remaining 28 mixes on at least one of the sites. An extensive laboratory programme to classify the blocks is in progress and 90% complete.

Three freeze/thaw test methods have been compared. A specially constructed environmental chamber is being used for fundamental research prior to its use for accelerated durability test.

KEYWORDS Construction; Concrete; Materials characterizaton/Testing; Durability; Freeze/Thaw; Block paving.

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Proposal no: P-2085

ECOPAVE - THE DEVELOPMENT OF A MULTI-PURPOSE COMPOSITE PAVEMENT SYSTEM

Starting date: October 1988 ***Duration:*** 48 months

OBJECTIVES

A variety of concretes and treated cement and bituminous materials are used for the construction of rigid or flexible pavement structures. Each material demands specialised technologies, research, experience and a wide range of paving equipment. The objective of this research is to exploit the most advantageous features of conventional concrete and flexible pavement and to integrate them into a new multi-purpose composite pavement system to be constructed with plants, commonly used for the construction of flexible bituminous pavements.

The ECOPAVE project aims at breaking through established disciplines and industrial boundaries to examine the integration of selected material characteristics and construction methods from different backgrounds to create an improved pavement product.

ACHIEVEMENTS TO DATE

A large number of materials and aggregates which are different for each country, have been selected and investigated. A large number of concrete trial mixes, both from virgin and recycled aggregates have been proportioned, cast and examined. Two test pavement sections with predetermined, controlled cracks systems have been carried out and are being monitored. A third test pavement section with alternative, cheaper mixes is to be carried out in August 1991.

KEYWORDS

Engineering (civil); Recovery/Recycling; Concrete/Building materials; Multilayers/Multimaterials; Rocks/Stones/Aggregates; Research/ Development.

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Proposal no: P-2414

EPOXY POLYMER CONCRETE FOR PRECISION ENGINEERING (EPOC)

Starting date: August 1991 ***Duration:*** 36 months

OBJECTIVES

Within the last two decades polymer concretes developed into an interesting alternative to several classic materials such as cast iron, cement concrete, and ceramics. Polymer concretes are used for structural components in mechanical engineering (machine tools, casings, foundations, etc.), in building industry (pipes, elements for chemical plant units, sanitary products, elements for roofs, floors, and walls, etc.), and in electric heavy current engineering (isolators, transformers, etc.). The new technology is still mainly empirical and not scientifically covered, as it is for cement concretes.

The aim of the project is to elaborate tools for an optimized polymer concrete technology, including computational methods for element design, strain and stress analysis for different temperature histories during hardening and for external in-service loading. This enables the producers (mainly medium sized companies) to optimize their products, to economize production and to systematize the quality control measures.

This very challenging goal can only be achieved through inter-disciplinary cooperation between chemists, physicists, research engineers and production engineers.

KEYWORDS

Mechanical engineering/Machinery; Construction/Building/Civil engineering; Composites (polymer matrix); Concrete/Buiding materials; Chemistry; Materials science; Mathematical modelling

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Contract no: BREU-0468
Proposal no: BE-4501

OPTIMISATION OF THE SURFACE PROPERTIES OF CONCRETE ROADS IN ACCORDANCE WITH ENVIRONMENTAL ACCEPTANCE AND TRAVEL SAFETY

Starting date: 1990 ***Duration:*** 36 months

OBJECTIVES

The main purpose of the project is the construction of concrete road top layers with due regard to six essential optimisation parameters.

- Traffic safety: the skid resistance must meet for at least 20 years the requirements in the national road standards
- noise reduction: for dense concrete surfaces the noise production must be reduced to the average value of low noise dense asphaltic concrete
- useful life and economic feasibility: the lifetime of concrete road top layers must be at least 20 years, as is normal for concrete roads. Construction and maintenance costs must be competitive with other types of asphalt and concrete roads, taking into account that for these roads acoustic walls might be needed in order to reduce the noise emission to the surroundings to the level given in national specifications (reduction 3dB as an average compared with present used dense concrete for porous concrete and 5-6dB for dense concrete)
- in the case of a porous concrete top layer the porosity must guarantee over the whole lifetime that even under heavy rainy conditions on the base of maximum rain measured by national meteorological institutes, there is no more water than a thin film (20-25μ as a maximum) on the surface
- construction methods must be developed and approved in test sections in order to meet the goals mentioned above. These construction methods must be available for new roads as well as for overlays on existing roads
- description of all knowledge obtained in a code of practice and a guideline to be used in all EC countries.

KEYWORDS Road construction; Civil engineering; Concrete

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Contract no: BREU-0331
Proposal no: BE-3415

THE PREDICTION OF LONG-TERM SEALANT PERFORMANCE FROM DYNAMIC ACCELERATED WEATHERING

Starting date: September 1990 ***Duration:*** 48 months

OBJECTIVES

- To develop and utilise realistic accelerated weathering regimes.
- To design and manufacture devices for subjecting joint sealants to cyclic movement while undergoing accelerated or natural weathering.
- To develop sensitive techniques for analysing degraded sealants.
- To develop a model to predict the life expectancies of sealants in three chosen climatic zones to within expected limits of +/- 3 years.
- To provide end users and designers with information on performance and life expectancy of sealants on which to base their product selection.

ACHIEVEMENTS TO DATE

- Development of realistic accelerated weathering regimes.
- Design and manufacture of prototype devices for subjecting joint sealants to cyclic movement while undergoing accelerated or natural weathering.
- Initial analysis of photoproducts from polyeurethane, silicone and polysulphide sealants.

KEYWORDS

Sealant performance; Building/Construction; Accelerated weathering; Adhesives/Bonding; Cyclic movement; Polymers

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Contract no: BREU-0217
Proposal no: BE-3290

IMPROVING LOAD BEARING AND WATER RESISTING PROPERTIES OF GYPSUM AS A SECONDARY RAW MATERIAL

Starting date: February 1991 ***Duration:*** 36 months

OBJECTIVES

The aim of the research is to provide qualitative and quantitative insight into the underlying phenomena of strength and durability of both pure gypsum and gypsum reacted with pozzolanic materials.

Such a basic materials science knowledge is required for an expansion of gypsum applications in the building industry.

ACHIEVEMENTS TO DATE

The project has just been started. Therefore, no achievement to date can be given.

KEYWORDS

Construction/Building/Civil Engineering; Chemistry; Building/Construction; Materials science; Recovery/Recycling; Building materials; Materials characterisation/Testing

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Proposal no: BE-3474

DEVELOPMENT OF ADVANCED PREFABRICATED URBAN SLAB TRACK SYSTEMS BY APPLICATION OF INNOVATING DESIGN METHODOLOGIES FOR IMPROVING OVERALL SYSTEM PERFORMANCES TAKING INTO ACCOUNT ENVIRONMENTAL FACTORS

Starting date: July 1991 ***Duration:*** 30 months

OBJECTIVES

The usual track typologies now employed on urban railways consist of traditional systems made of sleepers embedded in ballast beds. Such systems do not satisfy on the whole the new demands imposed by the increased public awareness of the need to reduce the environmental impact and to devote maximum attention to safety and reliability. The development of advanced urban track systems for improving the overall track system performances with particular regard to environmental factors is therefore required. Innovating design methodologies and new concepts through implementation of accurate analytical models will be employed; experimental tests both in lab and in situ will provide the input data needed for the numerical predictions and validate the design models employed in the study. The main problems of interest are those related to induced ground vibrations and acoustic noise. Furthermore, the research project will also consider other important needs such as the demand of overall system performances improvement in terms of reliability, durability, maintenability and the necessity of enhancing the manufacture process both in factory and in situ by producing and by laying prefabricated concrete products. In this regard the present state of the art in the field of railway track systems shows the potential optimal solution to be the employement of prefabricated slab tracks, possibly with other components and devices integrated in order to provide the requested performances. The project, which will develop through real needs specification, design methodologies implementation, specimens construction and experimental tests, will make for the design of better cost-effective track systems and thus have a significant economic impact on the basis of a real industrial need both for new railways and for renewals.

KEYWORDS Railways; Track systems; Environment; Acoustic noise and vibrations; Testing; Mathematical modelling; Total life cycle cost.

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HI PER VIB: HIGH PERFORMANCE VIBRATORY PILE DRIVERS BASED ON NOVEL ELECTROMAGNETIC ACTUATION SYSTEM AND IMPROVED UNDERSTANDING OF SOIL DYNAMICS

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

One of the major issues in civil engineering and the construction industry is urban development on soft soil. It requires special foundations and pile driving works.

A more detailed understanding of factors which influence the efficiency of vibratory pile-driving together with new concepts for generating unidirectional vibrations are required.

Fundamental research will be undertaken to establish an improved physical model of the pile-driving action in order to investigate how the soil, pile, and vibrator parameters influence driving under the combined weight of the element and vibrator. Predictions will be validated against site tests on different soil characteristics for which optimum vibrator parameters will be obtained. Novel forms of electromagnetic actuation systems will be examined and the potential for large and very large versions investigated. The most promising concepts will be embodied in prototype devices whose performance will be assessed against predictions.

The project should set the basis for a feasibility study of a low cost large pile driver, twice as productive and reliable than present machines.

KEYWORDS

Mechanical engineering; Civil engineering; Construction; Vibrators; Piling; Foundation

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INTEGRATED SYSTEM OF FLEXIBLE PREFABRICATION FOR PERSONALIZED ARCHITECTONIC FACADE

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

(i) Design of a flexible prefabrication work station and a flexible mould

Design of one or several flexible moulds, geometrically changeable, and their environment, for manufacturing complex shapes and diverse relief. Research on the materials of the moulds (metal, composite, resin, wood, plastic, polymer, etc.) to substitute the changeable parts of the moulds, currently reusable, by readjustable, mouldable, recyclable materials.

(ii) Design of a finishing work station around a multifunctional and flexible finishing robot

Adaptation of available robots to a "hostile" environment (outside, dust, water, acid, etc.) equipped with a claw capable of holding finishing tools. Design of an intermediate system between 100% manual apparatus and 100% automated. Multifunctional for 3 finishing treatments (washing, brushing, standing) realized with 4 finishing tools (sand hose, high pressure hose, rotary metal brush system, simple brush with acid jet).

(iii) Production and test on a pilot site of two prototypes: flexible mould and finishing robot

Parts 1 and 2 - End of 1993

Part 3 - End of 1994.

KEYWORDS

Construction/Building/Civil engineering; Prefabrication; Building/Construction; Prototyping; Concrete/Building materials

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INTEGRATED PRODUCTION CELL FOR THE STEEL COMPONENTS OF REINFORCED CONCRETE BUILDING ELEMENTS (INPROROS)

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

InProRos will research and develop a hardware and software environment for the integrated production of the steel components of reinforced concrete sections. The integration and automation will make use of compatible technologies based on modular and open industrial solutions to achieve the project's objectives. The input data for InProRos will consist of a description of the position, shape, size and placing of the steel sections for a reinforcement cage. This data will be converted into a form understandable by the various straightening, cutting, bending, transportation and integrating machines. The machines will be overseen by a production planning, scheduling and monitoring computer which will ensure the optimum usage of the machines and materials, and hence optimised through-put. The requirements of the system will be derived from PARTEK, Europe's largest producer of precast elements and an SME, HOUSE, which manufactures insulated walls. Machine components will be developed for a novel reinforcement-steel-cage producing machine, and the integrated system will be evaluated in a pilot plant of PARTEK in Holland. The integrated system will greatly improve and promote prefabrication practices and provide the user with an intelligent automation system for the production of the steel components of reinforced concrete sections; The end-products will be software, a strategy for the application of CIM in the construction industry, and enabling hardware and development.

KEYWORDS

Construction/Building/Civil engineering; Concrete/Building materials; Automation/CIM; Reinforcement technology

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DEVELOPMENT OF BUILDING MODULE TECHNOLOGY

Starting date: August 1991 ***Duration:*** 36 months

OBJECTIVES

The use of prefabricated building modules fully fitted with internal finishing and services is a major growth area. It is also an area where current European construction technology is lagging behind recent advances in Japan and the USA.

This project aims to develop an enhanced design methodology and production technology for modules, that will enable the development of appropriate standards for the commercial development of the building module industry.

It will also review material usage, procedures and design practices from various allied industries and develop and modify them if appropriate to enhance the production and quality of standardized elements which will allow the rapid design and costing of highly configureable modular building units.

The project will develop module technology to facilitate the later development of modules for particular applications.

Project objectives are to provide a clear definition of the building module production and customer requirements, internal finishes and services, develop design methodologies which can form the basis of efficient design, production and costing, improve methods for the installation of modules into the final structure and the inter-connection between modules. A software data base framework will be developed to form the basis for the implementation of a cost linked production knowledge base.

KEYWORDS

Construction/Building/Civil engineering; Design; Other industrial processes; Computer science/Software; Codes/Standards; Research/Development; Building/Construction

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Contract no:
Proposal no: BE-4417

HIGH RISE CONCRETE APARTMENT BUILDINGS WITH LIMITED CONSTRUCTION TIME

Starting date: 1991-1992 ***Duration:*** 24 months

OBJECTIVES

The objective of the proposed research and development project is to reduce the construction time of high-rise apartment buildings as much as possible. There is a substantial demand for such building, especially in inner cities. The proposal involves the development of new combinations of fast construction, infill and finishing techniques, including new solutions for the connection between different construction materials. These developments are the result of a total new approach of constructing high-rise buildings. Some aspects of this approach are :

- Using slipform systems for the construction of concrete outer walls
- making optimal use of the permanent structures, limiting of the use of temporary structures
- producing concrete floors in a package on the ground floor and hoisting them to their destinations within the concrete facades.

For the calculation of the concrete structures, the use of the most advanced computer programmes is necessary, based on the most recent knowledge of concrete mechanics and concrete materials technology. Logistics are most important in the project. The proposal includes the developing of a computerized logistic system.

KEYWORDS

Construction/Building/Civil engineering; Building/Construction; Logistics/ Management/Prod. plan.; Concrete/Building materials; CAE/CAD/CAM systems;

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Proposal no: BE-4468

MATHEMATICAL MODELLING OF 3-D FLEXIBLE MATERIAL SURFACES TO AID DESIGN AND MANUFACTURE OF CLOTHING

Starting date: May 1989 ***Duration:*** 12 months

OBJECTIVES

The objective is to produce mathematical models, from existing numerical representations of 3-D curved surfaces, to accurately visualise surfaces representing clothes worn by a model. These surfaces can then be developed into 2-D pieces for pattern making. The challenge will lie in taking into account the physical properties of the material when making the mathematical model of the surface including creases and folds at the elbow, knee, and so on. Modelling will be carried out on 2-D and 3-D graphics workstations allowing deformations to be visualised and respecting the drape and cut of the clothing, the physical properties of the cloth and the posture of the model.

KEYWORDS

Textile/Clothing; Flexible/Non rigid materials; Textiles; Imaging/Image processing; Mathematical modelling

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Contract no: RI1B-302
Proposal no: P-2096

REALISATION AND TEST OF A PROTOTYPE OF A BASIC MODULE OF COMPUTER INTEGRATED MANUFACTURING (CIM) IN THE CLOTHING INDUSTRY

Starting date: February 1989 ***Duration:*** 36 months

OBJECTIVES

The European clothing industry must respond to increasing international competition with high quality clothing, higher productivity, shorter order processing times, smaller batch sizes and greater readiness to deliver. Automation of production and computer integrated manufacturing (CIM) are ways of reaching this goal. The automation of production will justify higher investments if it enables step-by-step expansion to flexible integrated production. The project partners are building on a comprehensive concept of computer integrated manufacturing (CIM) in the clothing industry (developed in BRITE 1478) in order to realise and test a working prototype of a manufacturing communications system.

ACHIEVEMENTS TO DATE

A heterogeneous manufacturing network (Ethernet, IEEE 802.3 TCP/IP, NFS) has been constructed in an industrial concern. Data is being exchanged via network interfaces using existing computer applications. Remote computer systems are being integrated using the X.25 protocol. Core applications of the manufacturing communications system are being tested at present in the industrial concern. Newly developed applications are the process planning system, a workshop planning and control system as well as a production data management, whereby distributed relational data base applications are supported. The workshop planning and control system supports alternative methods of short term planning and control. An Advanced Factory Data Aquistion and Management System are integrated. Software modules are under development using the UNIX V operating system. More complex planning and control modules for multi-week planning of flexible manufacturing groups, for synchronised buffer contol and graphic monitoring are under development and will be gradually integrated in the industrial test.

KEYWORDS Textile/Clothing; Logistics/Management/Prod. plan; Process/Production monitoring; Textiles; Automation/CIM; Databases/Expert systems; Research/Development.

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Contract no: RI1B-299
Proposal no: P-2478

DEVELOPMENT AND EVALUATION OF TECHNOLOGIES AS SUPPORT FOR FLEXIBLE PRODUCTION GROUPS IN THE CLOTHING INDUSTRY

Starting date: January 1991 ***Duration:*** 48 months

OBJECTIVES

If the European clothing industry is to compete with non-European countries, it has to compete on parameters such as quick response to market demands, short delivery times, frequent change of collections and high quality. This demands greater flexibility and quicker reconversion than is possible with the existing production apparatus.

The objective of the project is therefore to work with small flexible autonomous production groups and to develop the necessary equipment (sewing machines, automats, transport equipment, information and planning systems and auxilliaries) to make these groups work optimally. This development will enable clothing manufacturers, in an economical way, to produce small series, to reduce direct production time and to change models more frequently than today.

ACHIEVEMENTS TO DATE

- Flexible production groups have been established at the two clothing companies.
- Experience with flexible production groups and flexible production systems has been compiled.
- On this basis specifications for equipment to be developed are being discussed.

KEYWORDS

Textile /Clothing; Manufacturing; Textiles

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Contract no: BREU-0273
Proposal no: BE-3345

COMPUTER INTEGRATED MANUFACTURING OF SYNTHETIC FILAMENT YARN

Starting date: December 1988 ***Duration:*** 36 months

OBJECTIVES

Current manufacturing routes for melt spinning of synthetic fibres utilise measuring and control devices in separate parts of the operation. Integrated systems which give total control are not available, but are necessary if progress is to be made towards improving process reliability and product quality and give additional manufacturing flexibility for cost effective product specialisation.

The programme will require the development and integration of on-line process control sensors with computer directed monitoring and guidance systems, to handle the highly interactive and complex process and product data.

ACHIEVEMENTS TO DATE

After the achievement of operability of the data acquisition system and the development of new sensor systems, the project has entered a phase where most significant scientific and technical results are obtained.

KEYWORDS

Materials processing; Forming/Shaping/Casting; Fibres; Polymers; Automation/CIM

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MATHEMATICAL MODELLING IN WORSTED SPINNING, ALLOWING THE OPTIMIZATION OF THE PROCESS AND THE DEVELOPMENT OF CIM

Starting date: May 1991 ***Duration:*** 36 months

OBJECTIVES

The introduction of CIM in the domain of spinning requires, in order to be completed, not only computer control of several types of automatic devices, such as feed and removal of the products at each machine, transfer of products from one machine to the next, etc., but also automatic adjustment and if necessary regulation under computer control of the settings of all the important machines, as a function of the characteristics of the ingoing textile material and of the properties required from the semi-finished or finished product (top sliver or yarn). To achieve this goal, it is necessary to study new machines, where all the main settings are controlled and possibily regulated by computer.

This research programme contributes to the introduction of CIM in worsted processing, through the study of such a computer-controlled machine with the development of the corresponding software for the automatic adjustment of the settings, for the most important and most complex passage of the process, the worsted card. For this purpose, the research programme includes the following parts:

- study of new mathematical models of the high production worsted card (based on a massive experimental campaign), having the particularity that they describe the effects of the settings of the individual elements of the card
- preparation of a software based on these mathematical models, optimizing the main card settings by achieving a compromise between quality criteria and economical criteria (production, minimization of losses)
- basic study of a new high production worsted card, entirely controlled by computer, providing automatic adjustment of the card settings as a function of the characteristics of the raw textile material through the use of optimized software, with maximum safety and reliability in an industrial environment.

KEYWORDS

Textile/Clothing; Textiles; Automation/CIM; Mathematical modelling

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Contract no: BREU-0521
Proposal no: BE-4481

RESEARCH INTO THE CARDED YARN PROCESS IN THE COARSE YARN COUNT SECTOR USING MODERN NON CONVENTIONAL SPINNING TECHNOLOGY

Starting date: 1991-1992 ***Duration:*** 48 months

OBJECTIVES

This research project intends, to increase the productivity and efficiency of the carded wool spinning system, which is predestined to produce valuable and fashionable textiles from high quality fibres.

With help of alternative process operations, like a compact carder with or without a following drafting unit and non-conventional spinning systems, carded yarns should be produced without high deviations from the characteristics demanded by the market .

If the new yarns produced with these alternative processes have other structures and qualities, then they will be geared to new products, which would result in the economic benefit of opening very new market segments.

Within the framework of this project a new compact carding machine and new drafting units for the spinning machines will be developed and incorporated into the production of typical carded wool yarns.

The ultimate goal is to put a shorter and much more efficient production line for carded wool yarns on the market.

KEYWORDS

Textile/Clothing; Engineering (mechanical); Textiles

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Contract no:
Proposal no: BE-4478

DEVELOPMENT OF STANDARDISED MATERIAL TRANSPORT DEVICES FOR THE SEQUENTIAL AUTOMATION OF THE PROCESSING OF FLEXIBLE MATERIALS

Starting date: July 1986 ***Duration:*** 66 months

OBJECTIVES

Material handling is of significant importance for automation of the production procedure in the garment industry. Today's requirements of production flexibility, however, demand the use of flexible solutions to automatically process a defined variation in scope of work operations. This will be achieved by the following objectives:

- Development of a new technical handling solution for flexible material using the freezing principle.
- Development of standardised material transport devices whose combinations results in varied sequential automation solutions. The modules shall be designed for overlapping material and product application.

ACHIEVEMENTS TO DATE

Based on comprehensive product and process analyses, numerous modules were designed and developed step by step and realised within the entire concept. The modules are designed under the aspect of being included in material transport systems for the sewing industry as an integrated part with flexible operation. Automation of the actual sewing process is the start of the development work. A test device with fully automatic linkable handling and material transport modules has been achieved as a prototype for a task sequence with three pocket sewing operatons. Another focus of development was the application of the frozen-gripper idea. This principle has considerable advantages in functions compared with conventional gripper systems. Gripping and holding of pattern parts is ensured without any material adjustment setting. Although the test device shows the principle technical solution is functioning more development work must be done to ensure a reliable and efficient prototype.

KEYWORDS Textile/Clothing; Assembly/Joining; Handling/Transportation; Flexible Non rigid materials; Textiles; Automaton/CIM.

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Proposal no: P-1535

DEVELOPMENT OF AN INTEGRATED SYSTEM ABLE TO OPTIMIZE THE FLEXIBILITY LEVEL IN THE TEXTILE-APPAREL PRODUCTION PROCESS

Starting date: July 1991 ***Duration:*** 36 months

OBJECTIVES

The world textile-apparel market is marked by a fierce fight for competitiveness between DCs and ICs. The latter ones have relatively strong positions in high-quality production sectors, but, in order to maintain such a relative advantage, they have to improve more and more their operative flexibility.

A textile firm, in order to achieve the maximum flexibility in the production process, faces two fundamental problems :

- to reach complete harmonization between the production technical data and the product structural characteristics requested by the costumer (garment mill)
- consistent production planning, meeting scheduled delivery times, keeping to assigned priorities, coping with disruptions to the outlined production planning.

There are therefore two lines of action in this project:

- By telematic linkage, garment collection data, as requested by the garment mill, are converted into suitable parameters to be transmitted to the production departments
- by the development of an expert system allowing production management through a short term production planning, as outlined in the former phase, and constant adjustment in the light of the daily production performances.

KEYWORDS

Textile/Clothing; Process monitoring; Textiles; Databases/Expert systems

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Proposal no: BE-4507

FLEXIBLE UNIT FOR REMOVING TEXTILE WORKPIECES FROM A PILE AND OVERLAYING THEM

Starting date: January 1989 ***Duration:*** 36 months

OBJECTIVES

The main objective of the programme is to develop workstations which would be able to grip and seperate a single ply fabric, from multiple pre-cut stacks, making a new multi-ply stack (with possibility of joined plies). New research has started in order to define handling techniques useful for local gripping, local separation, total gripping and separation, and also vision techniques for supervising and checking the operations.

Main characteristics of the final systems will be:

- reliability of gripper process better than 99.9%,
- accuracy of position and superposition better than 3mm,
- total cycle time (from destacking to joining) in less than 6s for one ply.

ACHIEVEMENTS TO DATE

After more than two years of work, the principal modules necessary to the workstations are in place:

- a destacking module of cylindrical form; it has a fixed arrangement of oblique pins for local fabric engagement and instrumentation to check the reliability of separation.
- a destacking module of spiral form in order to separate and grip locally the first ply of a textile stack; the spiral destacker rolls without slippage onto the stack.
- gripping by vacuuming through cellular materials equal to an infinity of suctiongrips regularly disposed on the whole surface.
- algorithms of vision to detect and orientate the objects; the vision system can capture and process images of 512 x 512 pixels resolution and linear images of 1728 pixels.

KEYWORDS Textile/Clothing; Handling/Transportation; Textiles; Automation/CIM; Image/Image processing; Robotics.

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Proposal no: P-2431

RESEARCH ON AND PERFECTION OF ON-LINE SENSORS AND CONTROLLING PROCESSES FOR CONTINUOUS TEXTILE FINISHING

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

The object of this project is to develop sensor and controlling systems for in-process quality control:

- in order to measure and to control hydrogen peroxide consumption
- in order to measure the relaxation in textile materials in heat-setting units
- in order to detect the state of swelling by relaxation measurements.

In all about 15% of the total costs are related to repeated treatments because of deviation in quality.

The project will develop a sensor system for the finishing industry in order to follow up hydrogen peroxide consumption during bleaching and the internal stresses as brought to the textile material during heat-setting and during mercerization to cut down repeated treatments.

Monitoring of hydrogen peroxide concentration in a bleaching bath is discontinuous. Special methods are to be evaluated in order to achieve a completely on-line sensoring system. Heat-setting of synthetic fibre-material and treating cellulosic material in caustic soda solution (mercerizing) also need measuring-systems for controlling the tension brought about by changes in fibre structure during processing.

KEYWORDS

Materials processing; Textile/Clothing; Processing (food, non rigid materials); Quality assurance; Textiles; Measuring systems; Mathematical modelling; Materials science

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Proposal no: BE-4373

FLEXIBLE SEWING CELL

Starting date: May 1988 ***Duration:*** 36 months

OBJECTIVES

The main general objective of the project was a working prototype to perform the operation of setting pockets and fronts in shirts. The prototype was planned to be composed of the following three main modules: Feeding module (including front pick-up and separation device and pocket feeder); Recognition and Positioning module; Sewing module. The Feeding module was planned to pick-up a shirt front from one pile of fresh cut fronts; and deliver it to the Recognition and Positioning module. It was also planned that another feeder deliver a Pocket to the Recognition area. The Recognition and Positioning module identifies the parts and supplies the necessary information to the handler of this module to position the parts perfectly. The sewing module then, performs the operation of folding the pocket and sewing it to the front.

ACHIEVEMENTS TO DATE

The project has been finished according to the objectives, achieving a cycle time of 25 sec. and a matching accuracy of +0.5mm. The Front seperator is able to pick-up and seperate one front from a fresh pile, using aerodynamic principles and deliver it to the regonition module. The Pocket feeder is an endless conveyer able to receive the pocket from the previous operation and deliver it to the Recognition module. The controller of this module is based on a Programmable Logic Controller.

- The recognition and Positioning modul is based in a special purpose robot and clamp; the module incorporate a CCD camera and a digital servocontroller.
- The sewing module is a modified N.C. Sewing unit, including: pocket folder, sewing head, stacker and CNC controller.
- A central controller communicates with the controller of each module using a protocol based in an ISO standard.

KEYWORDS Clothing; Handling; Image processing; Assembly; Processing non rigid materials.

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Contract no: RI1B-204
Proposal no: P-2197

FLEXIBLE ASSEMBLY CELLS FOR AUTOMATIC PROCESSING OF COMPLETE SUB ASSEMBLIES OF CLOTHING PRODUCTS

Starting date: February 1988 ***Duration:*** 47 months

OBJECTIVES

The aim of the project is the development of an assembly cell in which parts to be sewn, prefabricated or semi-fabricated are processed fully automatically in a sequence of work operations. All necessary parts are manually loaded into a flexible jig unit which positions and holds the parts during various work operations. The loaded parts will be kept stationary while the sewing head carries out the stitching movements in the x/y plane according to programmed geometrical contour. Folding, material manipulating and sewing operations will be carried out alternatively depending on the individual application.

ACHIEVEMENTS TO DATE

The manufacture of a flexible assembly cell for the fly operations as a test model could be completed in June 1991.

At the actual cell the work module was designed to process a fly-section of pants. The individual parts as cut parts and zipper to be assembled are loaded into the workstation and subsequently sewn together in an automatic operation, in which sewing, folding and manipulating of the workpieces takes place.

Testing and time studies are made under real working conditions in a garment manufacturing plant.

For another flexible application cell for the wing pocket operations a test model is in the stage of development.

KEYWORDS

Textile/Clothing; Assembly/Joining; Textiles; Automation/CIM; Stitching of garments; CNC stitching; Automatic stitching cell.

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Contract no: RI1B-174
Proposal no: P-2242

SEWING MACHINE WITH TRADITIONAL DRIVING MEANS PERMANENTLY ORIENTED IN THE DIRECTION OF SEAM UNDER ELECTRONIC CONTROL

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

To obtain the best quality seam in automatic sewing systems, requires that the whole sewing mechanism rotates to keep the stitch forming device always tangent to the seam path. A mechanical device has been developed employing differential mechanism, but the resulting machine is complicated and cumbersome. In the proposed project the motions of the upper sewing mechanism (needle-bar and upper feed-dog) and the lower one (hook and lower feed-dog) are assured by two independent DC motors controlled in phase, without any mechanical connection. The rotation around a vertical axis of the upper and lower mechanism is obtained by means of two DC motors. The sample to be sewn is moved along two perpendicular directions X and Y axes are interpolated and the speed tangent to the seam-path is kept proportional to the rotation velocity of the sewing head to obtain constant stitch length. The new automatic unit will be appreciated especially in the leather goods industry, with possibilities of applications also in the clothing industry in general.

ACHIEVEMENTS TO DATE

Up to now we have created a simplified prototype in which the upper sewing mechanism (needle bar and upper feed-dog) and the lower one (hook and lower feed-dog) are assured by two independent DC motors controlled in phase, without any mechanical connection. On this prototype tests have been performed with different kinds of fabrics, in order to settle parameters and features of the entire prototype.

KEYWORDS

Mechanical engineering/Machinery; Shoe/Leather; Textile/Clothing

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Contract no: BREU-0105
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AUTOMATIC ON-LINE SYSTEM FOR DETECTION, EVALUATION AND MAPPING OF DEFECTS AND SHADE VARIATION MONITORING ON FINISHED FABRICS

Starting date: November 1988 ***Duration:*** 44 months

OBJECTIVES

The availability of a comparatively low price modular system for automatic on-line detection and evaluation of defects and shade variation monitoring on finished fabrics — also capable of supplying information for the commercial evaluation of the finished product besides automation of the cutting and shipping phase and numeric control cutting machines in garment making — has been identified as a key factor in the automation of textile manufacturing industries and is the aim of the project.

ACHIEVEMENTS TO DATE

The design, construction and debug of the modules of the first experimental system occupied the research team in the second year.

On-line laboratory tests on the prototype and the function of the different light sources have been carried out. Field tests will be started using a special inspection station built to match the specifications for both visual and automatic inspection.

As support for the technicians a photographic fault catalogue characterising a large set of fabric defect was set up..

KEYWORDS

Textile/Clothing; Textiles; Qulity inspection; Image processing.

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Proposal no: P-2213

DEVELOPMENT OF A SYSTEM TO DETECT AND TO MARK DEFECTS

Starting date: April 1988 ***Duration:*** 42 months

OBJECTIVES

The aim of the project is to develop a completely integrated system to detect and to mark defects in woven goods. The types of defects to be detected are irregularities in pattern, structure (spinning, weaving, finish), sheen and colour.

The system is to be installed on the loom, the finishing machine and the inspection table; this is only possible up to a width of 20 cm at the present time. After detection of the defect, it is to be evaluated. This information is to be processed in order to:

- give a warning, if necessary
- evaluate the quality of the piece of fabric
- control the production.

Therefore the appropriate software is to be written. Also a marker/reader device is to purchased and tested. It will be integrated in the inspection system.

Finally the information on the number and type of defect is to be used in the clothing industry, in order to control the folding/cutter system. This will lead to optimal use of the fabric.

ACHIEVEMENTS TO DATE

A detailed description of the system's requirements has been given. These requirements include specifications for defects (type, number, importance, etc.), environment (production stage, speed, physical shape, etc.) and processing of results (marks, reports, host computer, etc.). In the first stage denim fabric is considered. A broad range of algorithms to indentify the defects has been developed and tested.

The software structure for textile inspection is designed and implemented. A prototype of an inspection machine has been designed and will be installed soon.

KEYWORDS Textile/Clothing; Quality control/Inspection; Imaging/Image processing; Textiling; Vision/Optical systems; Automation/CIM; Research/Development.

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Contract no: RI1B-193
Proposal no: P-2387

STUDY OF A MODULAR DEVICE PERMITTING AUTOMATIC RECOGNITION OF FLEXIBLE MATERIAL DEFECTS

Starting date: November 1988 ***Duration:*** 48 months

OBJECTIVES

The purpose of the study is the development of a defect detection device for soft materials in the production process. Based on the use of a camera the detection will first be applied to structural defects of single-coloured fabrics with recognition of the type of detected defect. Detection of structural defects and design defects will then be undertaken on materials with different coloured elements, for instance dyed yarn fabrics. Detection on an inspection table, for example, should show the real time identification and classification of different defects as well as the characteristics of each defect on the tested matrials.

ACHIEVEMENTS TO DATE

The lighting of the fabric, the configuration of the cameras and the defect detection algorithm are firmly established. They have been tested on a roller prototype. This prototype detects the defects in our unbleached samples.

KEYWORDS

Textile/Clothing; Processing (food, non rigid materials); Textiles; Automation/CIM; Vision/Optical systems

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Proposal no: P-2424

MUVI – MULTISENSOR VISUAL INSPECTION IN HIGH SPEED GARMENT PRODUCTION

Starting date: July 1990 ***Duration:*** 36 months

OBJECTIVES

An automatic system for quality control in high speed garment production based on the current state-of-the-art in computer vision techniques and involving advanced hardware architectures has been identified as a key device to increase the competitiveness of the European textile industry. The major technical objectives which represent significant technological advances in the textile manufacturing and in the incipient automatic inspection industry are:

- development of a computer vision system for automatic defect detection in whole finished garments with a reliability of at least 90%;
- defect detection in real time at high speed production flow (at least 300 doz. in 8 hours), and with a reduction from 2.5% to 0.3% in the produced faulty pantyhose;
- development of new techniques for defect detection based on the latest advances in CCD cameras, parallel hardware architectures and parallel computer vision algorithms.

ACHIEVEMENTS TO DATE

- A detailed description of the project requirements has been established.
- A full characterisation of panty hose flaws has been completed.
- A mechanism to provide uniform illumination has been designed to cope with the high frequency line acquisition needed in the production flow.
- A first mechanical prototype has been built up to serve as a platform to integrate the acquisition hardware to provide real images.
- Simulation of algorithms to design the hardware/software architecture.

KEYWORDS

Textile/Clothing; Sensors/Signal processing; Quality control/Inspection; Vision/Optical systems; Imaging/ Image processing.

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Proposal no: BE-3555

QQR-QUICK QUALITY RESPONSE STRATEGY FOR VERTICAL COORDINATION OF QUALITY AND MATERIAL FLOW OF TEXTILE PRODUCTS IN THE TEXTILE, CLOTHING AND RETAIL STAGES

Starting date: January 1991 ***Duration:*** 36 months

OBJECTIVES

European clothing and textile enterprises compete on the international market by quality improvement, flexibility in response to customer demands, flexibility on manufacturing processes, higher investments in automation and computer integration. Communication and standardisation are the backbone of all these efforts. Through effective communications it is possible to reduce costs, manpower and time.

The quality requirements of textile products are closely related to customer demands. Within textile, clothing and retail chains, both communications and quality need commonly agreed standards. Today technical and organisational barriers exist and to reach the goal of Quick Response and Quality Improvement, the partners are developing a working prototype that fulfills the requirements of the OSI (Open Systems Interconnection) reference model and that supports the interchange of agreed quality data.

ACHIEVEMENTS TO DATE

In the early period of this project analyses of the vertical coordination of information and material flow in the textile, clothing and retail stages and requirement specifications for quality management and flexible group production are being made. Evaluations on the state of OSI-standardisation and the adoption of proven standards are worked out. Most important standards on the upper OSI-layer are X.400, FTAM and the international standard of Electronic data interchange UN/EDIFACT.

The design of an open connectivity model between textile, clothing and retail enterprises that supports quick computer-computer interaction and quality data exchange has started. The architecture supports the connectivity independent of used computer and operating systems UNIX, VMS, OS/400, OS/2, MS-DOS, etc. An OSI reference architecture for small to large textile, clothing and retail enterprises that supports faster flow of "textile" information is in preparation.

KEYWORDS Textile/Clothing; Logistics/Management/Prod. Plan; Quality assurance; Quality control/Inspection; Textiles; Automation/CIM; CAE/CAD/CAM Systems; Codes/Standards

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RESEARCH INTO THE FUNDAMENTAL PARAMETERS OF CONTINUOUS DYEING AND THEIR EFFECT ON SUBSTANTIVITY, MIGRATION AND YIELD OF DYESTUFFS, IN ORDER TO DEVELOP ON-LINE SENSORS AND REAL TIME CONTROL MECHANISMS THAT GIVE CONSISTENCY AND REPEATABILITY IN SHADE

Starting date: August 1988 ***Duration:*** 36 months

OBJECTIVES

In order to establish a good control system, it is necessary to know which process parameters determine the final shade of the fabric. Two approaches will be used, theoretical models and statistical analyses of data. The theoretical models will be based on the knowledge of fundamental dyestuff properties and dyestuff/fibre interactions. Mathematical models are to be formed and tested, in particular to describe:

- the influence of process-variables on the shade of the fabric;
- the interaction of process-variables;
- the behaviour of the dye-system during the start-up period.

In order to achieve this goal, sensors are to be designed or selected, and tested, for colour measurement, monitoring and control of relevant process variables. One of the main problems in this area is the real-time measurement of the concentration of dyestuffs in the padder. Finally, the system will advise on the best course of action when process parameters or shade of the fabric deviate outside set targets. All this must lead to higher quality, increased production and saving of chemicals, water and energy.

ACHIEVEMENTS TO DATE

a/ Fundamental research: some basic dyestuff properties have been defined and measured and models for dyestuff/fibre interactions have been established. A link is made between the basic dyestuff properties (and behaviour) and the models. A technique for measuring the dyestuff concentration on-line has been developed and industrially tested.

b/ Statistical approach: all sensors, as well as the monitoring system, have been installed. Data on process and fabric parameters have been gathered.

The key factors to be controlled to ensure consistent production and their control limits have been established from statistical analyses.

KEYWORDS Sensors; Process monitoring; Textile; Control systems; Mathematical modelling; Statistics; Research/Development.

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OPTIMISATION AND CONTROL OF ACRYLIC FIBRE SURFACE AND CRIMP CHARACTER FOR MODERN YARN SPINNING PROCESSES

Starting date: December 1988 ***Duration:*** 48 months

OBJECTIVES

The manufacture of yarns from acrylic staple fibres and tow has been moving from conventional ring spinning to higher productivity modern spinning processes. This trend is expected to continue at an increasing rate. These high speed processes are less tolerant than traditional ring spinning of fibre properties being both different from the optimum and being variable. Hence acrylic fibres, with well characterised variations in crimp, and surface properties, will be trialled through them. Correlations will be established between processing performance yarn properties, fibre properties and fibre variability. Larger scale trials will be carried out to establish, with a greater degree of certainty, the dependence on certain critical properties. This will give information regarding the required degree of accuracy necessary for all fibre parameters such that 'optimum' fibre can be produced.

ACHIEVEMENTS TO DATE

The following have been in the first two years:

- Measurement of yarn frictions at different temperatures and humidities for fibre treated with a wide range of finish chemistries.
- Development of high-tech methods for measuring the factors which contribute to a fibre's frictional character. These are finish level (using NIR), finish distribution (using ESI) and crimp level (using fast fourier transformation imaging techniques).
- Processed 90 fibre variants which had been selected using experimental design to incorporate the following fibre parameters: finish type, finish level, DTEX, crimp and staple length. All were spun into yarns on either high speed ring, rotor open end or air jet machines. Predictions have been made as to which combination of fibre parameters is expected to give optimum spinning performance.

KEYWORDS Textile/Clothing; Chemistry; Fibre/Reinforcing materials; Imaging/Image processing.

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UNMANNED KNITTING PLANTS DEVELOPING A PROTOTYPE AND PRESCRIBING OPERATIONAL REQUIREMENTS

Starting date: April 1989 ***Duration:*** 26 months

OBJECTIVES

The objective of the project has been to assist European Knitting Machine manufacturers to retain leadership in this field of industrial technology by developing a prototype for extended unmanned operation of a CNC,V-bed knitting machine.

ACHIEVEMENTS TO DATE

Innovative pneumatic and mechanical devices have been developed to achieve an automatic loading capability. As well as loading of yarn to the machine feeders from cones, the automatic system has been developed to deal with yarn thread breakages, cone run-outs and programmed cone changes with automatic splicing. This system has been laboratory tested but needs further development to make it sufficiently commercial for industrial use.

An automatic unloading system for discrete knitted pieces together with a take-away conveying device has been fully proven, and is now commercially viable.

A fault detection system which offers exciting possibilities is at an advanced stage. This system can recognize, as they happen, knitting faults such as dropped stitches and tension variations, locate them and cause the knitting machine to stop. As well as Quality Control opportunities prospects for reduced operator attendance are obvious.

KEYWORDS

Textile/Clothing; Automation; Quality control/Inspection; Knitting/CIM; Yarn; Laser technology.

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RESEARCH FOR A MATHEMATICAL AND RULE BASED SYSTEM WHICH OPTIMISES A COTTON MIXTURE BASED ON THE INTERDEPENDENCE OF SIGNIFICANT FIBRE PROPERTIES, PROCESS PARAMETERS, YARN PROPERTIES AND SPINNING MACHINERY PERFORMANCES

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

Development of a mathematical system to predict which spinning machinery performances and final yarn characteristics can be expected (regularity, tensile strength, etc.) once the characteristics of the blend of cotton are known (length and irregularity of the fibres, tensile strength, trash, micronaire, maturity, etc.).

This is why it is necessary;▪ to define all parameters of the raw material and their interactions which can influence the final result;▪ to define the best blend and manufacturing process in order to obtain the best cleaning and regularity of the raw material.

It is necessary to define the opening line, study the settings and the speed of the whole spinning equipment. In order to reach these mathematical formulas and rules it is necessary to create a data and knowledge base.

This system allows the use of cheaper cotton (±10%), increases flexibility and productivity (±10%), improves the stability of spinning and yarn quality and follows the spinning process in a better way.

ACHIEVEMENTS TO DATE

Different cottons have been selected for single bale tests. Fibre properties have been studied in detail. In parallel, new test methods are being developed.

From each bale, different yarns were spun on small and medium scale with different machine settings.

Statistical analysis has started in order to establish the data and rule base.

KEYWORDS Textiles; Fibres; Data bases/Expert systems; Mathematical modelling; Manufacturing; Statistics; Spinning

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Contract no: BREU-0052
Proposal no: BE-3499

RESEARCH ON AUTOMATIC HANDLING TECHNIQUES FOR NON-RIGID MATERIALS BASED ON THEIR PROPERTIES

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

The principal objective of the research is to generate knowledge for use by systems engineers to develop machines for automated handling of a broad range of non-rigid materials. Catagories of materials and industrial handling processes will be defined through manipulation requirements, deformation tolerances and other qualities relating to handling machine system specification. Handling processes across the material range pastas, meats and textiles will be considered and a suitable process will be identified as a focus for detailed study. The studies will enable comparison of handling needs and likely solutions across the range of materials through construction of a demonstrator system integrating sensing, manipulator and expert system technologies.

The handling strategy employed by the system will depend upon task requirements and properties of the materials. Vision, force and torque sensing methods will be developed for identification of the properties of the non-rigid material strategies and an expert sysem will be developed relating the properties and requirements of the handling process to handling strategies.

Deformation reference models will be developed based on mechanical and physical properties, and schemes for the automatic selection and application of control strategies will be investigated using experimental and simulation methods. Sensing schemes to provide real-time fedback for purposes of automatic control of the manipulator and end-effectors will be investigated by experimentation.

KEYWORDS

Handling/Transportation; Flexible/Non-rigid materials; Control systems; Data bases/Expert systems; Robotics; Sensors/Signal processing

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Proposal no: BE-4259

MANUFACTURING PROCESSES FOR FLEXIBLE MATERIALS - INSTANT DYEING LEATHER PRECUTS

Starting date: April 1990 ***Duration:*** 36 months

OBJECTIVES

This project aims at carrying out, in the best way possible, continuous instant dyeing operations on leather precuts to be finished. This should enable materials to be dyed on both sides and eventually throughout their thickness before applying the finish according to a traditional technique.

The provisional stages are:

1. Investigation of rapid instant dyeing of pre-sorted crust leather for 'just-in-time' response to shoe and leather goods manufacturers.
2. Broad-operating parameters and identification of the classes of dyes (and formulation) most suited to 'instant' dyeing techniques.
3. Selection of monomers allowing a controlled penetration and fixation of dyes with a minimum rewetting of the substrate (leather precuts).
4. Development of ternary systems: solvents — monomers — dyes allowing a minimum of drying and evaporated products, in comparison with the long float water base systems.
5. Definition and construction of prototype of dyeing of leather precuts: characteristics - specifications.
6. Optimisation of the coupling of microwave, high-frequency and U.V. drying - curing systems adapted to the formulation products used.
7. Instant dyeing performed in less than one hour as compared to a one to two-week delivery time between the tannery and the shoe factory.
8. Specifications of industrial prototype and formulated products for instant dyeing on line with instant finishing of leather.

KEYWORDS

Materials processing; Instant dyeing; Leather; Chemistry.

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DEVELOPMENT OF AN ENVIRONMENTALLY-FRIENDLY PROCESS FOR THE MANUFACTURE OF COATED FABRICS (ARTIFICIAL LEATHER PROCESSING FOR ENVIRONMENT SAFEGUARD) - ALPES.

Starting date: August 1991 ***Duration:*** 36 months

OBJECTIVES

A great deal of emphasis is being placed on developing polyurethane products that respond to customer's needs, while recognizing concern for the environment.

The covering material of technical textiles currently used for conveyor belts or for artifical leather is made by a spreading technique of PU dissolved in solvent.

The toxic solvent spread on fabrics creates air pollution and workshop contamination requiring costly environmental protection systems.

The development of a new process will be based on a new chemical formulation and technology avoiding the use of solvents.

The process will be environmentally friendly. The resulting processing system will be cost-performance quality competitive with present coating processes in artificial leather, in conveyor belts and in other technically coated textile applications.

After extensive tests on the prototype plants of two partners the technology and the production equipment will be specified in order to be suitable for S.M.E. workshops as well.

KEYWORDS

Chemical/Petrochemical; Textile/Clothing; Processing (rubber & plastic); Coatings/Thin films; Polymers; Textiles; Ecology/Environment

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Proposal no: BE-4045

MANUFACTURING TECHNOLOGIES FOR LEATHERS ADAPTED TO THE NEW ADHESION ASSEMBLY AND DIRECT INJECTION PROCESSES FOR THE SHOE INDUSTRY

Starting date: March 1989 ***Duration:*** 36 months

OBJECTIVES

Given its natural condition and its characteristic of comfort and mechanical resistance, leather is a suitable component for the manufacture of quality footwear. When using leather as a material for footwearuppers, some problems may arise during the cementing of the sole to the upper, due to the need to perform prior roughing operations on leather to obtain a good cementing resistance. These problems can affect the quality and appearance of the finished product and result in serious economic problems for the manufacturer.

The aim of this programme has been to eliminate or considerably reduce the problems arising during the bonding process of the sole to the upper, when leathers are used as upper material.

The two main objectives of the project have been:

- to maintain the hide's intrinsic properties during the process of curing and conversion of the hide into leather.
- to improve these properties through chemical or physical processes.

ACHIEVEMENTS TO DATE

The results so far are positive and patented by one partner. Treatments only performed on the assembly margin before cementing operations, permit simplification or suppression of buffing and carding operations, which - mainly when dealing with thin hides of low hardness - may have unfavourable effects as regards both the quality and appearance of the final product. Furthermore, it was intended to develop an operation that can be easily automated. Laboratory tests have been corroborated by seperation tests and wearing trials, and this enables us to envisage a technico-economic application that would be favourable for the footwear industry.

KEYWORDS Leather fabrication; Footwear manufacturing; Adhesive joining; Assembling; Surface treatment.

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Proposal no: P-2132

AUTOMATION AND INTEGRATION OF CUTTING AND STITCHING WORKSHOPS IN A FLEXIBLE SHOES MANUFACTURING SYSTEM

Starting date: March 1988 ***Duration:*** 39 months

OBJECTIVES

The purpose of this project is to set up a flexible shoe manufacturing system for cutting and stitching workshops. It uses and improves upon existing state-of-the-art processes and techniques, its modules adapted to small and medium-size shoe companies. The following operations are included: removal of cut pieces from the cutting workshop (water jet cutting), storage of pieces in boards, storage of boards in containers, containers, automatic container circulation and distribution to stitching stands, automatic supply of automated stands thanks to markings on the cut parts. An in-depth packaging study should reduce the size of the batches handled, permitting flexible production control in order to reduce the time involved in launching new models and completing current products.

ACHIEVEMENTS TO DATE

This project terminated in research models and prototypes which are installed in a test workshop at an experimental site PAIC-A, in Bordeaux, France. Connected with a water-jet cutting machine (4 workstations), these experimental prototypes are: leather pieces conditioner (container and board), removal system of cut pieces with piece grip mechanism, board piece conditioning system, conveying system of containers, automatic feeding of stitching work station, pieces superposition work station.

KEYWORDS

Computer integrated manufacturing; Flexible automation; Leather; Stitching workshop; Shoes

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TOPSYS - TOOL PRODUCTION SYSTEM FOR DESIGN AND MANUFACTURE OF MODELS FOR HIGH QUALITY AND PROPERLY FITTING SHOES IN THE FOOTWEAR INDUSTRY

Starting date: January 1991 ***Duration:*** 48 months

OBJECTIVES

The main objective of the project is the development of a computer-aided system for tool production in order to reduce production development periods and permit flexible production of high quality and properly fitting shoes. The model development period will be reduced from the average of 3 weeks necessary today to less than 1 week. This will enable shoe manufacturers to meet market demands within increasingly shorter product innovation cycles. In contrast to the main seasons per year, more assortments could thus be realised per year in shorter intervals. Due to the uncertain sales forecasts close to the time of sales, planning must include a large number of sample shoes which are made under great time pressure. Under the new system this large number should be reduced by at least half.

ACHIEVEMENTS TO DATE

The project is currently in the conceptual phase. Analyses of the processes in connection with development, construction and production of lasts and moulds are being made. High technology solutions of digitalising systems, CAD systems and NC-manufacturing systems are being studied, tested and evaluated. Information for the database specification regarding foot anatomy and fit as well as modelling applications have been collected.

KEYWORDS

Design; Machine Tools; Machining; Surface Treatment Technologies; CAE/ CAD/CAM Systems

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AUTOMATION OF A LEATHER PIECE FEED SYSTEM FOR THE MANUFACTURE OF SHOE UPPERS

Starting date: 1991 ***Duration:*** 30 months

OBJECTIVES

The aim of the project is to achieve highly flexible automation of the tasks involved in the manufacture of shoe uppers. We are already capable of conveying single piecs of leather of a recognized size and shape to work stations in a predetermined position. The project aims to exploit thto automate the transfer and dynamic conveying of pieces for pre-stitching and stitching in a flexible, adaptable and cost-effective way.

We shall restrict ourselves to "flat" work surface operations, which form a considerable part of the work of stitching lines and prepare for the subsequent stages of the automated process. Study and experiment prototypes will be produced for two complementary and representative examples of piece conveying constraints : skiving and flat seaming.

The first work will be to obtain a standard principle for the guiding of pieces on a flat plane work surface. The guide principle will be validated by experimenting on research models. The second part of the project will be to adapt the results obtained for guiding to skiving and flat seaming. Local and general actuators will be used. The results will be validated by experimenting on prototype automatic skiving and stitching stations.

The results of the project may give rise to industrial-scale development by machine manufacturers to produce automatic machines and make it possible to couple and handle the production rates and flow of data in an integrated factory production line.

We estimate that 30 to 50% of shoe upper manufacturing operations will be affected by these results.

KEYWORDS

Flexible automation; Stitching; Skiving; Leather; Shoes

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APPLICATION OF ULTRASONICS IN THE PHYSICO-CHEMICAL CLEANING OF TEXTILES IN DOMESTIC WASHING MACHINES

Starting date: July 1990 ***Duration:*** 36 months

OBJECTIVES

The main objective of the project is to provide the theoretical and experimental basis for a new technology for the washing of domestic textiles, based on the application of high power ultrasound. It is known that the acoustic phenomena associated with the application of ultrasonics, i.e. cavitation and acoustic streaming, strongly promote the loosening of soil from solid, rigid substrates. Very little is known, however, on the effect of US on the cleaning of textiles dispersed in a detergent-water mixture.

To achieve this objective, the following research elements have been defined:

- study of the linear and nonlinear propagation of ultrasonic waves in an inhomogeneous medium consisting of textile substrates in a liquid;
- determination of the effects of ultrasound on the basic phenomena of any cleaning process, soil loosening and mass transfer;
- study of the effect of ultrasonics on chemical reactions involved in, or potentially applicable to the wash process;
- development of design principles and experimental set-ups for an integrated flexible washing system using ultrasonics.

ACHIEVEMENTS TO DATE

At this ealy stage of the project, three main results have been demonstrated:

- US radiation leads to an increased rate of emulsification at the oil/water interface. This effect is accelerated in presence of detergents.
- Improved fluid flow inside yarns in presence of US was demonstrated. This showed that US waves contribute to the detergency process by the induced improved transport process.
- The interaction between US waves and cotton fibres was shown to be a two stage process: first, the fibres become rounded and more resistant. Then, enhanced by improved chemical access, the depolymerisation process takes over and the fibres become damaged.

KEYWORDS Ultrasonics; Textiles

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Contract no: BREU-0137
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SYSTEM FOR AUTOMATED FAULT DETECTION AND DIGITISATION OF LEATHER SKINS AND FABRICS

Starting date: February 1989 ***Duration***: 36 months

OBJECTIVES

- Design and implementation of image processing algorithms for the automated detection of leather faults and hide contour.
- Development of a Leather Scanner Prototype based in imaging techniques for the auto,ated detection and digitisation of leather hides. Resolution 1mm, scanning dimensions: 200 x 300 cm.
- Development of a software package for automated quality level classification of digitised leather hides.
- Development of a software package for automated nesting of patterns on digitsed hides meeting quality and industrial requirements..

ACHIEVEMENTS TO DATE

- Full characterisation of leather faults.
- Creation of a complete catalogue including samples for every type of fault and for many different types of leather.
- Design and implementation of new image processing algorithms for leather fault and contour detection.
- First prototype of Leather Scanner. Scanning area: 100x180cm
- First release of software package for automised Quality Level classification of digitised leather hides.
- First release of software package for automated pattern nesting of digitised leather hides.

KEYWORDS

Shoe leather; Quality control/Inspection; Leather; Imaging/Image processing; Automation/CIM.

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Contract no: RI1B-266
Proposal no: P-2195

RESTORING COMPETITIVENESS OF THE EUROPEAN LEATHER INDUSTRIES THROUGH NOVEL MANUFACTURING PROCEDURES MEETING SAFETY, HEALTH, ENVIRONMENTAL NEEDS

Starting date: September 1991 ***Duration:*** 42 months

OBJECTIVES

This project concerns the R&D which will enable the traditional sequential working practices of leather manufacture to be replaced by a fully integrated production system using reduced quantities of less environmentally damaging chemicals, hence improving the position of the European Industry. Machines and chemical products will need to be harmonised by physical modification of the mechanics of the process, with short baths and better penetration by ultrasonics/vibrators/pressure, and by the selection of the chemical products used, their environmental nature and reactivity.

If successful, this novel process will improve the competitiveness of the European Leather industry by the introduction of novel production systems designed also to meet the needs of downstream industries, such as footwear, upholstery and garments for shorter response times.

Particular regard is to be made to : a) environment; b) hygiene and safety of workers; c) productivity; d) reduction/elimination of dangerous chemical products; e) quality of the skins and quality control; f) optimal use of the substance of the raw material - "skin"; g) use of by-products and waste for other industries-fertilizers, gelatines, etc.

Understanding and knowledge of the fundamental parameters is to be acquired and its relevance to the requirements of downstream industries is to be captured in a data and rule-based intelligent expert system in order to maximize the experience gained and enable the technology to be widely adopted in a minimum period of time.

KEYWORDS Shoe/Leather; Recovery/Recycling; Leather; Databases/ Expert systems; Ecology/Environment; Safety management

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Contract no:
Proposal no: BE-4184

EXCIMER LASER PROCESSING OF FLEXIBLE MATERIALS

Starting date: March 1990 ***Duration:*** 36 months

OBJECTIVES

In the proposal, schemes for the adaptation of excimer laser processing, technology for plastics and flexible material industries will be examined; in order to promote the introduction of high power excimer laser technology in industries dealing with flexible materials.

The research programme's aims are:

- to assess the feasibility of using high power excimer lasers such as PVC and polyethylene:non-woven combination.
- to determine specific technical; economic and quality advantages of using excimer laser for flexible material processing compared to conventional machining techniques.
- to build prototype excimer laser based workstations for automated cutting and drilling of the above mentioned materials.

ACHIEVEMENTS TO DATE

During the first year of the project the following work has been performed:

- cutting and drilling experiments of PVC and PVC/fabric samples to establish the basic cutting rates using; KrF and XeCl excimer laser
- cutting experiments of polyethylene/non-woven samples in thin sheet form, in order to assess the excimer laser processing parameters; using ArF KrF and XeCl lasers.
- assessment of the cutting and/or drilling quality and comparison with the other conventional techniques.
- evaluation of appropriate prototype beam delivery system including optical fibres.
- preliminary design of the automated laboratory prototype systems for cutting thin sheets of polyethylene:non-woven material.

KEYWORDS Materials processing; Flexible material; Polymers; Excimer laser; Laser technology; Machining

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Contract no: BREU-0263
Proposal no: BE-3612

INTEGRATING AUTOMATIC HANDLING OF FLEXIBLE MATERIAL COMPOSITE COMPONENT DESIGN AND QUALITY ASSURANCE PROCEDURES

Starting date: March 1990 ***Duration:*** 36 months

OBJECTIVES

The broad objectives are to develop an integrated system to automatically process flexible sheet material, particularly composite prepegs, from the delivery condition to a consolidated rigid product.

This involves automating the de-reeling, cutting, handling and laying up of a range of prepreg materials. These processes must be integrated with a vision system which will inspect the raw material for defects, and check the consolidated layers for a range of known manufacturing defects.

Other objectives include defining the manufacturing capabilities and limitations of the process. This information will be used by a database being developed for use by designers to help them design to cost.

ACHIEVEMENTS TO DATE

The definition and study phases are complete. A schematic layout of the system is agreed and detailed design is being started.

Experimentation has included peeling the backing sheets from the prepreg, simulation of the handling system to predict collision avoidance, cutting materials with different types of tooling, detection of known material defects and consolidation using a robot arm. The database structure has been determined and subcontract modules identified. A prototype of each subsystem will be available in late 1991.

KEYWORDS

Processing (food, non rigid materials); Composites (polymer matrix); Flexible/Non rigid materials; Automation/CIM; Imaging/Image processing; Materials processing; Machine systems integration

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Contract no: BREU-0108
Proposal no: BE-3414

COMPUTER INTEGRATED MANUFACTURING (CIM) SYSTEM FOR THE MEAT PROCESSING INDUSTRY

Starting date: February 1989 ***Duration:*** 35 months

OBJECTIVES

The objectives of the research work are:

- a generic CIM concept for the meat processing industry;
- methods for implementation of specific CIM systems based on the generic concept as a platform;
- a number of CIM key software modules (domain specific cell controller);
- a Test Workstation for computer simulation and evaluation of selected CIM key software modules.

The research work will be based upon the experience from implementation of a full blown CIM system for production of sausages and other minced meat based products and the results will be validated through a realistic case study considering a future CIM system for production of ham and shoulder products.

ACHIEVEMENTS TO DATE

The results achieved to date are the development of the following methods/tools, all generally applicable within the meat processing domain:

- a generic concept of a CIM system;
- a project model for implementation of CIM systems;
- a tool for analysis and specification of CIM systems;
- a cell controller core including flexible planning and scheduling functions (interactive manipulation of graphical Gantt chart is possible) using UNIX, C++, ORACLE and XVIEW as implementation platform.

A realistic case for validation of all results has been described (Target Factory).

KEYWORDS

Food industry; Food processing; Automation/CIM; Control systems; Planning/ Scheduling; Simulation

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Contract no: RI1B-282
Proposal no: P-2248

ROBOTIC BUTCHERY FOR MEAT PRODUCTION

Starting date: 1991-1992 ***Duration:*** —

OBJECTIVES

The aim of this project is to achieve a demonstration of a robotic system to be developed for the butchery of pork carcasses into primals. The knowledge gains will help the development of a production machine after the project end but the full specifications of such a machine will be reached within the project time scale.

The programme of work will examine the products and the processes of butchery aiming to define automation solution based on developments in the following fields :

- Artificial vision for the recognition of carcasses for the purposes of cutting
- Sensors and cutting devices for robot guidance. Automatic handling and fastening for automatic manipulation of carcasses for cutting of primals
- Software for control and real-time optimization of the cutting process with the use of an integrated robot system
- Modelling to support decisions and strategies for automatic handling, manipulation and cut-up of pork.

The proposed system will be the first butchery machine to be developed and demonstrated in an industrial environment.

KEYWORDS

Food/Drink/Water; Processing (food, non rigid materials); Robotics

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Contract no: BREU-0484
Proposal no: BE-4420

DEVELOPMENT OF SENSING, CONTROLLING AND HANDLING OF AUTOMATION TECHNOLOGY FOR SEPARATION OF FLEXIBLE FOOD MATERIALS WITH EVISCERATION OF PIG CARCASSES AS MODEL PROCESS

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

The main objectives are to develop and demonstrate technologies for automation of handling and processing of flexible materials in manufacturing processes with small tolerances and high quality and high productivity.

A fully automated system capable of measuring, classifying and processing pig carcasses is needed by the food industry. The large variability in the shape of pigs makes it difficult to obtain exact cutting and handling which is compatible with the high manual processing speed, i.e. 5 to 10 sec. per pig, that is carried out in most slaughterhouses.

The aim of the present proposal is to produce a fully automated system which will measure the pig in three dimensions, process the information, and transmit the relevant data to the mechanical system which is to perform the evisceration process of the pig carcasses. New methods for handling and manipulating flexible products such as pork will be developed.

A positive outcome of the project may also be applied for automation in other parts of the slaughtering process. Furthermore, the results may be applied for automatic production of other flexible heterogeneous products.

A major motivation for the present project is also to ease the environmental constraints on employees, this is considered essential in order to maintain a competitive food production industry in Europe.

KEYWORDS

Process automation; Materials processing; Flexible/Non Rigid Materials; Handling; Evisceration; Pig Model; Sensor Systems

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Contract no: BREU-0474
Proposal no: BE-4152

QUALITY IMPROVEMENT IN MEAT TRANSFORMATION PROCESS BY VISION SENSORS AND KNOWLEDGE BASED TECHNIQUES - PROMEAT

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

Fundamental characteristics, common to all meat transformation processes are the biochemical complexity and cost of the raw material, the difficulty in making objective measurements through non-destructive techniques, and the lack of sensors suitable to describe all the processes.

The project addresses these problems to improve process control capabilities, final product quality and to reduce costs.

A system based on computer technology is developed to be integrated within present-day manufacturing installation.

It will improve data collection, process supervision and quality control. The implementation of two demonstrators will permit the assessment of system performances into two important meat processing sectors.

Two advanced Information Technology branches,will provide the necessary technological background to address the above problems : *Artificial Intelligence and Computer Vision.*

The main objectives of the project are:

- to realize a general system architecture allowing reduction of miseconomies and production costs and improving the final product quality both in meat processing and in related industrial sectors
- to develop an innovative data acquisition system, based on computer vision, to measure, in an objective way, meat quality parameters usually evaluated only in subjective manner
- to develop an intelligent module able to integrate input information from multiple sources to support process supervision and quality control
- to experiment and assess the developed prototype system through two demonstrators.

Seven partners from three EEC countries will participate in the proposed project, according to a well-balanced structure showing both a horizontal (among countries) and a vertical one (among technological sectors).

KEYWORDS Quality control; Food; Vision; Expert systems; Meat processing; Process control

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Contract no: BREU-0476
Proposal no: BE-4265

SCHEDULEZ-DYNAMIC SCHEDULING TOOLBOX

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

The goal of ScheduleZ is to create a system for the configuration of highly efficient dynamic scheduling systems for manufacturers and distributors of short shelf-life and fast turnover products. These manufacturers are faced with problems of decreasing lead times, smaller batch sizes, increasing product variety, and little opportunity to manufacture to stock. Consequently, efficient utilization of resources (both capital and labour) is becoming evermore difficult. Current product offerings are too generic. They require the user to map his production onto a basic and restrictive set of functions which take no account of the particular manufacturing problems encountered in his market segment. The alternative,which is generally too costly to contemplate, is for the manufacturer to commission a bespoke system. ScheduleZ aims to create a tool box for these industries, that can be used to model manufacturing strategies and configure production scheduling systems which explicitly map onto the real world production and supply chain problems encountered. The system will make use of innovative OOD reusable code libraries. It will provide highly innovative multicriteria objective setting facilities and will be researched and tested in a live manufacturing environment.

The Consortium partners represent a vertically integrated team, including two major end-users, system houses and research establishments.

KEYWORDS

Logistics/Production planning; Automation/CIM; Scheduling.

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Proposal no: BE-4140

AREA 4

Technologies for manufacturing processes

MODIFICATION OF SURFACE PROPERTIES OF MATERIALS BY ION BOMBARDMENT

Starting date: January 1987 ***Duration:*** 52months

OBJECTIVES

In this project, ion bombardment for surface properties improvement will be studied in two practical applications: electrical contact materials and tool steels. For the contact materials the objective is to replace noble metals such as Ag and Au by implanted Cu to improve the corrosion resistance. In the case of tool steels, a variety of steels will be implanted and examined using laboratory tests and field trials to establish optimum wear resistance. The ion bombardment experiments are to be supplemented by surface analysis in order to characterize the microstructure of the implanted surface layers. The ion surface treatment will also include the intermixing of various thin overlayers deposited using IBED and PVD-based techniques.

ACHIEVEMENTS TO DATE

Sputter deposited MoSx films were bombarded by 400 keV argon ions to a dose of $10^{16}/cm^2$ and showed excellent lubrication properties. The coefficient of friction and wear of different types of steel were investigated after being implanted. Dose, energy and type of ions were varied. For some implants extremely good results were obtained. For these implants the microstructure was studied by Mössbauer spectroscopy. Punches-implanted covered with PVD and CVD layers- were tested. Some of the implantedpunches gave a significant increase in lifetime. Polycrystalline copper was implanted with different types of ions and exposed to an atmosphere of H_2O and H_2S. For a 5 x $10^{17}Al^+/cm^2$ implanted sample the amount of corrsion products was reduced by a factor of 50 when compared to an unimplanted one. Furthermore ion bombarded photoresist layers showed excellent wear reducing properties.

KEYWORDS

Aeronautics/Aerospace; Engineering (process); Machining; Coatings/Thin films; Machine tools; Surface treatment tecnologies; Tool/Dies.

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Contract no: RI1B-123
Proposal no: P-1357

THE DEVELOPMENT OF AN ION IMPLANTATION PROCESS AS APPLIED TO THE IMPROVEMENT OF SERVICE LIFE AND RELIABILITY OF ROLLING BEARINGS IN GAS TURBINE ENGINES

Starting date: April 1989 ***Duration:*** 48 months

OBJECTIVES

The objectives of the project are:

- develop an ion implantation technique for implanting bearing components with the metallic species chromium and tantalum and the dual implantation of yttrium plus nitrogen
- test implanted components in order to assess and quantify the anticipated benefits gained and also determine the optimum implant species and implantations parameters
- develop an industrially viable quality assurance technique and finally to prove that the benefits obtained prevail under severe service conditions.

The overall objective of the project is to improve the service life and reliability of gas turbine engine bearings by increasing their corrosion resistance and rolling contact fatigue life, particularly in situations where the lubricating oil is subject to salt water contamination.

ACHIEVEMENTS TO DATE

The main achievements to date include:

- manufacture of the test coupons and polymet rods in the main aero bearing steels, M50 and T1, and also the new carburizing steel M50 NiL
- design, manufacture and commissioning of component handling and beam scanning systems, including a dedicated ball manipulator for the uniform implantation of balls
- successful implantation of all test coupons and polymet rods with the metallic species chromium and tantalum and dual implantation of yttrium plus nitrogen, each at four different dosage levels
- corrosion testing of implanted test coupons using potentiometric polarisation, open circuit potential versus time, and cyclic voltametry. The results of the corrosion tests show a significant improvement in the corrosion resistance of M50, T1 and M50 NiL materials implanted with chromium and tantalum
- characterisation of the implantation regimes using RBS and NRA techniques.

KEYWORDS Ion implantation; Rolling bearings; Rolling contact fatigue; Surface treatment technologies; Corrosion resistance.

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Contract no: RI1B-284
Proposal no: P-2182

RESEARCH AND DEVELOPMENT OF ION BEAM ASSISTED DEPOSITION FACILITIES TO TREAT COMPLEX GEOMETRICAL SHAPES FOR HIGH DENSITY ADHESIVE AND WEARLESS COATINGS

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

The aim of this project is to overcome all the disadvantages of the present CVD and PVD techniques. To achieve this combinations of Physical Vapor Deposition (P.V.D.) or Plasma Assisted Chemical Vapor Deposition (P.A.C.V.D.) enhanced by high energy ion beam bombardment is studied.

ACHIEVEMENTS TO DATE

At the end of phase one the following results are shown.

1) Titanium nitride can be synthesized by numerous methods including C.V.D., P.V.D., P.A.C.V.D., I.B.A.D. The aim of this phase was to demonstrate the utility of ion assistance in low temperature deposition process for increasing the film quality and performances.

By comparison of different properties, mainly morphology, chemical composition, mechanical properties and chemical resistance, phase one has demonstrated that; ▪it is possible to obtain TiN at low temperature (250°C) with an acceptable growth rate; ▪the stoichiometry can be adjusted in a large range of composition; ▪the coatings are crystalline to XRD with a preferential orientation linked to the incident ion energy.

High energy bombardment leads to columnar structure

2) Ion Beam Assisted Deposition leads to film densification. The mechanism of this densification may be the related atomic displacement in the collision cascades, enhanced surface and bulk diffusion, recoil iplantation and ion-mixing mechanisms. One consequence of I.B.A.D. is void elimination.

3) Because of the line of sight nature of conventional I.B.A.D., a manipulator stage is required to rotate and translate the target in the beam to bombard al sides of the target.

To avoid this manipulator a new process is developed. In P.S.I.A.D. (Plasma Source Ion Assisted Deposition) the target is placed directly in the plasma source and is pulse biased to negative potential relative to the chamber wall. Ions are acclerated towards the target surface, across the plasma sheath, eliminating the line of sight problems of conventional I.B.A.D. and thus all the exposed areas are bombarded simultaneously. The elimination of target manipulation is a particular advantage of P.S.I.A.D., especially for heavy and large targets.

Objective of Phase II: Design and construction of a prototype machine.

KEYWORDS Plasma; Ion deposition; Coating; Low temperature.

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Contract no: RI1B-298
Proposal no: P-2234

ADVANCED SURFACE ENGINEERING PROCESSES TO ENHANCE THE DYNAMIC PERFORMANCE OF SPRINGS

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

This project aims to develop surface engineering processes that will improve the dynamic performance of coil springs to a level that is unattainable with current technology. Improved dynamic performance will enable the design of lighter springs, capable of operating at higher speeds, and with greater safety margins, thus affording improved reliability.

The effect of surface engineering processes such as shot peening, physical vapour deposition, ion implantation and carbo-nitriding, and combinations thereof, will be accurately measured by undertaking a very large number of spring fatigue tests. In order to verify that the results of these laboratory fatigue tests are reproduced in service, engine tests and component testing, incorporating redesigned springs with the newly developed surface engineering processes, will be undertaken by two of Europe's leading manufacturing companies.

The result of this research project will be disseminated to a large number of the SME springmakers upon whom European manufacturing industry is dependent if it is to remain competitive in world markets.

KEYWORDS

Automotive, Components & Parts; Mechanical engineering/Machinery; Ferrous; Reliability; Surface treatment technologies; Research/Development; Springs

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Contract no: BREU-0435
Proposal no: P-4585

IMPROVEMENT IN THE CONTROL AND ATTAINMENT OF HIGH SPEED ELECTRODEPOSITION PROCESSES

Starting date: June 1989 ***Duration:*** 48 months

OBJECTIVES

The project is concerned with methods of increasing the electrodeposition rates of metals whilst achieving the equivalent properties obtained from conventional techniques. Both theoretical and experimental approaches will be used The theoretical aspect enables a fuller understanding of the processes that control high speed deposition Different cell designs will be adapted to achieve optimum plating conditions. Pulsed currents will then be superimposed to increase the limiting current densities. The fully optimized processes will be extended to pilot scale and their efficieny tested for electrocoating of steel strips and the selective deposition of precious metals onto electrical contacts. From this, novel processes can be offered of special use to the electrical and steel industries.

ACHIEVEMENTS TO DATE

Demonstrators have been prepared using jet equipment. The initial construction of experimental apparatus has been accomplished and four devices for simulating and optimizing high speed electrodeposition processes are fully operational: a Rotating Cylinder Electrode with tangential electrolyte flow (RCE-TF), a Rotating Cylinder Electrode with a jet unit (RCE-JF), a Continuous Circulation Cell (CCC), a jet plating unit with a direct-write facility.and High Speed Selective Jet Electrodeposition (HSSJE) with direct-writing facility have been applied to Cu and Au electrolytes; high speed electrodeposition has been applied to concentrated zinc sulphate solutions. For both applications morphological diagrams have been produced qualitatively relating current density to Reynolds Number (Re) for Au, Cu and Zn, enabling max. or optimum current density to be fixed in advance, for deposits with optimized morphology. Fundamental interpretation and process enhancement in above mentioned systems, enabled limiting currents to be detected by classical polarization methods. Initial evalution of mass transfer enhancement due to turbulence produced by superimposition of motions was made. For zinc concentrated solutions and jet system it was necessary to investigate "the electrochemical tracer method", shown to be promising in quantifying limiting currents. For pulse plating, gold, copper and zinc deposits have been obtained. Preliminary indications have been obtained for jet system. First sets of pulsed zinc deposits have shown homogeneneous coatings equivalent to continuous ones.

KEYWORDS Automotive, Electronic industry; Engineering (process); Coatings; Fluid dynamics; Materials characterization/Testing; Pulse plating.

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Contract no: RI1B-304
Proposal no: P-2158

NEW PLATING TECHNIQUES FOR ALUMINIUM ALLOYS

Starting date: June 1990 ***Duration:*** 36 months

OBJECTIVES

The development of new surface treatment processes for high performance aluminium alloys used in the aeronautical industry is a key factor in improving the properties of these materials and solving environmental problems. The selected processes are:

- new applications of well-known processes, such as physical vapour deposition (magnetron sputtering, evaporation, low temperature cathodic arc deposition) and anodization
- original methods to modify the properties of the superficial oxide layers using ion beam bombardment such as ion implantation and ion beam mixing.

The major objectives are to:

- eliminate the surface treatment baths which use toxic chromium VI based products
- increase the resistance to corrosion of the unclad materials in order to reach an equivalent level to that obtained using clad materials
- reduce the fatigue strength drop observed using conventional treatments.

ACHIEVEMENTS TO DATE

The study has been in progress for 12 months. The completed tasks concern the standardization of test procedures, the choice and the supplying of substrates. The assessment of performance levels reached with the studied processes is on hand. The preliminary investigations demonstrate that the objectives fixed for the study should be achieved for all the studied processes.

KEYWORDS

Aeronautics/Aerospace; Processing; Coatings/Thin films; Surface treatment technologies

PRIME PARTNER

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Contract no: BREU-0161
Proposal no: P-3197

MODELLIZATION AND PROCESS CONTROL OF LIQUID-CONTAINING METALLIC ELECTROCOATINGS

Starting date: 1991-1992 ***Duration:*** 42 months

OBJECTIVES

Composite materials obtained from a judicious combination of different types of materials like metals, ceramics and polymers have been successfully developed and have pushed forward the frontiers of materials applications. This development was not restricted to bulk composite materials, also composite coatings like e.g. Ni-PTFE, Ni-SiC and Co-Cr_2O_3 are nowadays well-performing in specific applications where respectively self-lubrication, wear-resistance and high temperature oxidation resistance are required. Recently the possibility to incorporate large vol% of liquids in metallic coatings obtained by electrodeposition has opened new avenues. Codeposition of liquids is realized through the use of liquid-containing microcapsules added to the plating baths. The proposed research aims at supporting the development of liquid-containing metallic coatings by widening and deepening the insight into the basic principles governing the codeposition of microcapsules. This will be realized through a unique multidisciplinary research effort in which electrochemists, colloid chemists, materials and chemical processing engineers will join forces. Major tasks are the optimization of the production technology of liquid-containing microcapsules with tailored characteristics, the development of appropriate process control techniques allowing a qualitative and quantitative in-situ control of the codeposition and the achievement of a breakthrough in the mathematical modelling of the liquid-containing metallic electrocoating process. From this research a new type of coated materials designed as self lubricating or corrosion resistant materials, wear detector or metallic foam will result.

KEYWORDS

Coatings/Thin films; Surface treatment technologies; Tribology; Materials processing; Materials science; Particle technology

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Contract no: BREU-0402
Proposal no: BE-4172

THE AUTOCATALYTIC DEPOSITION OF GOLD, SILVER AND THE DEVELOPMENT OF NOVEL PRINTED CIRCUIT BOARDS

Starting date: January 1990 ***Duration:*** 48 months

OBJECTIVES

The project is aimed at the extension of the process of aqueous autocatalytic reduction of metals to incorporate the metals gold, silver and their alloys. A study of the theoretical considerations of the autocatalytic systems followed by the development of novel formulations is proposed. Additionally the study of catalytic activity and methods to deposit electroless metals onto anodized aluminium will be explored, aimed at developing a process for the production of novel printed circuit substrates. From this work it is anticipated that novel processes and products can be offered of special use to the electrical and electronic industries.

KEYWORDS

Surface treatment technologies; Coatings/Thin films; Materials science

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Proposal no: BE-3412

DIAMOND AND SILICON CARBIDE SENSORS (DISCS)

Starting date: April 1990 ***Duration:*** 36 months

OBJECTIVES

The DISCS project has taken three main objectives: **1.** to deposit diamond and silicon carbide thin films using a range of CVD technologies; **2.** to use advanced manufacturing techniques to process the diamond and silicon carbide films, e.g. using plasmas and ion beams; **3.** to fabricate prototype, advanced sensing structures in the carbide thin films.

ACHIEVEMENTS TO DATE

The DISCS project has demonstrated the following main achievements:

Diamond films have been deposited using thermal filament and microwave CVD technologies. Deposition onto substrates up to 50mm in diameter has been demostrated. In addition multilayer films have been grown of undoped and doped films using boron precursor gases as the dopant carrier. Selected area deposition of the films has also been demonstrated, especially in diamond technology. These results demonstrate that it is sensible to consider the fabrication of sensing structures of doped films. Downstream processing of the films has demonstrated that it is possible to reactive ion beam etch the structures required to give a very high quality of structure definition. Metal contacts to the films have also been formed in order to make an initial assessment of the electrical properties of the as-deposited and subsequently machined materials.

The performances of the films at high temperatures has begun. Laser Raman, resistivity, capacitance and x-ray measurements have all been undertaken at elevated temperatures. Depending on the technique being used, temperatures up to 850°C have been used to collect data. The results, thus far, indicate that the films are of high quality. There is evidence to suggest that the properties of the films are affected by temperature. However, above a minimum temperature of approximately 350°C, the properties remain stable and reproducible. There is evidence to suggest that this stability is connected with the movement of minority species, such as hydrogen, within the films. These initial observations are being further explored.

KEYWORDS Aeronautics/Aerospace; Automotive, Components & Parts; Electrical / Electronic industry; Sensors/Signal processing; Diamond/ Superhard materials

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Contract no: BREU-0058
Proposal no: BE-3404

THE DEVELOPMENT OF DIAMOND FILM TECHNOLOGY AND ITS APPLICATION TO IMPROVE THE QUALITY AND DURABILITY OF OPTICAL FIBRES

Starting date: March 1990 ***Duration:*** 48 months

OBJECTIVES

Low pressure diamond film deposition is an important emerging technology still at the precommercial stage worldwide, which has many important potential applications. To date there has been little serious European research on this topic.

This project aims to bring a European research consortium up to and beyond the forefront of this technology by designing and fabricating optimized hardware for diamond film deposition, and by systematically mastering the chemistry of the deposition process.

Furthermore, we intend to develop an application for the technology by focusing specifically on the coating of optical fibres to improve their long-term reliability. This will be a major innovation.

The main quantified targets are to produce diamond film coated optical fibres with stress corrosion susceptibility factors >200 at fibre drawing speeds up to 10 m/s. The successful achievement of these targets would result in world leadership in fibre optic technology for European industry.

The project will also lay the foundations for other commercial applications of diamond technology in various engineering and electronics markets.

KEYWORDS

Medical equipment; Laser technology; Coatings; Laser delivery systems; Sensors; Fibre optics; Gas systems

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Contract no: BREU-0056
Proposal no: BE-3296

THE DEVELOPMENT OF A NOVEL HYDROGEN PROBE FOR PLASMA CHARACTERIZATION AND CONTROL DURING DIAMOND FILM DEPOSITION

Starting date: August 1991 ***Duration:*** 36 months

OBJECTIVES

The need for precise control and characterization of thin film deposition over a wide range of pressures and plasma conditions is of paramount importance. A novel probe designed to quantify nascent atomic species, particularly hydrogen, will be developed.

This probe will be used along with other techniques to enhance the deposition of diamondlike carbon (DLC) films. The main emphasis centers on the measurement of the atomic hydrogen fraction in the reactor discharge since this has been found to be of fundamental importance. It is also proposed to measure the other basic plasma parameters such as electron density, electron temperature, the electron energy distribution function and the plasma potential.

It is proposed to develop a technique called Vacuum Ultraviolet (VUV) - Multiphoton Laser Induced Fluorescence (LIF) to quantitatively measure atomic hydrogen concentration in the plasma during DLC deposition. Other plasma parameters will be simultaneously measured using the techniques of emission spectroscopy and Langmuir probe-the latter modified both for operation at high pressures (50-100 Torr) and with high frequency discharges (1-13.56 MHz).

These measurements will be correlated with DLC film quality evaluated using surface characterization techniques. Upon successful development of this probe a field application study on its industrial relevance will be undertaken.

KEYWORDS

Coatings/Thin films; Diamond/Superhard materials; Laser technology/Power beams; Materials characterization/Testing; Surface treatment technologies

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IN-SITU CONTROL OF PLASMA CHEMICAL VAPOUR DEPOSITED CUBIC BORON NITRIDE FILMS

Starting date: July 1991 ***Duration:*** 48 months

OBJECTIVES

This type 2 project is an in-depth research study focussing on the in-situ control of plasma assisted deposition of cubic boron nitride film with the final goal to understand and model the chemistry and physical mechanisms of their generation.

By comparison of quality and chemical nature of cubic BN films generated by different plasma deposition techniques (radio-frequency, micro-wave, remote plasma and hot filament technique) the partners will collect data which allow clear judgement on which technique is the most promising one in terms of desired quality and costs effectiveness, and the most suitable one for up-scaling to large area films, and high deposition rates processes.

By development and deployment of in-situ and non intrusive diagnostics (ellipsometry, emission and mass-spectroscopy, electrical and thermal conductivity probes) both the film growth and the plasma gas phase will be analysed.

On a quantitative basis, the target is to obtain deposition rates of the order of micrometres per hour on substrates areas up to 1 dm^2.

The project is divided into two parts:

Part 1 (24 months): set-up of PACVD chambers, plasma diagnostics techniques and in-situ measurements.

Part 2 (24 months): investigation of the influence of hardware and process parameters settlings on plasma composition and cubic BN properties on Si and steel substrates.

KEYWORDS

Materials processing; Coatings/Thin films; Surface treatment technologies; Plasma CVD

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LASER TREATMENT AS A TOOL FOR TAILORING THE SURFACE COMPOSITION OF ALLOY COMPONENTS TO ENGINEERING APPLICATIONS

Starting date: April 1988 ***Duration:*** 48 months

OBJECTIVES

Previous studies on simple flat samples have shown that surface structures and compositions with unique properties can be produced by laser surface-alloying and cladding.

The main objectives of the project are to develop both the application techniques and the composition and structure of the surface alloys to allow parts of more complex shape to be welded.

The aim is to improve the current lifetime of 100,000 and 200,000 hours for steam and gas turbines by at least 50%, by developing surface alloys and claddings with greater erosion, fatigue, and wear resistance than those currently available.

A further aim is to obtain better erosion and stress-corrosion cracking resistance of the order of 50% and a reduction in temper embrittlement and residual stresses for component shape.

For the next generation of steam turbines designed for higher efficiency and greater economy, the blade length of the last blades must be increased by 30-35%, making for an increase of 50% at the steam passage section, which necessitates the use of cladded titanium alloy blades instead of cladded steels. The minimum goal is to achieve the same statistical lifetime of the titanium blades as currently obtained for the smaller clad steel blades.

ACHIEVEMENTS TO DATE

Laser processing procedures have been optimzed for surface treatment of Cr-steel, Ti and Ni-specimens, using a number of different coatings.Specimens of complex geometry have been processed in order to determine the influence of the geometry on the resulting surface layer.Encouraging results have been obtained as regards properties of the laser processed surface (i.e. erosion resistance, corrosion resistance).Work is now directed towards the processing of real world components, e.g. turbine blades and valve seats.

KEYWORDS Energy/Power generaton; Processing (minerals & metals); Metallic structeral materials; Laser technology/Power beams; Research/ Development.

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Contract no: RI1B-185
Proposal no: P-2178

LASER SURFACE TREATMENT OF MECHANICAL COMPONENTS FOR IMPROVED MECHANICAL AND PHYSICAL PROPERTIES

Starting date: August 1988 ***Duration:*** 48 months

OBJECTIVES

The objectives are to:

- create new surface with new alloy systems, particle injection and cladding, using laser treatment on six metallic substrates of SG cast iron, low alloy steel, stainless steel, a 7000 series aluminium alloy, Titanium TA6V alloys, and INCONEL superalloy
- characterize their surface treatments (wear, fatigue and corrosion resistance)
- apply optimized laser surface treatments to industrial case studies in automotive, nuclear and aeronautical
- adapt laser tooling to 3D treatment handling and monitoring. Targets to be reached are beam position ±0.2mm, power density +5% maximum, table speed 20m/min
- improve surface characteristics of industrial components.

ACHIEVEMENTS TO DATE

The objectives achieved are:

- gas lenses can be used with high power beams to reshape the beam laser
- the extent of the beam reshaping is understood and calculations can be made for any gas structure
- two copper domes were constructed to collect the laser radiation reflected from the treated metal surfaces. The systems efficiency is good, permitting 60-70% of the total energy to be absorbed without use of photo-absorbed coating
- curves of isodepth of transformation hardening treatment are available for Pearlistic Cast Iron and Iron steel
- tempering zone of transformation hardening treatment does not depend on the percentage of overlap.

KEYWORDS Laser technology/Power beams; Surface treatment technologies; Aeronautics; Automotive; Energy; Mechanical engineering

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Proposal no: P-2357

UPGRADING ALUMINIUM AND STEEL BY LASER SURFACE TREATMENT FOR ENHANCED CORROSION RESISTANCE

Starting date: July 1991 ***Duration:*** 36 months

OBJECTIVES

Beam/workpiece interaction variables during laser surface processing of Al and steel for the control of composition and microstructure will be investigated to allow the development of the science and technology underlying the formation of surface engineered passive alloys with outstanding resistance to corrosion in aqueous environments.

Novel processing techniques to be investigated include: mixed beam processing of aluminium; laser surface alloying via incorporation of metered mixtures of metal powders for control of alloying element composition; depth and uniformity of alloying in one step processing; bithermal powder incorporation; localised area alloying; increase in the area processed in a single pass.

Laser surface processed materials to be investigated include aluminium and aluminium alloy surfaces with ▪ enrichment of Cr and Mo ▪ microcrystalline microstructure with absence of anodic secondary phases ▪ amorphous microstructure; plain carbon steel and medium alloy steel with: ▪-surface composition analogous to high alloy stainless steel of Fe-Cr-Ni-Mo alloys for specific corrosion resistance applications ▪ amorphous surfaces based on Fe-B or Fe-Cr-B-C.

Evaluation procedures include characterisation by metallography and microscopy (SEM, EDAX, TEM, scanning Auger, X-ray microprobe techniques) and corrosion testing in relevant electrolytes to determine enhancement of passivity with respect to conventional bulk materials of the same composition by a range of immersion and electrochemical techniques (which include dc polarisation, cyclic voltammetry, ac impedance) and in situ optical techniques. Iterative linkage of these elements with laser processing investigation and mathematical modelling of conditions required for control of surface alloying will allow the optimization of corrosion resistance in a range of applications for a broad spectrum of European industrial sectors.

KEYWORDS Materials processing; Laser technology/Power beams; Materials science

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Contract no: BREU-0494
Proposal no: BE-4305

PLASMA AND LASER INDUCED VAPOUR DEPOSITION OF HERMETIC COATINGS ON OPTICAL FIBRES ('PLAID')

Starting date: March 1990 ***Duration:*** 42 months

OBJECTIVES

The goal of the project is the development of an efficient and reliable hermetic coating technology to improve the resistance to corrosion and static fatigue of optical fibres. This will allow small radius bendings (a few centimetres), well adapted to spools for opto-electronic devices such as fibre optic sensors and delay lines, and suitable for fibre optic equipment interconnections. The objectives are:

- the set-up and evaluation of laser induced and plasma enhanced chemical vapour deposition (CVD) methods for the coating of optical fibres
- the analysis of the deposited layers (composition, adherence, uniformity, cohesion)
- the assessment of the improvement of mechanical properties and resistance to environment (corrosion, temperature...) to be expected
- the selection and implementation of CVD methods for the coating of moving fibres
- the specification of a viable industrial process to be developed by the industrial partners.

The work programme comprises two 21 month-long phases. The phase 1 is a feasibility phase, for the evaluation of fibre coating by plasma and laser CVD methods. The phase 2 is a laboratory process implementation of the fabrication of coatings on moving samples.

ACHIEVEMENTS TO DATE

- The set-up of a specific RF plasma CVD machine and the obtention of homogeneous carbon deposits on silica rods and flat silica substrates, which have been chartacterized
- the study of laminar flow protection of the windows for laser CVD deposition and preliminary deposits on flat substrates
- four point mechanical bending strength experiments on bare silica rods.

KEYWORDS Optical fibres; Chemical vapour deposition; Surface treatment technologies; Coatings/Thin films; Carbon/Graphite

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Proposal no: BE-3153

SURFACE PREPARATION OF COMPOSITES

Starting date: June 1990 ***Duration:*** 30 months

OBJECTIVES

The use of composites materials in the aircraft industry allows weight saving and manufacturing cost benefits but their surface properties are insufficient to cover the electrical, mechanical and chemical specifications of aircraft structures.

In this programme:

1. Several metallization processes will be optimized to be industrially applied on composite surfaces in order to improve their electrical and mechanical properties:
   - two dry processes: physical vapour deposition (sputtering) and thermal plasma spraying
   - one wet process: electroless plating.

The deposited layers and coated systems properties will be studied to check that they meet the required specifications.

2. A new surface activating process "corona treatment" will be evaluated as a pretreatment for adhesive bonding in terms of adhesion properties processing cost and quality control equipment.

ACHIEVEMENTS TO DATE

The different studies are in progress.

The optimization of the metallization processes parameters is likely to be achieved by December 1991.

KEYWORDS

Surface treatment technologies; Composites (polymer matrix); Metallization process; Bonding surface treatment

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Contract no: BREU-177
Proposal no: BE-3459

PRINTING, WORLDWIDE INDUSTRY: PIGMENT SCREEN AND COLOUR JET PRINTING OF TEXTILE MATERIALS UNDER UV AND EB CURING SYSTEMS

Starting date: November 1990 ***Duration:*** 36 months

OBJECTIVES

Pigment printing is the most important process used in the textile printing industry. This process presents the following disadvantages: •low speed of printing (washing and rubbering resistance, dry-cleaning speed) •bad touch due to the hardening of the binder necessary for the link formation between pigment particles and the fibre •energy consumption due to the thermal treatment needed for fixation (150-160° from 1 to 4 minutes).

The objectives of this project are: •to increase the speed by the use of polymerizable materials cured under UV or EB irradiation so as to involve in-situ-network formation in which the pigment particles are occluded and local covalent-bondings with the chemical structure of the textile material •to significantly decrease energy consumption by elimination of the drying operation.

ACHIEVEMENTS TO DATE

There has already been a significant amount of work selection, synthesis and study of formulations. New radio-curable products adapted to textile support have been synthesized. Pigment-binder compatibility has been studied in depth and polymerization conditions have been determined. The optimization of the polymerizable material chemical structure is being processed, by physical and mechanical evaluation of cured material.

Samples of printed textiles with good characteristics of fastness, printing quality and touching aspect have been obtained and a production-prototype line is being constructed.

KEYWORDS

Pigment; Printing/Textile/Irradiation; EB/UV; Curing

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Proposal no: P-3261

USE OF MICROENCAPSULATION TECHNIQUES IN PAINT SYSTEMS

Starting date: January 1989 ***Duration:*** 48 months

OBJECTIVES

The aim of the programme is to develop a new paint using microencapsulation techniques to improve the strippability of high performance paint systems. The main interest of such a paint is to allow the use of more environmentally friendly chemical paint strippers without lowering the high performance level of the paint system.

Two directions are simultaneously explored:

- incorporation of capsules containing a polymer swelling under the action of alcalinised water, resulting on weakening of the paint film
- incorperaton of capsules containing a stripping activator such as cresol, released under the action of a mild stripper.

ACHIEVEMENTS TO DATE

For the capsules of the first type, several swelling polymers have been selected. Some are commercial products, the others have been developed during the project. Their encapsulation does not raise any problem and the resulting capsules are solvent resistant, non sticky and of appropriate size. However the encapsulaton of the polmer reduces its swellability. It should be necessary to use a sensitzing agent like N methyl pyrrolidone to make the paint film more permeable to water.

The encapsulation of cresol to form the capsules of the second type has been perfected by using the method of the cyclon (air dryer) and a association of acrylic resin and derivative of melamine. The problem of the solvent resistance of the microcapsules has been overcome but the high reactivity of cresol is probably the reason for its low content inside the capsule.

Experiments on paint are now running.

KEYWORDS Aeronautics/Aerospace; Engineering.

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Proposal no: P-2058

SELF-STRATIFYING COATING

Starting date: January 1989 ***Duration:*** 48 months

OBJECTIVES

1. To formulate experimental self-stratifying coatings on the basis of preliminary screen resin families, in particular to develop liquid pigmented systems. Self-stratifying systems will be formulated for steel, plastics and wood. Research will be focused on the systematic study of the variables governing stratification, taking into account the choice of materials (viz resins, solvents, pigments and additives), length and conditions of cure, film thickness, etc.

2. To determine the influence of application technique on stratification.

3. To characterize promising stratifying coatings at both the film formation and dry film stages. To carry out standard performance and environmental tests to evaluate applied coatings.

4. To establish a model of the scientific principles governing stratification on the basis of which industry could develop proprietary systems.

ACHIEVEMENTS TO DATE

Combinations of resins suitable for providing coatings on wood, steel and plastics have been selected. Physical properties, eg solubility parameters, surface energies, have been measured and phase equilibria of the resin solutions have been determined experimentally. A data base of known properties has been compiled. An analysis of solvent parameters has indicated that the essential characteristics of a solvent may be defined using only three parameters.

A range of possible stratifying systems has been investigated and characterized by FTIR-attenuated reflectance and electron-microscopy. Many promising candidate coatings have been identified.

KEYWORDS Chemical/Petrochemical; Multilayers/Multimaterials; Paints; Coatings/ Thin films; Polymers

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Contract no: RI1B-246
Proposal no: P-2335

PLASMA POLYMERIZATION IN EXTRUSION PLANTS

Starting date: August 1988 ***Duration:*** 48 months

OBJECTIVES

The field of surface technologies has developed fast over the years. The problems of increasing demands on, for example, product durability can partly be solved using enhanced surface properties. A new technique for obtaining a high-quality surface is plasma polymerization. A plasma is a gas with a high frequency induced concentration of positive ions and free electrons. In particular high-energy electrons offer the ability to cut chemical bondings and to initiate reactions. When an organic monomer is introduced to a plasma the plasma polymerization can take place. The polymer resulting from such a process is highly cured and has therefore excellent properties. Moreover, very thin layers down to a few µm can be achieved without pin-holes. Using this technique plastics as well as metals can be provided with an organic layer. In this project the online coating of extrudates by means of plasma polymerization will be tested and the properties of the surfaces examined. To implement the project a machinery manufacturer, a university institute and a small extrusion enterprise are working together. At the moment this seems to be the first attempt to use plasma polymerization in an extrusion line.

KEYWORDS

Mechanical engineering/Machinery; Manufacturing; Processing (rubber & plastic);Multilayers/Multimaterials; Plastics/Rubbers; Surface treatment technologies.

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THE DEVELOPMENT OF AN INDUSTRIAL PRODUCTION PROCESS FOR WC COATING FOR HS TOOLS AT LOW TEMPERATURES AND OF NEW WEAR RESISTANT COATING AND OPTIMIZATION OF PVD PROCESS ON HS TOOLS

Starting date: February 1988 ***Duration:*** 40 months

OBJECTIVES

1. Development and optimization of new wear-resistant PVD coatings on differnet types of HSS tools.
2. Optimization double treatment of plasma nitriding and PVD process.
3. Development of an industrial low temperature CVD process for WC CVD equipment.
4. Job-shop comparisons between different coated HSS coated tools.
5. Application trials and comparisons between different coated hot-working steel tools.

ACHIEVEMENTS TO DATE

- objectives 1-2: choice, setting-up and optimization of different new PVD coatings.
- objective 3: developing and setting-up of different machinability tests; optimization of the machinig cycle parameters for the different coated tools; comparisons and classification of the different coated tools tested
- objective 4: design and construction of a hot-wall CVD reactor W2C coating; optimization of process parameters; secondary security provisions
- objective 5: Realization and characterization of different hot working steel tools; setting-up and organization of different application trials

KEYWORDS

Instruments/Sensors/Precision equipment; Mechanical engineering/ Machinery; Coatings/Thin films; Multilayers/Multimaterials; Tools/Dies.

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Contract no: MA1E-0014
Proposal no: P-0357

ADVANCED SUPER FINISH WIRE-EDM AND COATING TECHNOLOGIES FOR IMPROVED TOOL PRODUCTION

Starting date: 1991-1992 ***Duration:*** 48 months

OBJECTIVES

Since its introduction in 1969, wire-ED cutting with a continuous wire electrode has achieved a monopoly position in toolmaking as well as in series production of aerospace components. The process allows virtually force-free fully-automated processing of electrically conductive materials. Remaining weak spots are the lengthy processing times involved and the poor coatability of wire-ED processed surfaces.

The objective of the project is partly to achieve a drastic reduction in wire-EDM processing times, in order to open up completely new applications for the process, and partly to sophisticate wire-EDM and TiN-coating technologies to a point at which wire-cut surfaces can be coated with a high-adhesion TiN film without complicated post-processing.

In order to attain these objectives, it will be necessary to develop a high-speed and a super-finish generator, together with suitable wire electrodes. In addition, a real-time expert system with integrated wire break prevention strategy will need to be realized and the machine will have to be equipped with a multi-wire head. The associated Physical Vapour Deposition (PVD) coating technology will have to be adapted to the characteristics of wire-cut surfaces by means of special process combinations and modifications.

Successful completion of the project is of decisive importance for a number of industrial sectors. Apart from the participating partners, manufacturers and users of punching, pressing and extrusion tools are affected; the total turnover of EC companies in this sector is some 80 . 10 9 ECU/a.

KEYWORDS

Mechanical engineering/Machinery; Manufacturing; Coatings/Thin films; Machine tools; Tools/Dies

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Contract no: BREU-0461
Proposal no: BE-4117

SURFACE GENERATION, SURFACE PRETREATMENT AND SURFACE CHARACTERIZATION OF TOOL MATERIALS IN RELATION TO PVD COATING - A NEW AND SYSTEMATIC APPROACH

Starting date: 1991-1992 ***Duration:*** —

OBJECTIVES

Surface characteristics of substrates are very important for obtaining a coating with good adhesion,producing lifetime improvement by surface treatment of industrial components. This is especially the case for Physical Vapour Deposition (PVD). The purpose of this research project is, on the one hand, to study in detail the effect of surface generation or manufacturing processes like grinding, polishing and spark erosion on the surface characteristics of the substrate to be coated, and, on the other hand, to study the influence of these surface characteristics (chemical contamination, residual stresses, texture, roughness, etc.) on the functional properties of the coating. Based on this new knowledge, it will be possible, for tool makers and tool users, to deliver tools for which the amount of rejected ones is currently too high to the job-coaters with an optimal surface state in respect to PVD coating. This can be obtained by adaption of the tool manufacturing processes and/or by introduction of new surface pretreatments (chemical, thermal, mechanical) prior to PVD coating. The aim of this innovative approach is to replace the traditional "trial-and-error" approach as a consequence of the lack of data concerning the various manufacturing processes by a more systematic controlled and inspected industrial approach. It will then make the coating quality more reliable and the combination of manufacturing, pretreatment and coating processes will reach an economical and technical optimum.

KEYWORDS

Manufacturing; Coating/Thin films; Tools/Dies; Codes/Standards; Surface treatment technology; Materials characterization/Testing.

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Contract no: BREU-0523
Proposal no: BE-4003

DEVELOPMENT AND APPLICATION OF PVD-COATINGS FOR THE TRIBOLOGICAL SYSTEM OF FINE BLANKING ASDA CENTRAL OPERATION FOR STAMPING AND COLD FORMING PROCESSES

Starting date: May 1991 ***Duration:*** 36 months

OBJECTIVES

The main goal of this project is to increase the performance of fine blanking tools by developing new hard coatings and adapting these to the tribological conditions in fine blanking. This will be achieved by a further enhancement of the wear resistance using new developed binary, ternary or quaternary titanium- and chromium-based PVD hard material coatings, which withstand the specific stress-load-combination of fine blanking. In order to improve the surface conditions of tools a new developed coating technology will be tested. This technology and the new hard-material will help to extend the application of fine blanking towards parts with more complex shapes and towards work materials of higher strength.

Compared with TiN, the new coatings are characterized by greater hardness, greater toughness, more favourable friction properties, better smoothness and greater resistance to oxidation.

As a result of the greater number of load cycles on the basis of increased tool life quantities, failure of the tools due to fatigue is possible under certain circumstances. The surface engineering is therefore aimed at reaching a favourable residual stress condition of coating, interface substrate with regard to increased resistance to material fatigue.

In particular, the improvement of tool surface is accompanied by an improvement in workpiece quality, especially higher surface quality of the sheared edges and higher accuracy-to-shape-and-size.

KEYWORDS

Materials processing; Coatings/Thin films; Surface treatment technologies; Research/Development; Fine Blanking

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Contract no: BREU-0498
Proposal no: BE-4118

SPUTTER COATINGS - ADJUSTMENT OF THE COATING DESIGN AND APPLICATION

Starting date: September 1991 ***Duration:*** 42 months

OBJECTIVES

For technological development in coating applications in many sectors of the manufacturing industry it is necessary to adjust the production of new coatings which present good laboratory performance to the manufacturing process requirements. The cutting tool industry is endeavouring:

- to obtain a coating with properties more suitable to increase the efficiency of tools in service
- to adjust the tools design to the presence of the coating , which can change the function of the tool, designed to be used without coating, taking into account the coating deposition procedure.

The aim of this project is to optimize the industrial production by reactive sputtering of a new coating W-C/N-M, where M can be any metal to achieve good properties of high temperature stability, wear and corrosion resistance.

Moreover, studies to adjust the tools geometry to the coating will be developed in order to achieve the best compromise between the surface properties and the cutting efficiency of precision cutting tools, evaluating the quality of the tools in real conditions.

KEYWORDS

Coatings/Thin films; Multilayers/Multimaterials; Tool design.

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Contract no: BREU-0403
Proposal no: BE-4210

DEPOSITION OF WEAR AND CORROSION RESISTANT COATINGS BY LOW TEMPERATURE CHEMICAL VAPOUR DEPOSITION

Starting date: January 1988 ***Duration:*** 43 months

OBJECTIVES

This project aims at the deposition wear and/or corrosion resistant coatings by low temperature CVD techniques in order to allow the coating of substrate materials whose properties are deteriorated by a high temperature coating process. Two low temperature coating techniques are to be compared: rf plasma enhanced CVD (at SCK/CEN) and laser activated CVD (at TU Delft). The deposition of boron nitride is the main goal of the programme, the most promising coatings will be tested in industrial conditions on prototype dies for aluminium extrusion (at SIDAL nv).

ACHIEVEMENTS TO DATE

At SCK/CEN the influence of the deposition parameters on the properties if BN-films grown by PECVD has been studied. Diberone and nitrogen (or ammonia) diluted in hydrogen are used as reactant gases. Stoichiometric films could only be obtained for films grown with a growth of c-BN. The coatings are very hard but a rather high coefficient of friction (0.4) against hardened steel.

For LACVD a new reactor has been designed at TU Delft. Assembly of the system was finished at the end of 1990. Different metallo-organic precursors have been tested by PECVD for later use in LACVD. Dimethyl-amino borane was found to give a t-BN layer at low temperatures and presumably c-BN at a very small B/N ratio in the gas phase.

KEYWORDS

Coating/Thinfilms; Diamond/Superhard materials; Surface treatment technologies; Tools/Dyes; Tribology; Reseach/Development.

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Contract no: MAIE-0011
Proposal no: P-0054

HIGH PERFORMANCE COATING MATERIALS FOR APPLICATION IN CORROSIVE AND ABRASIVE ENVIRONMENTS (HIPERMAT)

Starting date: June 1990 ***Duration:*** 36 months

OBJECTIVES

The aim of the project is to develop a reliable method for coating steel with an impervious layer of refractory metal, such as Nb or Ta. In order to increase the wear resistance of the layer, methods will be developed to cover the deposited layer with a boride layer by diffusion of B into the formed metal layer. The project will address the following problems:

- the salt bath deposition process
- the boriding process
- methods to measure the oxygen content of the salt bath
- suitable methods for control of the quality of the layers.

ACHIEVEMENTS TO DATE

All partners have followed the workplan and the readjusted budget. The process equipment has been designed, dimensioned and specified and is under construction. Methods have been developed for production of chemicals for the electrolytical saltbath in the quantities necessary. An analytical method for analyzing these chemicals and the saltbath, has been developed. The quality of the oxygen content influence on the saltbath, and the deposited quality are very near the optimal condition for Nb. Investigations are still going on for Ta. Equipment for boriding experiments on Ta and Nb sample has been designed. Investigations show both hard, brittle and ductile borided layers. The quality depends on the pressure, temperature and protective gas atmosphere in the boriding furnace. Samples, manufactured from different ceramic compositions and squeeze methods, have been corrosion tested in order to construct a ceramic oxygen sensor.

KEYWORDS

Chemical/Petrochemical; Materials processing; Engineering (chemical); Engineering (process); Coatings/Thin films; Materials science; Surface treatment technologies

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Contract no: BREU-0118
Proposal no: BE-3359

IMPROVED CERAMIC COATINGS FOR RESISTANCE TO ATTACK IN AGGRESSIVE ENVIRONMENTS

Starting date: January 1988 ***Duration:*** 42 months

OBJECTIVES

The aim of the work is to further develop amorphous protective layers based on SiO_2 to improve their tolerance to thermally induced strains and to increase the maximum temperature of operation and thereby enhance their effectiveness as a diffusion barrier to aggressive.

ACHIEVEMENTS TO DATE

It has been established that amorphous silica coatings deposited by plasma assisted chemical vapour deposition (PACVD) are excellent barriers to ingress of aggressive species at temperatures up to 450°C for 16000h and 750°C up to 8000h. Increased stability of these layers was achieved by incorporating a TiN interlayer to prevent solid/solid reactions between the silica and the substrate steel (Incoloy 800H and $2^1/_4$ Cr ferritic) and thereby maintain the amorphous nature of the silica layer. Silica coatings have been deposited by laser chemical vapour deposition (LCVD) and laser fusion. In former case it has been demonstrated that the protective properties of the silica can be modified by deposition conditions, and this way a strain tolerant coating has been produced. Laser fusion processes have been developed to allow independent control of powder and substrate temperature in a single laser beam so that substrate heating is minimized. Optimized coatings using the PACVD system have been produced on a gas turbine blade and a laser fusion coated boiler tuber is currently undergoing a trial in a power station boiler.

KEYWORDS

Coatings; High temperature corrosion resistance; Power generation; Laser technology; Materials science; Ceramics.

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Proposal no: P-0339

THE DEVELOPMENT OF ADVANCED EROSION RESISTANT COATINGS FOR GAS TURBINE COMPRESSOR APPLICATIONS

Starting date: 1990 ***Duration:*** 36 months

OBJECTIVES

Erosion of titanium alloy compressor components has been identified as a life/performance limiting factor in gas turbine engines operating in dusty/sandy environments. It has been shown that some 'hard' materials are potentially very erosion resistant but not sufficiently so to enable them to be used as thin coatings in gas turbine compressors where particle impact energies are extremely high; there are indications that such materials in multilayer combinations can more readily approach satisfactory erosion resistance in these conditions.

This research project will investigate new multilayer coatings by an iterative process of complete metallurgical understanding of the coatings under development, erosion testing of the deposited coatings and erosion modelling based on theory and test data generated during the project. The 'best' coatings developed (and the predictive nature of the computer model) will be tested in the later phases of the project by investigating the erosion behaviour of compressor components in 'real' engine conditions.

ACHIEVEMENTS TO DATE

The first year work (investigation of titanium nitride multilayers) is now complete and has demostrated that titanium nitride/titanium "hard/soft" multilayers give improved protection against large particle impact; titanium nitride/hafnium nitride "hard/hard" multilayers behave as monolayers and do not reveal this improvement.

Preliminary results from the computer model have shown that there is good correlation between erosion rig testing and the predictions of the model.

KEYWORDS Aeronautics/Aerospace; Coatings/Thin films; Multilayers/ Multimaterials; Erosion resistance; Gas turbine compressor; Computer model

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Proposal no: BE-3339

DEVELOPMENT OF HARD CARBON BASED COATINGS FOR OIL FREE TRIBOLOGICAL SYSTEMS FOR HANDLING AND RECOVERY OF POLLUTING CHEMICALS (COTE)

Starting date: 1991 ***Duration:*** 36 months

OBJECTIVES

There is an urgent economic and environmental need to engineer surfaces to operate under oil free conditions. Carbon-based coating technology is now reaching a state of research which promises to provide a solution to this problem. However, research in Europe in this field has to date been confined principally to the optical and opto-electronic industries and to abrasive contact conditions. Furthermore, there is an urgent need to carry out research to study the scaling-up of the deposition, so that they can be used in "real world" systems, especially in the mechanical engineering sector. Industries benefitting from this project will include aerospace, food production, hydraulics, chemical, biomedical and automotive. It is important to learn from the Japanese approach to research and to bear the market need in mind. We shall thus be utilising two "example applications" as vehicles for the research. Achievements of the project will include:

(1).The development of new carbon-based coatings with improved oil free tribological properties

(2) The identification of interlayer structures and compositions to improve loading capacity of such films on a range of engineering materials

(3).Improvement in the quality and reliability of engineered surfaces

(4).An overall improvement in European capability in the field of friction and wear testing (including vacuum conditions)

(5).The development of coatings for handling and recovering polluting chemicals

(6).The replacement of oil as a sealing fluid in a large scale of applications (no waste oil, no PCB contaminants).

KEYWORDS Mechanical engineering/Machinery; Abrasives; Carbon/Graphite; Coatings/Thin films; Materials science; Surface treatment technologies; Tribology.

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Proposal no: BE-4052

STEERED ARC ION PLATING FOR THE DEVELOPMENT OF NEW TERNARY AND QUARTERNARY CERAMIC COATINGS FOR CUTTING AND FORMING TOOLS

Starting date: April 1988 ***Duration:*** 48 months

OBJECTIVES

Three partners collaborate to develop and to evaluate new ceramic coatings:

- Gühring is a German tool manufacturing company.
- Hauzer Techno Coating is a Dutch industrial coating company.
- The Department of Metallurgy and Materials Engineering of the Catholic University of Leuven is a Belgian research institute.

The strong demand for coated tools to machine new materials like Al-Si-alloys and fibre reinforced composite materials was one reason for this project.

The three partners combine their practical and theoretical knowledge to evaluate and further develop the potential of the flexible steered arc ion plating technology to manufacture wear resistant ternary and quarternary ceramic coatings on cutting and forming tools..

ACHIEVEMENTS TO DATE

- the necessary technology for the deposition of ternary (Ti,Al)N and (Ti,Nb)N coatings by steered arc ion plating has been successfully developed
- the cutting performance of TiN, (Ti,Al)N and (Ti,Nb)N coatings on drills has clearly shown the relation of the use and the appropriate coating procedures
- the results of this programme leads to the industrial use of the (Ti,Al)N coating
- specific investigation techniques for the structural characterizaton of these binary, ternary and quarternary ceramic coatings have been developed. It was shown that wear testing under well defined laboratory conditions is comparable to results of performance test in the field test laboratory.

KEYWORDS Mechanical engineering/Machinery; Ceramics; Quality control/Inspection; Surface treatment technologies; Tribology; Research/ Development; Ceramic coating.

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Contract no: RI1B-0201
Proposal no: P-2133

WEAR AND FATIGUE CHARACTERISTICS OF SURFACE ENGINEERED MATERIALS AS APPLIED TO MULTIPOINT AND SHEAR ACTION CUTTING TOOLS

Starting date: February 1989 ***Duration:*** 42 months

OBJECTIVES

The successful application of surface engineering to multipoint and shear action tools has been identified as a major step forward in their evolution. The potential of surface engineering techniques has already been demonstrated on single point lathe tools, drills and press tools. The major objectives which represent significant advances on current practice are:

- to derive surface techniques which will suppress the wear fatigue mechanisms relevant to multipoint and shear action cutting tools
- to modifiy the substrate to optimize the surface property
- to modify tool geometry
- to enhance product value on relatively low cost consumable tools.

ACHIEVEMENTS TO DATE

Improvements in the performance of multipoint cutting tools have been made via various surface engineering techniques. Variability in performance is however a major problem and work is continuing to isolate the primary contributing factors.

KEYWORDS

Surface treatment technologies; Sawing; Cutting tools.

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Contract no: RI1B-0221
Proposal no: P-2136

FINITE ELEMENT MODELLING OF THE PLASMA NITRIDING PROCESS AND THE RESULTANT LOAD BEARING CAPACITY OF LOW ALLOY STEELS

Starting date: 1991 ***Duration:*** 36 months

OBJECTIVES

In spite of the growing commercial maturity of a wide range of surface engineering technologies, there are no comprehensive design systems for surface engineering. Accordingly, the overall objective of the present research proposal is, in the anticipation of an increased industrial awareness and application of surface engineering, to develop a design system for surface engineering through mathematical modelling and computer simulation of various plasma enhanced surface engineering processes as well as the properties of the resultant surface engineered components.

The detailed scientific objectives of the programme are:

- to produce a design database for the Processing and Properties of Plasma Nitrided Low Alloy Steels
- to produce a Finite Element Model software package capable of predicting the plasma nitriding processing perfomance of low alloy steels
- to produce a Finite Elemnt Model software package capable of predicting the load bearing properties of plasma nitrided and duplex treated low alloy steels.

This will mean that not only will design engineers be able to use the models in engineering design, but also materials processing engineers can use the models in the selection of optimum process parameters.

KEYWORDS

Materials processing; Surface engineering; Surface treatment technologies; Coatings; Plasma nitriding; Design; Steels

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Contract no: BREU-0410
Proposal no: BE-4242

SILICON CARBIDE-SILICON NITRIDE COMPOSITE COATINGS WITH IMPROVED ADHESION PROPERTIES PRODUCED BY A PLASMA-ENHANCED CVD PROCESS

Starting date: January 1989 ***Duration:*** 36 months

OBJECTIVES

- Design, building and construction of a PECVD system for the production of silicon carbonitride coatings with variable composition at low substrate temperatures (100 - 400°C)
- Development of an in situ substrate cleaning procedure to enhance adhesion of thin films.
- Deposition, characterisation and testing of silicon carbonitride coatings on various substrates.
- Development of a coating to be used on a seaming chuck for the seaming of cans; optimisation towards excellent corrosion and wear resistance.
- Development of a non-destructive analysis technique for the characterisation of substrate-film interfaces w.r.t. composition

ACHIEVEMENTS TO DATE

Silicon carbonitride coatings have been deposited onto steel and hard metal substrates with good adhesion.

By varying the composition of these films it is possible to influence the stress state and the wear resistance properties.

An in situ plasma treatment of the substrate material is very beneficial for the adhesion between film and substrate.

Currently the process is optimised towards deposition on complicated forms using electrodes of variable geometry.

The project will be concluded with the development of coatings for seaming chucks in order to enhance the wear and corrosion resistance properties.

KEYWORDS

Materials processing; Manufacturing; Coatings; Materials characterisation /testing; Surface treatment technologies; Tribology; Materials science.

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Proposal no: P-2412

PLASMA SPRAYED SILICON CARBIDE FOR CRITICAL TRIBOLOGICAL COMPONENTS

Starting date: June 1991 ***Duration:*** 36 months

OBJECTIVES

The objectives of this project are:

- to develop a cost-effective processing route for the deposition of silicon carbide layers onto system components for critical tribological applications requiring a combination of wear and corrosion resistance, particularly those which will be operating in fluids with poor lubricating properties.
- to establish optimum precursor cermet powder characteristics for subsequent processing via low pressure plasma spraying.
- to systematically optimise the deposition process using the results from a comprehensive study of coating wear and corrosion behaviour and physical property measurements.
- to redesign and manufacture complex components to accomodate plasma sprayed coating.
- to produce and test coated components under conditions of severe corrosion and wear. Identify coating compositions and processing routes for specific applications.
- to compare the behaviour of silicon carbide cermet coating with that of existing state-of-the-art cermet and ceramic coatings, such as tungsten carbide-cobalt and chromium oxide based materials.
- to identify those applications which would benefit from the substitution of existing bulk or coating materials with a silicon carbide based cermet layer.

KEYWORDS

Coatings/Thin films; Powders; Engineering (process); Surface treatment technologies; Composite coatings; Wear & corrosion resistant materials

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Contract no: BREU-0465
Proposal no: BE-4329

PLASMA ENHANCED DEPOSITION OF CORROSION AND WEAR RESISTANT COATINGS

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

The objective is the development of industrially compatible plasma assisted processes for the deposition of corrosion and wear resistant layers on high duty parts of industrial products and on cutting tools to enhance lifetime and reliability. The central theme will be the development of a metal-carbon layer by plasma assisted deposition. To build experience towards this end, the deposition of a pure metal by Plasma CVD is to be studied. The metal layers (such as Chromium and Tantalum) will be explored as corrosion resistant layers. Also the deposition of i-carbon by plasma assisted deposition will be studied to support the Me-C deposition experiments. The whole thrust of the research will necessarily lead to the development of diamond films by means of Plasma CVD and PVD.

ACHIEVEMENTS TO DATE

The achievements can be summarized as follows:

Metallic Tantalum films can be deposited at low temperature by Plasma CVD showing an improved corrosion resistance compared to the substrtate material. Dense, hard and adherent i-carbon coatings can be deposited on silicon and on glass. On steel samples small additions of metal in the coating improve the adhesion. Successful deposition of some metal-carbon films such as Zr:C, Ti:C, B:C and SiC_x has been demonstrated on a number of test samples as well as on real tools by means of Plasma CVD and a combined Plasma CVD-PVD technique.

KEYWORDS

Materials processing; Ceramics/Glasses; Coatings/Thin films; Diamond/Superhard materials; Multilayers/Multimaterials; Refactories; Suface treatment technologies

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Contract no: BREU-0098
Proposal no: BE-3320

LASER BASED CHEMICAL VAPOUR DEPOSITION OF CORROSION AND WEAR RESISTANT LAYERS

Starting date: January 1990 ***Duration:*** 48 months

OBJECTIVES

The fundamental objective of the proposed project is the development of industrially applicable laser CVD processes for the local deposition of corrosion and wear resistant layers on high duty parts of industrial products and cutting or forming tools to enhance life time and reliability.

Both pyrolytic LCVD, in which the highest deposition rate is to be expected, and photolytic LCVD, which can play an important role in the early stages of deposition, will be studied.

Also combinations of photolytic and pyrolytic LCVD will be examined because of the interesting new possibilities in controlling layer composition and the production of multilayer coatings.

The films to be investigated include metals, e.g. chromium, nitrides, carbides and borides of a transition metal, e.g. titanum. Coated steel and cemented carbide products and tools will be functionally tested and the potential of coating and deposition method will be evaluated with respect to its use on an industrial scale.

ACHIEVEMENTS TO DATE

The achievements can be summarized as follows:

Development, building and improvement of equipment has resulted in adequate deposition equipment for all partners. A fibre optic pressure sensor, to measure the partial gas pressure close to the sample in the cell, and an LCVD pyrometer at a single wavelength with the necessary software have been developed.

Hard TiN layers have been deposited at temperatures of 80-350°C, only at very low deposition rates. Titanium, boron and carbon were deposited in preliminary experiments for TiB_2 and TiC deposition at a later stage. Hard, well-adhering, corrosion resistant layers of Cr_2OC were made on high duty parts and functionally tested. The interaction of the laser beam with different steel substrates was examined and the interchange of samples for characterisation was promoted.

KEYWORDS

Materials processing; Coatings/Thin films; Multilayers/Multimaterials; Refactories; Laser technology/Power beams; Surface treatment technologies

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Contract no: BREU-0049
Proposal no: BE-3327

DEVELOPMENT OF NEW COATINGS FOR SLIDING SURFACES AND OF SUPERFICIAL TREATMENTS ON PISTON RINGS FOR BIG 4-STROKE DIESEL ENGINES UNDER SEVERE TRIBOLOGICAL CONDITIONS

Starting date: September 1988 ***Duration:*** 42 months

OBJECTIVES

The present trend for the manufacturers of big 4-stroke diesel engines is to increase the combustion pressure from 140 to 200 bars. For reasons of economy, these engines are run on low quality fuel oils. Combustion pressure and the use of these fuel oils cause tribological problems to the components of the combustion chamber (adhesive, abrasive and corrosive wear) and structural problems (mechanical resistance of the base material and the coatings). The purpose of this research is to deal with the problems arising from the running of the piston rings on the cylinder liner. This research is expected to develop the most suitable coatings by using plasma spray, plasma remelt, chromium galvanic dispersion coating techniques and high velocity flame spray coating techniques applied to piston ring and cylinder liner.

ACHIEVEMENTS TO DATE

Coating samples have been developed and thoroughly investigated in the laboratory. These investigations led to improved results with respect to thermic stability and tribological behaviour. Tests on small engine showed no problems on investigated coatings and cylinder liners but the absolute wear results were not transferable to bigger diesel engines. The preselected coatings have been pre-tested on 4-stroke 1-cylinder engine ø 240 mm. The most promising coatings are on test in original medium speed big 4-stroke diesel engine under simulated operating conditions. The first results are very encouraging with respect to ring and cylinder liner wear. Piston rings and cylinder liner coated by high velocity flame spray technique are in production.

KEYWORDS

Mechanical engineering/Machinery; Tribology; Surface treatment technologies; Research/Development.

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Contract no: RI1B-224
Proposal no: P-2297

THE DEPOSITION OF IMPROVED CORROSION RESISTANT COATINGS ONTO SURFACES OF COMPLEX SHAPE

Starting date: June 1988 ***Duration:*** 33 months

OBJECTIVES

The objectives of this project were:

- to optimize an ion plating technique for the deposition of dense, corrosion resistant coatings of uniform thickness and structure onto substrates of prescribed shapes
- to develop a model of the coating process which will predict the process parameters required for the deposition of such coatings onto substrates of complex shape.

ACHIEVEMENTS TO DATE

Optimization of ion plating parameters for aluminium coating of specially designed samples, which contain features relevant to industrial components, has been performed in the initial phase of the work. Coating experiments were done using diode ion plating, triode ion plating and RF ion plating techniques. Gaseous and aqueous corrosion tests were carried out on specimens coated under different conditions. RF ion plating technique was found to give substantially improved coating quality on metallic substrates compared with diode ion plating technique.Coating of uniform thickness on a complex shape could only be attained by manipulating the specimen during coating. Certain features were identified, principally sharply re-entrant cavities, which could not be coated under conventional ion conditions.A general model of the coating process could not be developed, only general guidelines for the coating ofcomplex shapes could be established.

KEYWORDS

Coatings/Thin films; Metallic structural materials; Manfacturing; Surface treatment technologies.

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Contract no: MA1E-0025
Proposal no: P-0347

APPLICATION OF NEW MATERIALS FOR WATER TURBINES AND PUMPS

Starting date: February 1990 ***Duration:*** 36 months

OBJECTIVES

Water turbines and hydraulic pumps are susceptible, under operating conditions, to high erosion and cavitation. Such problems can be solved thanks to the mechanical properties of amorphous metal alloy coatings. For this purpose, we shall coat metal surfaces with alloys cooled at a greater speed and having hardness and ductility values. This method is different from the conventional plasma spraying method widely used in aeronautics in that the temperature of the substrate low. The first stage of our work will consist in using the existing data on amorphous alloys in order to adapt our chemical analyses to the deposition conditions. The second and third stages will be optimization of deposition parameters and the characterisation of coatings. The various industrial and scientific participants have joined their efforts to have a better control of the possible potential offered by the application of these materials. In this way, after the future industrialisation work, the new materials will be able to meet the ever increasing requirements of the world market in this field.

ACHIEVEMENTS TO DATE

- during this first design stage, we have determined the metal alloy grades that give an amorphous structure after fast cooling.
- the characteristics of such grades are high ultimate tensile strength ductility and resistance to corrosion under various physical conditions. The crystallisation temperature is greater than or equal to 400°C.
- it has been shown that the plasma spraying procedure under controlled atmospheric conditions and temperature allows 0.5mm thick depositions of amorphous structure to be obtained on large surfaces.
- the characterisation and optimisation of deposition conditions with respect to the chemical analyses specified are under way.

KEYWORDS

Mechanical engineering/Machinery; Engineering (mechanical); Surface treatment technologies; Ceramics/Glasses

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Proposal no: BE-3182

IMPROVED PRODUCTION OF THIN WALLED DUCTILE IRON CASTINGS - COMPUTER SIMULATION OF SOLIDIFICATION AND MOULDFILLING

Starting date: October 1989 ***Duration:*** 48 months

OBJECTIVES

The main aims of this research project are: ▪ weight reduction in automotive components and utilization of the full potential of mechanical properties of ductile iron ▪ controlled casting technology suitable for the actual modern foundry situation to produce complex shaped 3 mm thin ductile iron castings ▪ mathematical modelling of the casting process with concentration on mould-filling and validation and secondly solidification and microstruture.

ACHIEVEMENTS TO DATE

More than halfway through the contract period the group of participants are joined by DAF Trucks. The achievements of the experimental work by particpating foundries, WTCM and TU Delft and the achievements of the mathematical modelling activities of Hoogovens, WTCM, TU Delft and VTT can be summarized as follows: ▪ process specifications to produce thin castings free from carbides ▪ design and production of 3mm thin protoypes ▪ operational fast reacting temperature measurement equipment ▪ operational electrical method for registering mould-filling sequence ▪ microscopic solidifcation model for prediction of the microstructure ▪ mathematical model to describe fluid flow together with free surface and heat transfer for complex geometries ▪ low pressure pouring equipment.

KEYWORDS Automotive; Casting; Prototyping; Composites (metal matrix); Ferrous; Research/Development; Mathematical modelling.

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Proposal no: P-2437

IMPROVING CONTINUOUS CASTING OF $CuSn_6$ - STRIPS BY OPTIMIZING DIE GRAPHITES AND PROCESS CONTROL

Starting date: March 1990 ***Duration:*** 36 months

OBJECTIVES

- development of high density and high strength graphite materials to improve casting product quality and to increase lifetime of dies
- determination, recording and optimization of the decisive process parameters
- computer aided development of process control systems
- catalytical effects of the alloy and their impurities between the liquid/solid metal surface and the surface of the die graphites are tested
- reaching of the production start of bronze strips without surface defects on the micrometre level as an improved material for new electric connectors compared with conventional brass materials.

ACHIEVEMENTS TO DATE

- operative tests of present and competetive die-graphites lead to comparable lifetimes of the dies and defect concentrations of the strips
- an advanced graphite material with high density and high strength was developed
- recording and determination of the decisive process parameters was performed whereby the present graphite gives a lower pressure level than the competetive graphite
- computer aided development of process control systems was started by recording force profiles.

KEYWORDS

Forming/Shaping/Casting; Continuous casting; Special alloys; Carbon/Graphite; Quality control/Inspection; Process control; Machining; Chemistry

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Proposal no: BE-3383

SHAPE CASTING OF PARTICULATE REINFORCED ALUMINIUM ALLOY FEEDSTOCK

Starting date: April 1990 ***Duration:*** 36 months

OBJECTIVES

The aim is to demonstrate the feasibility of producing near-net-shape components from particulate reinforced aluminium alloy matrix composite ingot material via a range of casting processes of relevance to mass production applications.

Whilst concentrating on specific metal matrix composite (MMC) formulations and specific casting processes the programme will also provide generic enabling technologies relevant to a wider range of MMC formulations and applications.

Amongst the specific technical objectives the following are expected to have generic significance to the wider field of cast MMC developments:

- identification of MMC formulations of potential use to mass production applications;
- development of new melt treatment and handling practices to facilitate component manufacture from MMC materials.

ACHIEVEMENTS TO DATE

The programme has been broken down into 16 different tasks of which 9 have been started within the first 12 month period. The prime task within this period has been the initial set of trials on six different casting processes. These trials have identified the suitability and limitations of both the initial feedstock material selected and the particular casting process. Assessment has required mechanical property testing, determination of heat treatment response and metallography of the cast material. Suitable mould and die coatings are being identified. Generic studies on fluidity measurement are being undertaken and the potential for recycling scrap material is being assessed.

KEYWORDS Materials processing; Forming/Shaping/Casting; Recovery /Recycling; Composites (metal matrix); Non ferrous; Particulate reinforced

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Proposal no: BE-3564

ADVANCED ALUMINIUM-PRECISION CASTING FOR INTEGRALLY STIFFENED NET-SHAPE-COMPONENTS ("ADVACAST")

Starting date: September 1991 ***Duration:*** 48 months

OBJECTIVES

With increasing industrial interest in mass reduction and material costsavings, as well as public concern about recycling and saving of resources, near net shape techniques like precision casting become more and more attractive. There is a wide field of applications appearing for many branches such as motor engineering, automotive and aerospace-construction and automation or conveyor industries.

The efficiency of precision casting for high strength aluminium applications can be optimized with specialized techniques such as advanced directional solidification parameters and variation of heat treatment. Potentials up to 20% have been mentioned in technical literature. In house basic research work has been done and an innovative casting technique was described and initially tested. First tests gave excellent mechanical properties and improved microstructural results. The proposed variation of the alloy composition with additional elements will further the improvement of the property level.

"ADVACAST" is a proposal for further scientific and technical development that is necessary to establish an adequate industrial performance.

Optimized shell form techniques will ensure exact measurements, which together with the high material properties are a key factor for implementation for castings, thus reducing the mass of components, cutting amount and the material quantities.

The results achieved by this new technique with conventional aluminium silicon based alloys and the result of the current Brite/EURAM Project No 0612 (Squeeze casting).

The well balanced project structure, including small and medium enterprises, brings together four European industries and three universities with broad experience and equipment. After the project the consortium will have a consolidated position to start the realization of technical and economic benefits from "ADVACAST".

KEYWORDS Aeronautics/Aerospace; Forming/Shaping/Casting; Superalloys/Special alloys

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Contract no: BREU-0401
Proposal no: BE-4084

CENTRIFUGAL CASTING OF METAL MATRIX COMPOSITES FOR THE PRODUCTION OF REINFORCED NEAR NET SHAPE COMPONENTS

Starting date: July 1991 ***Duration:*** 36 months

OBJECTIVES

The project aims to model and develop a near-net shape fabrication process based on centrifugal casting which is able to produce economically metal based components locally reinforced by ceramic particles for improved mechanical properties. Four main tasks will be carried out:

- the modelling of solidification of composite materials during centrifugal casting in order to predict the influence of the process parameters on the structure and position of the reinforced zone. Model centrifugal casting experiments with transparent materials will be carried out to help the modelling
- the determination of particle pretreatment conditions for introduction in liquid metals. Production of coated particles for the experiments and feasibility of upscaling of the process will be carried out
- the realization of centrifugal casting experiments with Al-alloys and coated ceramic particles in order to produce components for further characterization and assessment of the validity of the model
- the microstructural and mechanical characterization of the produced componets for evaluation of the properties due to reinforcement.

Each part of this project will be simultaneously handled during the 3 years of the programme, with a discrepancy of 4 months. This 4-month period will be spent realizing the device for incorporating the reinforcement elements into the alloys and determining the coating conditions of the various reinforcement particles in order to start the first casting operations.

KEYWORDS

Forming/Shaping/Casting; Composites (metal matrix); Non ferrous; Reinforcement technology; Centrifugal casting.

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Contract no: BREU-0419
Proposal no: BE-4340

DEVELOPMENT OF NEW CALCULATION PROCESSES FOR COMPUTERIZED CASTING SIMULATION AND MODEL VERIFICATION UNDER MANUFACTURING CONDITIONS

Starting date: November 1990 ***Duration:*** 36 months

OBJECTIVES

The use of modern computer techniques in product and process development will play a decisive role in the future competitiveness of industry. The enormous increases in calculating power, dramatic drops in prices and improving user-friendliness in hard- and software, are opening up new applications for these techniques. In contrast to current computer supported design, drafting and manufacturing methods, the development of numerical simulations for complex processes in technical data processing has only just begun. The aim of the project is to increase knowledge in this area., the partnership wish to attain this objective in close cooperation with each other. Technical foundry processes in particular need even more comprehensive research and development in order to identify and quantify the controlling factors of the system and also make modern computer data manipulation techniques more accessible.

The results they obtain by the partners in the development of new calculation procedures could open up new possibilities for computer simulation. At the same time the solutions to these fundamental problems should also include interfaces between computer simulation and other computer assisted technologies. The objective is a comprehensive proven concept for computer integrated manufacturing in foundries.

ACHIEVEMENTS TO DATE

Achievements run from 11/90 to 4/91.▪ application of the solidification model to large castings with complex geometries using CAD data ▪ application of the solidification model on mass production casting ▪ determination of simulation parameters and creation of simulation geometries ▪t est of the CAD-simulation-CAM interfaces and verification by casting experimentation ▪ fundemental application of the solidification model on castings of medium complexity for use in aerospace technology ▪ casting experiments with aerospace-typical alloys to determine their physical solidification and control parameter ▪ computer simulation of selected casting processes and model verification by prediction of mechanical properties for casting ▪ design and construction of a test facility ▪ development of a computer model for the cooling process.

KEYWORDS CAE/CAD/CAM systems; Metallic structural materials; Processing (minerals & metals); Forming/Shaping/Casting; Thermodynamics; Super alloys/Special alloys; Training; Computer science/Software

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Contract no: BREU-174
Proposal no: BE-3473

CONVECTIVE EFFECTS IN SOLIDIFICATION

Starting date:November 1990 ***Duration***:48 months

OBJECTIVES

Complementary aspects of convective effects in solidification will be treated in a series of experimental and theoretical tasks, in order to build a numerical code to be used by companies working in the field of foundry and of solidification technology. It is restricted to four different aspects of flow interacting with solidification:

(i) directional solidification in centrifugal conditions. Such action could extend the conditions for planar front growth of large cystals for the optical or electronics industry

(ii) floating zone crystal growth in the presence of surface tension driven flow. The numerical module will describe how it can be influenced by modifications of heat input distribution

(iii) interactions between solidification and filling flow in the casting of thin parts. It can lead to the defect called "cold shut", according to the conditions of heat transfer and of solid structure formation

(iv) interactions between the solidifying front and particles in suspension, either reactive (equiaxed grains), or non-reactive (inclusions).

ACHIEVEMENTS TO DATE

The experimental devices have been set up, and a first series of experiments have been performed.

KEYWORDS

Materials processing; Casting; Metallic structural materials; Optical materials; Super alloys; Software; Fluid dynamics

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Contract no: BREU-0262
Proposal no: BE-3628

PROCESS ANALYSIS, COMPUTER MODELLING AND PRODUCTION OF HIGH-PRESSURE DIE CASTING

Starting date: 1990 ***Duration:*** 36 months

OBJECTIVES

High pressure die casting is an extremely important industrial operation for the SME sector of the market, there being an estimated 5000 casting machines in use in Europe. However, there is little fundamental understanding of the process and cast metal quality, particularly from cold chamber machines, is the worst of all commercial casting processes. In order to improve both, the quality of die cast products and the efficiency of the die casting process, a four-fold attack on the problems of high pressure die casting has been mounted:

Computer simulation: based on the existing MAGMASOFT package for heat and fluid flow simulation a multiphase flow software is developed in order to optimize the metal flow in the runner and gating system in the die cavity. To date a turbulence flow model has been developed and integrated. For the optmization of the thermal balance of the die the software simulates the batch production characteristics of the process. A dedicated module has been developed which takes into account all the heat losses during spraying of water soluable lubricants. The calculated results are validated by detailed microstructural analysis of the die castings produced from dies of variable geometry. Excellent agreement is achieved especially for calculated and experimentally determined cooling rates.

Full internal and external monitoring of the die cavity supplies pressure and temperature profiles for validation of the software.

Technology transfer of squeeze casting to high-pressure die casting will take place to reduce porosity levels in high pressure die castings.

KEYWORDS

Materials processing; Engineering (process); Forming/Shaping/Casting; Computer science/Software; Control systems; Sensors/Signal processing; Tools/Dies

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Proposal no: BE-3248

NUMERICAL SIMULATION OF INDUSTRIAL SHEET FORMING PROCESSES

Starting date: January 1989 ***Duration:*** 48 months

OBJECTIVES

The project aims to develop a completely interactive system for the numerical simulation of two and three dimensional sheet metal forming processes encountered in practical situations in can, moulding, automobile and aerospace stamping industries. The development includes the following modules: a) Prepocessing facilities for detailed definition of the problem, sheet and tooling geometries, loading, boundary conditions, material data and all further parameters required for the stamping operation (task 1.1); b) Analysis package based on viscous flow (task 2.1) and large strain elastoviscoplasticity finite element approaches (task 2.2) for prediction of sheet deformation, thickness, strain and stress distributions, load-displacement history, material failure and spring-back effects; c) Postprocessor module to present analysis results graphically and digitally, suitable for use in numerical control of the industrial process (task 3.3). The system developed will be tested by comparison with experimental tests carried out by the industrial partners on the stamping of metal sheets of axisymmetric and arbitrary shape (task 4).

ACHIEVEMENTS TO DATE

The project is progressing satisfactorily. Task 1.1 is completed; 2.1.a (2-D analysis module, flow approach) is 80% completed; 2.2.a (2-D analysis module, elastoviscoplastic approach) is 70 % completed; 2.2.b (3-D analysis module, elastoviscoplastic approach) is 60% completed; 4.1 and 4.2 are on schedule with 50% completed (the experimental tests have been defined and are being developed by the industrial partners).

KEYWORDS

Forming/Shaping/Casting; Mathematical modelling; Sheet forming; Finite elements

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Contract no: R11B-240
Proposal no: P-2029

A COMBINED NUMERICAL-EXPERIMENTAL APPROACH TO THE SIMULATION OF HOT DEFORMATION OF METALS

Starting date: August 1990 ***Duration:*** 36 months

OBJECTIVES

The primary objective of the research project is to develop a combined numerical-experimental technique, based on inverse finite element approaches and the visioplasticity method, for indirect evaluation of stresses at the tool-workpiece interface during bulk metal forming operations. This will lead to developments in advanced frictional models to be used in numerical simulations, which are becoming necessary for the design of new forming technologies and optimization of existing ones.

ACHIEVEMENTS TO DATE

The research to date has been centred on two fronts:

- development of the numerical tools necessary to undertake the numerical simulations
- setting up of the experimental facilities for the practical measurement phase.

The computational work has involved the development of consistent linearization processes for both the elasto-plastic material response and contact-friction phenomenon to produce solution algorithms which are robust and exhibit quadratic convergence rates.

Coupling between the thermal and mechanical behaviour has been implemented and constitutive laws have also been included to account for microstructural changes taking place during deformation.

The experimental facilities have been initially tested and modified in the light of trial results. Experimental data is now available for both the spike forming and hot flat rolling tests in the form of visioplasticity plots, displacement histories and load and torque measurements.

KEYWORDS

Materials processing; Forming/Shaping/Casting; Instrumentation/Measuring systems; Mathematical modelling; Mechanics/Solid mechanics; Tools/Dies

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Proposal no: BE-3650

DIE CAVITY ELASTICITY CONSIDERATIONS FOR NETT-FORMING

Starting date: June 1991 ***Duration:*** 45 months

OBJECTIVES

The elastic deflection of the die-cavity metal-deformation processes detracts the product shape from the expected form. Industries such as the automotive aero-engine, hydraulic, mechatronics and consumer goods, accommodate this deflection by using information extruded form production trials. The basic criteria for enabling die-designers to completely negate the effects of die-cavity elasticity at the design stage have, as yet, not been defined.

The required die-cavity form can be developed either through production trials or by using Finite Element (FE) analysis. Production trials are expensive and current FE analysis based on an assumed force contour is deficient; a major advance in the design of die-cavities for nett-forming will be achieved if the Finite Element Analysis was initiated with a precise description of the force contour on the die-cavity during forming.

Research which defines the basic criteria for the description of the force contour will enable the subsequent development of a die-design support system which will enable die-manufacture without the need for production trials. This proposal encompasses the use of an innovative transducer cluster, physical modelling techniques for the simulation of flow and FE analysis to define the basic criteria for determining the force contour on the die-cavity; this will lead, with further development to a die-design support system.

KEYWORDS

Mechanical engineering; Forming; Tools/Dies; Elastic deflection; Model material; FEM-analysis; Force contour

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Contract no: BREU-0392
Proposal no: BE-4129

INVESTIGATION FOR AN INNOVATIVE DESIGN METHODOLOGY IN SHEET METAL FORMING

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

The principal objective is to create a sound basis for a fully CAD integrated industrial numerical simulation, design and analysis code, and a methodology which permits more cost effective and faster execution, optimization and rational tooling design for complete industrial sheet metal forming processes. The new integrated industrial cost and delay saving stamping methodology will be applied directly to the urgent stamping problems of the European car industry which must react to the declared goal of the Japanese car industry to reduce the new car model design cycle from presently more than four to two years, or less.

First, the complete physical phenomena encountered in sheet metal stamping are studied, tested and integrated into the code, which is verified with basic laboratory tests. Next the code is calibrated on non trivial industrial stamping examples with well identified stamping problems. Then the code is validated with real life car industry stamping examples. Finally the code is integrated into the car industry CAD environment. the resulting basic methodology and prototype code can now be adapted to problems of general stamping industry.

ACHIEVEMENTS TO DATE

The major achievements to date include:

- the characterization of sheet metal material with respect to the most relevant physical phenomenon encountered in sheet metal forming (anistropic, plasticity, friction, etc.)
- the development of a simulation code (PAM STAMP) capable of simulating sheet metal forming processes
- the validation of the code versus experiments carried out by the industrial partner or benchmark cases.

In the second half of the project, the simulation code will be integrated with the CAD systems of the car industry partners, which analysis of industrial are carved out.

KEYWORDS

Automotive/Components & Parts; Forming/Shaping/Casting; Manufacturing; Automation/CIM; Machine tools; Mathematical modelling

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Contract no: BREU-0062
Proposal no: BE-3486

FINITE-ELEMENT MODELLING OF THE DEFORMATION PROCESSING OF ANISOTROPIC METALS AND COMPOSITES

Starting date: February 1990 ***Duration:*** 36 months

OBJECTIVES

The overall objective of this fundamental research programme is to develop computer based finite-element (FE) modelling tools for forging and sheet forming of anisotropic materials (metals and composites). The research programme, by building upon earlier collaborative research between the partners, will:

- develop an anisotropic enhancement to an existing 3-dimensional thermo-mechanical, elastic-plastic, large displacement FE programme for the modelling of deformation processing of materials
- develop realistic anisotropic material models based on texture data (orientation distribution functions), for metals and composites, for inclusion in the finite-element programme
- validate the predictive computer models against forging, rolling and sheet forming trials.

The research programme represents a major advance in the field as it proposes, for the first time, to incorporate realistic anisotropic elastic-plastic material properties, derived from physical observations, into a finite-element plasticity programme for industrial applications.

ACHIEVEMENTS TO DATE

- material characterization: Yield stress data and initial texture measurements have been made for various steel and aluminium alloys. Test specimens have been prepared for trials involving flat rolling of wire, slab rolling, cup drawing and forging
- theoretical work and computer implementation: all the theoretical work is complete and the new anistropic FE plasticity code has been tested against simple isotropic, anisotropic and multi-material benchmarks.

KEYWORDS

Aeronautics/Aerospace; Automotive, components & parts; Forming/Shaping /Casting; Composites (polymer matrix); Composites (metal matrix); CAE/CAD /CAM systems; Mathematical modelling

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Proposal no: BE-3617

DEVELOPMENT OF DENSE, HIGHLY DURABLE NON-OXIDE CERAMICS FOR FORMING STEELS

Note: Updated information was not provided in time for publication.

Starting date: January 1988 ***Duration:*** 33 months

OBJECTIVES

The aim of this project is to improve oxidation and corrosion resistance of non-oxide ceramics of the silicon nitride and related types, through systematic, basic research. Sintered silicon carbides of good oxidation resistance will be used as reference materials, and it would be expected that the final quality of the silicon nitrides will approach that of the silicon carbides.

To provide guidelines for the direction of this basic study, and later to assist in the effective quantitative evaluation of material improvements, one potential application, metal forming dies, has been selected identifying a specific set of oxidation and corrosion conditions. This industrial application of non-oxide ceramics, and the silicon nitride based materials in particular, would appear to be ideally suited to their known high-temperature mechanical properties. The immediate economies to be achieved will result in large measure from the reductions in 'down-time' resulting from less frequent routine die replacement and premature die failure.

The economic value of the increased basic understanding of the oxidation and corrosion behaviour of the silicon nitrides, and of the resulting improved oxidation and corrosion resistance, cannot be easily quantified. It is certain, however, to have a very significant impact on the future acceptance of these materials as substituents for metals in a wide range of high temperature applications.

KEYWORDS

Materials processing; Forming/Shaping/Casting; Ceramics/Glasses; Materials science; Tools/Dies

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Proposal no: P-0475

DEVELOPMENT OF NEW BORIDE - BASED CERMETS AND CERAMICS

Starting date: January 1989 ***Duration:*** 48 months

OBJECTIVES

The aim of the project is to develop processes, based on scientific investigations, for the production of non-porous cemented borides and boride-based ceramics, by pressing, sintering and hot isostatic pressing, in order to produce work pieces which will be practically tested in the following fields of applications: cutting tools, engineering and mining tools, and wear parts. The programme will be as follows:

- investigation of the wetting behaviour of non porous borides (TiB_2, ZrB_2, CrB_2) by liquid metals (Fe, Co, Ni,Cr) and their alloys (influence of additional elements, temperature, atmosphere). Selection of 4 to 6 binding alloys
- determination of the optimum conditions for milling, sintering and hipping of these cermets and two boride-based monolithic ceramics
- structural characterization
- determination of the main physical, mechanical and chemical properties.
- study of the machining of the new cermets
- production on industrial workpieces and testing of their behaviour in collaboration with customers
- study of a possible recycling of worn pieces.

KEYWORDS

Materials processing; Forming/Shaping/Casting; Processing (minerals & metals); Composites (metal matrix); Non ferrous; Powder metallurgy; Tools-dies.

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Proposal no: P-2293

MANUFACTURE OF TOOLS AND DIES USING SPRAY FORMING TECHNIQUES (MUST)

Starting date: July 1991 ***Duration:*** 48 months

OBJECTIVES

Based on a process, Simultaneous Spray Peening (SSP), which is a development of spray forming, both processes pioneered by the Prime Proposer over the past twelve years, a new replication process for making production tools for manufacturing processes such as deep drawing, injection moulding and die casting is developed.

Development of this concept, named MUST in the proposal, engages three industrial companies and two research institutes in applied research in four main areas: The SSP process is explored and further developed with special attention paid to the above application. Research is carried out to find rational methods to make formers and patterns. Special attention is paid to the interface between pattern and sprayed shell. Electro forming is used to give high accuracy of replication. Two production units are produced and used to manufacture a number of sample tools which in turn are tested under real life conditions.

SSP is a process of metal spraying which has overcome the shortcomings of conventional metal spraying. Therefore the proposers firmly believe that the MUST concept will provide production tools characterized by low price, short production cycle and good quality. The provision of tooling constitutes a major bottle neck in the time span from design to production in mechanical industry. The project will have a significant influence on this bottle neck. If and when the concept is broadly implemented annual savings could well amount to millions of ECU in a user company.

The project proposal is based on a BRITE/EURAM feasibility study (FA 89-57) carried out by the Prime Proposer in 1989.

KEYWORDS

Materials processing; Forming/Shaping/Casting; Processing (minerals & metals); Composites (metal matrix); Metallic structural materials; Particle technology

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Contract no: BREU-0429
Proposal no: BE-4621

COMPUTER AIDED TECHNOLOGY FOR IMPROVED ACCURACY OF DROP FORGING TOOLS

Starting date: January 1989 ***Duration:*** 48 months

OBJECTIVES

The aim of the project is to develop computer-aided methods which assist the design and manufacture of forging dies with high accuracy. The project is subdivided as follows:

1. Programmes backing up the design process of forging impressions and the development of a tool system for the finishing operations in forging.

2. Numerical simulation of drop forging processes by FEM to describe thermo-elastic straining of dies and the material flow, to find out the best preform and flash-gap geometry in order to minimize sliding movements (reduction of wear) and stresses (reduction of elastic deformations).

3. FE-analysis of thermo-elastic deformations of forging dies.

4. Optimization of NC-milling of dies and automatic control of elastic tool deflections during the milling-operation.

ACHIEVEMENTS TO DATE

1. Development of a forging database. Rules for optimum flash geometry and module for flash-gap design. CAD of forging- and preform geometry.

2. CAD-modules for the design of clippin- and calibration-tool.

3. Contract formulaton in 3D-problems. Automatic remeshing for 2D-problems. Thermo-mechanical coupling in plastic FE-analysis.

4. Calculation of temperatures, strains, stresses and materials flow during the forging-process.

5. Influence of temperature and stresses on the deformation of forging-dies.

6. Influence of milling parameters on the accuracy of forging-dies. Determination of optimum cutting data. Pre-copensation of tool deflection.

KEYWORDS

Materials processing; Precision-forging; Tools; CAE/CAD/CAM-systems.

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Contract no: RI1B-281
Proposal no: P-2210

ADVANCED METALWORKING USING ELECTROMACHINABLE CERAMIC EXTRUSION DIES

Starting date: December1990 ***Duration:*** 42 months

OBJECTIVES

The objectives are to develop zirconia and silicon nitride ceramic materials suitable for dies for hot extrusion of metals. The ceramics are to be made electrically conductive so that they can be cut by conventional EDM machining techniques. The aim is also to improve the engineering design of the dies so that more complex shapes can be extruded without damage to the die.

ACHIEVEMENTS TO DATE

During the first six months of the project small samples of electrically conductive zirconia and silicon nitride have been produced and subjected to mechanical tests. The silicon nitride has been successfully cut by EDM and promising mechanical properties have been measured.

Engineering design work by mathemaical modelling has been progressing. The effects of realistic working pressures and temperature transients have been assessed on an axisymmetric die and die housing. It was found that the dies are not subject to significant tensile stress but failure is likely to be due to compressive stress or cycic thermal stress.

Extrusion trials of commercially available creamic dies are being undertaken by the extrusion companies. Two ceramic dies have already been tested in the extrusion of a nickel base super alloy at 1170°C. In a comparison with metal dies used for the same product a substantial increase in die life and an improvement in dimensional stability has been measured.

KEYWORDS Materials processing; Forming/Shaping/Casting; Ceramics/Glasses; Non-ferrous; Super alloys/Special alloys; Mathematical modelling; Tools/Dies

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Contract no: BREU-0204
Proposal no: P-3176

TOOL DESIGN METHODOLOGY FOR PRECISION FORGING OF ROTATIONAL PARTS

Starting date: December 1990 ***Duration***: 36 months

OBJECTIVES

Precision forging represents a new technology with high economic potential. Precision forged parts are ready-to-install, their manufacture requires considerably less raw material than other production methods and their mechanical characteristics are favourable. Currently the method to design precision forged tools is based on the "trial and error" procedure which leads to high costs in tool development.

The aim of this project is to eliminate the "trial and error" procedure and develop computer based tool design methods. Additional application packages are developed to support tool design taking into account forming forces, contact stresses, thermally activated effects, workpiece geometry and metal-forming machine tool characteristics. Existing calculation programmes are integrated into the programme development. Stage sequences are determined under economical aspects to permit the lowest possible tool deformations and wear using the UBE-Technique. The validity of the method will be proved by an example programme application for tool design of toothed gears and the experimental testing of tools.

ACHIEVEMENTS TO DATE

- for the design of preform stages case studies have been carried out to predict forging loads and metal flow in axisymmetric forging
- programmes have been developed in order to apply some design principles to the layout of rotating precision forged parts. 3-D CAD system EUKLID is used for this task
- 2-D Finite-Element calculations for the simulation of the manufacturing sequences have been carried out.

KEYWORDS

Forming/Shaping/Casting; Automation/CIM; CAE/CAD/CAM systems; Tools/Dies

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Contract no: BREU-0329
Proposal no: BE-3594

DEVELOPMENT OF AN USER-ORIENTED CAE SYSTEM FOR SIMULATING THE FORMING OF DUCTILE IRON PARTS

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

During the past decade, computer simulation has become an integral part of foundry practice for the design of new castings at a better cost and in reduced time. Nevertheless, numerical modelling of casting processes in industry has been limited to heat transfer simulation because of the complex phenomena encountered during solidification and to simple shapes because of the complex geometries involved.

Aiming to develop robust user-oriented numerical models for design purposes, this project includes the following technical objectives:

- Development of a specific iron casting process 3D finite element mesh generator from CAD data including errors estimators and adaptive refinement
- development of a 3D finite element model describing metal flow and heat transfer during mould filling
- development of a 3D finite element thermomechanical coupled model simulating stress/strain and temperature during solidification and cooling including a model for microstructure formation
- identification of consecutive laws taking into account the effects of the following manufacturing parameters on the ductile iron forming process: magnesium treatment, inoculation, chemical composition of the melt and mould properties
- finally, numerical methods for solving large practical casting problems will be developed in order to bring the simulation of industrial components at the reach of enhanced workstations. Time incrementation and partitioning techniques together with parallel algorithms for transputer based computers will be developed specificically for the ductile iron casting process.

KEYWORDS

Mathematical modelling; CAE systems; Finite element; Casting; Ductile iron

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Contract no: BREU-0443
Proposal no: BE-4596

QUALITY ASSURANCE AND REDUCED LEADTIME FOR CUTTING OPERATIONS

Starting date: February 1991 ***Duration:*** 40 months

OBJECTIVES

Managing modern manufacturing equipment requires reliable and updated information on processes, tools; machines and materials. Particularly for SME's the information must be related to small batches and customer related production. This project aims at the generation of knowledge of cutting processes in machining centres; resulting in a better controlled quality of the product, an improved productivity and a reduced lead time. We will try to reach these aims by: 1) evaluation of existing logic procedures and determination of new ones, based on existing software, 2) tests of machine tools, 3) tests of cutting tools, 4) development of models, 5) evaluation and test of acquired rules, recommendations and knowledge. The knowledge generated in the project will be made available to SME's by:

- a methodological guide with rules and recommendations
- a database with data on tools, materials and machines including rules and recommendations for the application of these.

Furthermore the developed models will be introduced in software for optimising the choice of cutting conditions.

KEYWORDS

Machining; Cutting; Software; Tools/dies; Quality assurance

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Contract no: BREU-0354
Proposal no: BE-3525

CERAMICS AND CERMETS FOR ROTATIONALLY SYMMETRIC TOOLS, DRILLS, MILLING CUTTERS, TAPS AND REAMERS

Note: updated information was not provided in time for publication

Starting date: 1990 ***Duration:*** 48 months

OBJECTIVES

In this project a new generation of hard materials (ceramic and cermets) for the complex geometry of rotationally symmetric tools will be developed.

Materials selected for development include: silicon nitrides with and without silicon carbide platelets and alumina based composites toughened simultaneously with zirconia and with silicon carbide platelets, cermets based on mixtures of titaniumcarbide and titaniumnitride and tungstencarbide with submicron grain size. Comprehensive microstructural analysis forms an essential part of material development methodology.

Shank tool geometries fitted to the properties of ceramics and cermets will be designed. Prototype tools will be produced and their functionality will be demonstrated on a high speed cutting and precision machining station.

The economic benefits are wide ranging: provision of new materials for high temperature wear applications; stimulation of the development of new CNC machining stations; improvements in manufacturing by increasing speed and quality and by creating the possibility for machining and finishing in one pass.

KEYWORDS

Machining; Ceramics/Glasses; Composites (ceramic matrix); Tools/Dies; Tribology

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Proposal no: BE-3294

COMPOSITE CERAMICS REINFORCED BY WHISKERS OR PLATELETS FOR CUTTING TOOLS AND WEAR APPLICATIONS

Starting date: June 1990 ***Duration:*** 48 months

OBJECTIVES

The use of SiC whiskers-reinforced alumina has proved an attractive way of producing wear parts and ceramic cutting tools. Tools are used more and more in the aeronautical industry for high-speed machining of super alloys, and the development of reinforced wear parts is forecast. Ceramix Matrix Composites cutting tools are mainly produced in the USA and Japan. SiC whiskers are also produced in those two countries.

The main objectives of this project are:

- to develop European source of SiC whiskers and Al_2O_3 platelets which could also be used
- to improve the technology developed to produce ceramic matrix composites for cutting tools, tips and wear parts.

ACHIEVEMENTS TO DATE

- evaluation of SiC whiskers and Al_2O_3 platelets commercially available
- selection, purchase and characterization of powders
- production at laboratory scale and supply of first grades of SiC whiskers and Al_2O_3 platelets
- quality optimization and synthesis of Al_2O_3 platelets at laboratory.

KEYWORDS

Materials processing; Processing (ceramic & glass); Materials characterization/Testing; Materials science; Tools/Dies; Composites (ceramic matrix).

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Proposal no: BE-3055

LASER ASSISTED MACHINING (LAM) PROCESSES & THEIR INDUSTRIAL DEVELOPMENTS

Starting date: June 1990 ***Duration:*** 48 months

OBJECTIVES

The industrial use of some materials (high strength steels, super alloys and ceramics) is at present limited due to their poor machinability.

Preliminary studies on LAM have shown that cutting force reductions of from 20 to 50% have been obtained on Inconel type alloys and high strength steels, resulting in some cases in tool wear reductions of 20% This has allowed directions for research work to be defined and pursued to optimize LAM.

The objective of this project is to provide industry with technological data on materials having different properties so as to give information on machining cost reductions.

To reach this target, LAM tests will be carried out with measurement of induced phenomena and completed by optical, thermal and mechanical parametric modelling of LAM.

ACHIEVEMENTS TO DATE

Measurements of thermophysical, optical and mechanical properties materials, and input on modelling work, are in progress. Available codes give comparable results. Comparison between experimental and calculated results have been made in turning and in milling configuration.

KEYWORDS

Machining; Laser technology; Machine tools; Engineering process

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Proposal no: BE-3366

ROBOTICS FOR ON-LINE LASER OPERATION FOR THE AUTOMOTIVE INDUSTRY

Starting date: August 1990 ***Duration:*** 36 months

OBJECTIVES

The present project aims to produce a high performance system with cutting and welding capacities for complete industrial operation. The industrial system to result from this project will be based on a high power YAG laser, fibre optic beam delivery and advanced sensory and robotics conjunction, all of these elements being robustly integrated with CAD/CAM and complex control functions.

ACHIEVEMENTS TO DATE

- specification of equipment: Robot, Laser, end effector, material handling, CAD/CAM system
- specifications of Control System
- specification of tests beds
- basic control functions
- integration of base systems and first investigation.

KEYWORDS

Materials processing; Machining; Control systems; Laser technology; Power beams; Robotics; Sensors/Signal processing

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Proposal no: BE-3558

RECOGNITION AND PROCESSING OF INDIGENOUS INDUSTRIAL MATERIALS BY LASER

Starting date: December 1988 ***Duration:*** 36 months

OBJECTIVES

The global objective of this project is the integration of recognition and cutting systems, to improve the competitiveness of traditional industries, namely those working with raw materials such as the wood, leather, cork and marble. The project is aimed at the use of laser technology, both for the recognition and cutting processes; although other means have all been tested.

To attain the proposed objective, strategies for the identification and classification of the type and severity of defects have been developed. For each of the four materials the laser cutting parameters will be optimized (power, cutting speed, focal distance, assisting gas, etc.), in order to achieve a cut surface quality acceptable by industry standards. The project includes the assembly of a demonstration system, where the cutting operations will be guided by the recognition information, through a nesting software tool to minimize waste.

ACHIEVEMENTS TO DATE

New techniques for fast defect identification have been developed, using visible light, with good results in cork and leather. Laser scanning produces quite good results in good in the detection of holes and changes in colour and thickness in leather. The use of CO_2 lasers as a cutting tool have produced good results mainly in leather, wood, cork agglomerates and marble. Very complex shapes can be cut with high cut surface quality at cutting speeds up to 60m/min for leather and cork agglomerates, with kerf widths lower than 4mm. Cutting speeds of 6.5m/min were obtained for a 16.5mm thick wood plate, with kerf widths lower than 1mm.

KEYWORDS

Materials processing; Shoe/Leather; Wood/Paper/Furniture; Image/Image processing; Laser technology/Power beams; Vision/Optical systems.

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Contract no: RI1B-272
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DEVELOPMENT OF REFURBISHMENT PROCEDURES OF INDUSTRIAL COMPONENTS BY NON CONTACT DAMAGE MAPPING AND CO_2 LASER WELDING AND CLADDING

Starting date: November 1991 ***Duration:*** 48 months

OBJECTIVES

The final strategic objectives of this project are the reduction of costs of electrical production in Europe and the increase of overall competitiveness of European Industries.

The technical goal of this project is to develop automatic procedures dedicated to repair the damage to turbine components by welding and cladding with a CO_2 laser robot. These procedures will include automatic acquisition of damages mapped with conventional methods and self-programming of the robot in order to improve the productivity of the system. This subsystem will DMSS (Damage Management SubSystem).

This proposal conforms with the aims and the objectives of the following priority themes in the BRITE/EURAM Information Package:

- 4.2.4 development of CO_2 laser processing procedures and optical subsystems integrated in robotic structure for welding and surface treatments
- 3.1.3 development of robotic controls for mapping individual damage in each component and then for repairing it by automated cutting, welding and cladding operations as necessary, for economical high integrity refurbishment
- 2.2.3 measurements of service damage contours using non-contact sensors, in the process of refurbishing the component
- 1.1.3 improved creep and fatigue strengths of welded gas turbine components by new, optimized welding processes.

KEYWORDS

Aeronautics/Aerospace; Electrical/Electronic industry; Assembly/Joining; Repair/Maintenance; Superalloys/Special alloys; Automation/CIM; Laser technology/Power beams

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Contract no:
Proposal no: BE-4314

DISTRIBUTED OPTICAL (LASER) ENERGY SYSTEMS FOR FLEXIBLE MANUFACTURING

Starting date: 1991/1992 ***Duration:*** 36 months

OBJECTIVES

The overall objective is to create an automatic laser beam alignment and stabilisation system for high power CO_2 laser beams. The system will stabilise the position, size, power and mode of the beam at any specified point, in particular at locations remote (30m+) from the laser.

The specific objectives are:

(i) to research systems for the in-process sensing of the beam location of both the alignment and infra-red power beams

(ii) to research systems for the in-process sensing of the beam size and mode structure

(iii) to design automatic mirror mounts and drive software to automatically control the beam alignment

(iv) to design an automatic collimation device and software to automatically control the beam size at aspecified location

(v) to design an automatic cavity tuning system for the stabilisation of the laser beam mode

(vi) to demonstrate the use of the above system for laser material processing at remote locations.

KEYWORDS

Laser technology/Power beams; Sensors/Signal processing; Engineering (optical); Manufacturing; Processing (minerals & metals); Mechanical engineering/Machinery; Sensors/Instruments/Precision

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Proposal no: BE-4046

DUAL WAVELENGTH LASER PROCESSING (DUWALP)

Starting date: ***Duration:*** 36 months

OBJECTIVES

The main objective of this project is to explore, develop and demonstrate the technological and economic benefits of dual wavelength (ultraviolet and infrared (IR)) laser processing for manufacturing technology. On metals preprocessing by an excimer laser significantly increases the processing efficiency and control of IR lasers due to an increase in the effective IR absorption coefficient. This effect will be studied in detail and utilised in applications including welding of aluminium alloys, cutting of Nimonic alloys and surface treatment of both aluminium and ferrous alloys. DUWALP processing will also be applied to fibre reinforced composites (FRC) where the benefits of the photoablative effects of the UV laser will be combined with thermal processing of the IR lasers to achieve fast, efficient processing along with high edge quality. Specific objectives include:

- cutting of FRCs with process speeds of >1m/min, an edge roughness of <0.1mm and HAZ restricted to <0.5mm
- cutting of Nimonic alloy at 2m/min with a reduced HAZ from CO_2 laser cutting alone
- welding of aluminium alloys with low porosity and tensile strengths of the welds 75% of the parent material
- improvement of the corrosion resistance of surface treated aluminium alloy by a factor of 1.5 with areduction in fatigue strength of no more than 5%
- improvement sistance of cast iron alloys by 20% with an increase in the friction coefficient with lubricant bya factor of 2:

KEYWORDS

Materials processing; Machining; Composites (polymer matrix); Metallic structural materials; Laser technology/Power beams; Surface treatment technologies

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Contract no: BREU-0517
Proposal no: BE-4370

RESEARCH ON DESIGN AND APPLICATION OF INDUSTRIAL SCALE HYDROABRASIVE JET - CUTTING HEADS

Starting date: April1990 ***Duration:*** 36 months

OBJECTIVES

To achieve the goals the technical approach must be as folllows:

- design-optimization of (a) the jet cutting system, (b) the cutting head, and (c) the ceramic nozzles
- improvement of B_4C-based ceramics and development of a boron carbide injection moulding/sintering process for mass production of dense ceramic nozzles
- testing of the ceramic nozzles: (a) on a new test cell; (b) in field.

ACHIEVEMENTS TO DATE

Due to better test results the multi-water jet system - instead of the annular jet system - chosen as a technological solution for the further work.

To decrease the nozzle's erosion new internal bore profiles and nozzle dimensions were created. For pressureless sintering boron carbide the requsite carbon doping was varied and quantified. New boron carbide/titanium boride composite materials were densified up to 100% TD.

First lots of defect-free standard nozzles (length: 2in., bore d_i=0.8mm, composition:95w/o$B_{4.3}$C-5w/o C) were manufactured for wear studies and life time tests. A new test bench was completed and visualization system installed. It will be used to gain a better understanding of the phenomena occurring during the cut with speed hydroabrasive jet. First wear tests of standard B_4C nozzles have been conducted using garnet and olivine sand as abrasives. The test results are encouraging despite unexplained failures of certain nozzles.

KEYWORDS

Machining; Ceramics; Power beams; Water-jets; Cutting; Design; Components

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Contract no: BREU-0142
Proposal no: BE-3111

PRECISION MACHINING USING ABRASIVE WATER JETS

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

Abrasive water jets can cut a wide variety of advanced materials that are very difficult to cut using conventional methods. Exploitation of abrasive jet technology is being seriously delayed because of a lack of experimentally and theoretically based models of jet behaviour related to nozzle/workpiece/manipulator/catcher parameters. These models combined with a better understanding of the physical processes involved are essential to design machines to generate cuts that do not require costly secondary machining operations, achieve adequate material fatigue properties, produce acceptable surface finish and edge shapes and avoid scrap components caused by jets deviating from the expected cutting path.

This project aims to:

- establish the characteristics abrasive jets need to meet specific machining objectives
- develop an understanding of jet/workpiece interaction and construct mathematical models of the interactions
- simulate the manipulation of jet/workpieces to achieve required workpiece shapes whilst producing acceptable surface characteristics
- provide models that will predict where and how a jet will leave workpiece so as to be able to catch it
- develop new designs of compact jet catchers that can be manipulated by robots.

The project will provide the experimental and theoretical base necessary to design and safely use a range of precision abrasive jet machine tools. These tools will help in the exploitation of advanced materials, strengthen the EEC's manufacturing base and provide the basis for exports of a new range of machine tools.

KEYWORDS

Mechanical engineering/Machinery; Forming/Shaping/Casting; Machining; Abrasives; Laser technology/Power beams; Machine tools; Abrasive jets

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OPTIMIZING STONE CUTTING PROCESS THROUGH IMPROVED DIAMOND SAW DESIGN AND OPERATION

Starting date: January 1990 ***Duration:*** 42 months

OBJECTIVES

When using disklike diamond saws, the main characteristic with significant influence on the cutting process and the quality of the workpiece is their vibration behaviour. This vibration behaviour is influenced by the dimensions of the saw blade, the state of residual stresses and the construction of the saw body and must be adapted to the machine and the cutting process. The main objective of this project is the adaption, transfer and application of innovative saw design practices in order to eliminate stepwise cutting with different diameter saws to achieve deep cuts and instead the use of saws with improved abilities. Economic benefits will be obtained through reduction of tool downtime, improved surface quality, narrower kerf and better use of the raw material.

ACHIEVEMENTS TO DATE

The achievements to date are the specification of current saw manufacturing practices on saw blade vibrational behaviour. The manufacturing steps heat-treatment, milling of the teeth, straightening and pre-tensioning, thickness grinding, diameter grinding, final straightening have been investigated in relation to vibration patterns, decay behaviour after excitation, natural frequencies and flexural rigidity. An improved diamond segment design was developed and the cutting conditions established. The characteristics and composition of the raw material (marbles) are described.

The next tasks will concern modal analysis of the machine and new design of saw blades.

KEYWORDS

Materials processing; Machining; Processing (minerals & metals); Quality assurance; Wood/Paper; Machine tools; Materials characterization/Testing; Vibration analysis/Acoustics

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Contract no: BREU-0080
Proposal no: BE-3328

IMPROVING SURFACE FINISH AND INTEGRITY IN CLOSED DIES USING ULTRASONICALLY AGITATED ABRASIVE MIXTURES

Starting date: October 1991 ***Duration:*** 48 months

OBJECTIVES

The proposal is directed to the optimisation and demonstration of a method for automatic-control finishing of die cavities in order to replace expensive manual finishing techniques currently employed throughout Europe.

As finishing typically represents from 5 to 30 percent of production costs, such an automatic process would result in significant cost savings. This factor coupled with the improved surface quality would increase the competitiveness of many European companies, many of which would be SMEs.

The suggested approach involves the ultrasonic agitation of polyborosiloxane polymer impregnated with abrasive grit. This compound is fluid at room temperature and will thus conform to the shape of cavities of any dimension, whether of simple design or of a more complex nature. Applications would include finishing of precision forging dies and moulds, removal of recast layers and the introduction of residual compressive stresses on aircraft engine components.

The programme would initially involve the determination of a suitable energization method for the polyborosiloxane/abrasive mixture. In addition the effects of curved transducers and the introduction of shear waves on the energy distribution, attenuation and heat generation would also be defined. Sample pieces would then be polished on test equipment to evaluate process variables.

The final stage of the research programme would involve the design, construction and evaluation of a prototype ultrasonic polishing machine.

KEYWORDS

Machining; Abrasives; Machine tools; Surface treatment technologies; Tools/Dies

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Contract no: BREU-0432
Proposal no: BE-4518

COMPUTERIZED SYSTEM FOR THE COORDINATED DESIGN OF MACHINE, TOOL AND PROCESSING PARAMETERS IN SUPERABRASIVE MACHINING

Starting date: August 1991 ***Duration:*** 48 months

OBJECTIVES

In modern production engineering, requirements in terms of accuracy, hardness and wear resistance of parts are constantly increasing. These parts can often be machined only with new, super-hard abrasives. In this context, the use of cubic boron nitride (CBN) grinding wheels for the machining of high precision components will be of growing importance, especially in fully-automated grinding processes.

Despite its favourable cutting characteristics and low wear rates, CBN has found acceptance in only a few production applications. This is because the superabrasive wheels are relatively expensive and the machine, grinding wheels and working parameters must be carefully adapted to be technically and economically successful.

To prepare for the introduction of superabrasive precision machining, a system permitting coordinated design of grinding machine parameters, grinding wheels specification and grinding process parameters will be developed in a joint linking a grinding machine manufacturer, a grinding wheel manufacturer, an industrial user and a research institute.

The integrated approach will reduce production costs by 20% or more, with improved part quality. The knowledge acquired will enable the European grinding industry to maintain its leading position in the world market, where Japan currently enjoys a growth rate in CBN consumption of 40% as compared to 20% in Europe.

KEY WORDS

Grinding; Machining; Cubic boron nitride

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Contract No: BREU-0304
Proposal no: BE-3125

INTELLIGENT MACHINE FOR INTERNAL GRINDING WITH VERY HIGH CUTTING SPEED USING ACTIVE MAGNETIC BEARING SPINDLE

Starting date: October 1991 ***Duration:*** 48 months

OBJECTIVES

The performance of internal grinding processes is generally very low, since the small tool diameters entailed by geometrical constraints would require extremely high speeds of rotation in order to achieve favourable cutting speeds. Conventional spindles attain high speeds only if power and rigidity are limited, ruling out high removal rates.

Material suppliers, manufacturers, a university institute and an end user will jointly develop an advanced, intelligent, high-speed, high-performance internal cylindrical grinding machine combining extreme rigidity with thermal stability and equipped with an active magnetic bearing (AMB) spindle. This machine will be capable of achieving substantially higher powers and speeds of rotation (more than trebling cutting speed), and will therefore allow advanced high-speed manufacturing technology to be applied to grinding. A key factor will be the development of a new greatly-improved manufacturing technology fully capable of exploiting the high cutting speeds. For this purpose, the machine control will have to be kept constantly informed of the process state and will need to maintain cutting values within the optimum range. These criteria demand the creation of a far more integrated control system with a much higher performance, capable of interpreting a large number of process signals autonomously and initiating the necessary corrective measures ("intelligence").

The overall system will provide a high level of relief for the operator and hence a considerable improvement in the quality of the industrial environment. The increased performance which can be attained makes the project extremely interesting from an economic point of view, and high user acceptance is consequently anticipated. It will safeguard favourable manufacturing of high quality components for machines, plant, vehicles and ball bearing systems in Europe and help the European machine tools industry to maintain its international marked lead.

KEYWORDS

Electrical/Electronic industry; Mechanical engineering/Machinery; Engineering (mechanical); Machining; Electronics

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Proposal no: BE-4127

PRECISION MACHINING SPINDLES

Starting date: 1991-1992 ***Duration:*** 42 months

OBJECTIVES

The next generation of leading edge optical and opto-electronic devices required optical components with 10 nanometre form accuracy and even lower roughness. Applications of these precise optical components are found in consumer electronics and in the next generation of lithographic equipment for the semiconductor industry. Such optics are manufactured by diamond turning and precision grinding. These precision machining operations have to be made 10 times more accurate (from about 100nm to 10nm form accuracy). Key components of diamond turning and grinding machines are the headstock and grinding spindles. Error budgets of these machines have shown that the spindles have to be improved to advance the current state of the art. From a conceptual phase, designs will result in a small high-speed grinding spindle and a larger, lower speed multipurpose spindle. The grinding spindle is built and tested first. Tests will be done to consolidate the predictions made in the design state (dynamic and thermal behavior), and the grinding process (measurement of cutting forces, grinding of accurate surfaces).

If the spindles can be designed and built so as to assure repeatable behavior at the nanometre level, they will be used as in-process measurement devices to enhance the control and quality of the precision machine operation.

KEYWORDS

Mechanical engineering; Machine tools; Nanotechnology

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Contract no: BREU-0519
Proposal no: BE-4445

AN ADVANCED COMPUTER BASED METHOD FOR THE DESIGN AND OPTIMIZATION OF GLOBAL MACHINING ASPECTS (DOGMA)

Starting date: January 1992 ***Duration:*** 30 months

OBJECTIVES

The main objective of the DOGMA project is to achieve a generalized procedure to apply the most modern modelling techniques to the milling process, including the CNC-Machine with its different components, the cutting-tool, the fixturing system and the workpiece.

The modelling techniques to be used are based on new research in the fields of:

- Finite Element Method and model reduction
- Experimental Model Analysis and parameter identification procedures
- Finite Element model updating
- Expert Systems.

On the basis of standard tools (CAD, FEM and Model Analysis packages) special programmes and the necessary interfaces will be developed to obtain an open and integrated environment for computer-aided modelling, simulation and analysis.

This environment and the procedures which will be also established in the DOGMA project will make a powerful tool that will be able to be used by two main sectors:

- machine tool manufacturers, particularly those dedicated to 3-5 axis CNC machines requiring high precision and speed
- high precision parts manufacturers like those used in automobile, aeronautical and aerospatial industries.

KEYWORDS

CAE/CAD/CAM systems; Machine tools; Machining; Modelling; Mechanical engineering; Expert systems

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Proposal no: BE-4273

IMPROVED PERFORMANCE OF MACHINE TOOL OPERATION THROUGH A CLOSED LOOP, TUNED VIBRATION ABSORBER

Starting date: July 1991 ***Duration:*** 36 months

OBJECTIVES

In 1989, the coordinator of this project was granted a feasibility award from EC-DG XII C to study the concept of "using active elements for introducing effective damping into structures". This was achieved by means of a closed loop tuned vibration absorber.

In the mechanical engineering industry the material removal rate of machine tools is often limited by their dynamic instability, called chatter. This effect is expressed in dangerous vibration levels, which also reduce the product quality and accuracy, tool life time and wear.

A closed loop vibration consists of a classical vibration absorber (mass-spring damper system eliminating vibration at only resonance frequency by acting in opposite phase), of which the spring-damper is automatically controlled to follow the changing behaviour (and changing resonance frequencies) of the machine tool during cutting. Therefore, a closed loop absorber added to the machine will limit the vibration level and increase the material removal rate over a wide range of cutting conditions.

After its development, the absorber will be integrated and tested on three specific applications of the industrial partners:

- a milling machine
- an eight pallet machining centre
- a headstock of boring and milling machine.

Subsequently, the assessment of acquired experiences will be used to facilitate and broaden its application range inside and outside the machine tool industry: increased stability and drilling speed of boring bars, friction welders, tool holders, lightweight machine foundations, overcritical operation of papermill rolls, etc..

KEYWORDS

Mechanical engineering/Machinery; Machining; Ferrous; Machine tools; Tribology; Vibration absorber; Drilling stability; Material removal rate

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Contract no: BREU-0426
Proposal no: BE-4503

ADHESIVE BONDING TECHNOLOGY FOR BUILDING CONSTRUCTION - ''CONCERTED ACTION'

Starting date: March 1988 ***Duration:*** 36 months

OBJECTIVES

This programme aims to develop adhesive bonding technology for building construction with the following objectives:

- to establish confidence in the long-term performance of adhesively bonded load-bearing structures in building construction
- to explore innovative design concepts and details through new material combinations and novel forms of attachment and reinforcement
- to develop predictive techniques which will enable bonded structures such as compound beams and structural elements to be designed from a sound theoretical base
- to achieve economies in building through improved manufacturing methods and by more efficient material utilisation.

ACHIEVEMENTS TO DATE

The "concerted action" facility has enabled the partners to bring their respective research interests into a coordinated programme, and progress has been made on a number of overlapping shared interests:

- adhesion and surface characterization, particularly for glass- silicon interfaces in structural glazing applications
- surface pretreatment and joint durability related to many adhesive and sealant - substrate combinations
- adhesive material characterization and test method development
- joint behaviour at both small and large scale, the latter including assembly details in aluminium structures and a composite flooring concept
- mathematical and numerical modelling of structural behaviour
- development of novel applications of bonded structures in building.

KEYWORDS

Building; Assembly/Joining; Building/Construction; Adhesives/Bonding; Testing/Evaluation; Sealants; Adhesion science.

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Contract no: RI1B-171
Proposal no: P-2006

DEVELOPMENT AND TESTING OF NUMERICAL MODELS FOR JOINT DESIGN IN COMPOSITE MATERIAL STRUCTURES

Starting date: July 1988 ***Duration:*** 36 months

OBJECTIVES

The use of composite materials offers evident advantages in fields where low weight structures are required to combine high strength in service loads and good resistance to corrosive agents. In the field of polymeric matrix composite materials very high mechanical performance beams are available on the market. However, today very expensive joints are used to connect these beams to reach a good reliability of the whole structure. To widen the use of these beams it is necessary a tool to design a reliable, cheap and low weight joint.

The objective of this research is to finalize a C.A.E. method, based on modelling techniques, to design the joints in order to extend the high performance of each single element to the whole structure.

ACHIEVEMENTS TO DATE

In order to design joints, an interactive graphic Mesh Generator System (MGS) has been developed. This software package is now interfaced with a well known F.E.M. code selected at the beginning of the research. During this research, several three-dimensional joints were designed by MGS, then manufactured an dtested in order to verify and finalize the developed design method. With MGS it is possible to optimize the design of joints, using F.E.M. code, and to examine the results clearly. The first results of the last testing phase are confirming a good approximation between theoretical predictions and experimental results in accordance with the imposed tolerance.

KEYWORDS

CAE Systems; Composites (polymer matrix); Joining; Civil engineering; Materials processing; Design; Construction.

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Proposal no: P-2331

LONG LIFE PUBLIC SERVICE VEHICLE PROJECT STUDY

Starting date: November 1991 ***Duration:*** 36 months

OBJECTIVES

The aim of the project is the production of a concept frame call for PSV vehicles in aluminium alloy using adhesive bonding in combination or/not with other joining methods It is an integrated, multidisciplinary project in that it covers the materials selection, design manufacturing processes and application requirements dictated by relevant international regulations.

- Overall geometry of the structural cell must comply with ECE 36 regulation
- Strength and stiffness must not be less than that currently specified for steel structures
- Aim for a 45% weight reduction
- Crash resistance in roll-over accidents following regulation ECE 66
- Cell structure durability under fatigue loads and corrosion resistance adequate for long term application (i.e. longer than that for current steel structures)
- Ease of manufacturing and cost effective fabrication.

Since the frame design is dominated by the beam sections used and joint performance, the research project will focus on the following objectives:

- design layout of structural frame similar to current practices
- selection of aluminium alloy on the basis of strength, formability and energy absorption
- evaluation of structural adhesives and manufacturing process
- design joints and beam sections for stiffness and strength
- design joints and beam sections for impact loads (crash resistance)
- design joints and beam sections for fatigue durability
- evaluation of structural cell assembly performance in roll-over test.

The innovative character of the project derives from the following aspects:

- use of adhesive bonding with aluminium alloy in a structural application with stringent requirements of strength, stiffness and crash-worthiness
- development of FEM model for the evaluation of crash-worthiness of components and complete structure with adhesive bonded joints
- modelling of adhesive joints under shear and peel loads
- fatigue durability analysis of bonded aluminum joints durability under alternate climate conditions and exposure to salt spray.

KEYWORDS Adhesives/Bonding; Non ferrous; CAE/CAD/CAM systems; Public Service Vehicles (PSV)

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Contract no:
Proposal no: BE-4079

BRAZE JOINING SYSTEMS FOR STEEL - SILICON NITRIDE AUTOMOTIVE COMPONENTS

Starting date: December 1988 ***Duration:*** 30 months

OBJECTIVES

The overall objective of this project is to develop an integrated metal to ceramic brazing technology, based on 'active' brazing and suitable for mass production, which enables the design of the joint and the choice of joint materials to be optimised for a wide range of applications. The specific objective is to select, manufacture and optimise multilayer brazing structures to join a steel automotive engine component to a silicon nitride based ceramic. A mechanical tappet has been selected as the component which will be used to demonstrate this technology.

ACHIEVEMENTS TO DATE

A finite element model was developed to predict the stress and deformations in multilayer brazed structures. It was used to finalise the joint design for the production of trial tappets.

"Active" brazing alloy tapes, manufactured by rapid solidification to produce enhanced metallurgical characteristics over conventional processing, were successful in vacuum brazing trials.

Using the above as a basis, sample tappets were manufactured for service trials. Laboratory assessment is presently underway and if successful will be by full scale engine testing.

KEYWORDS

Automotive, components & parts; Rapid solidification; Metal/Ceramic joining; Multilayer/Multimaterials; Mathematical modelling; "Active" brazing

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Contract no: MAIE-0024
Proposal no: P-0479

INVESTIGATION OF NOVEL COPPER PHOSPHOROUS SYSTEM FOR BRAZING STEELS

Starting date: December 1988 ***Duration:*** 48 months

OBJECTIVES

The main objective of the present programme is to research and develop new, low cost alloys for the brazing of steels at temperatures lower than those used when brazing with classical bronzes. The effect of braze composition, base metal, temperature, surface preparation, fluxes and binders on joining is under investigation. Braze metal interfaces are investigated by different methods including TEM, hot stage SEM, microprobe and US testing. Strength and corrosion resistance is investigated. Techniques of production of ribbons (including melt-spinning), wires, powders and, pastes are under investigation.

ACHIEVEMENTS TO DATE

Subsequent new aloys for brazing steels were produced:

- Cu-X-Y-Z alloys with melting range below 875°C and tensile strength of the brazed joints of the order of 500MPa for brazing of mild and stainless steels
- Cu-Sn-P-Y-Z alloys with melting range below 715°C and joint tensile strength of the order of 150MPa for large surface brazing or steel to Cu brazing
- Cu-Sn-A-B alloy with melting range below 850°C and joint strength of the order of 300MPa for brazing of Ti stabilized ferretic steels.

Specific fluxes have been developed. US system for non destructive examination and hot stage SEM is in working order. Hot stage SEM, TEM and US images of interfaces were produced.

KEYWORDS

Assembly/Joining; Ferrous; Non ferrous; Solders/Brazes/Welding.

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Contract no: RI1B-0231
Proposal no: P-2409

DEVELOPMENT OF IMPROVED BONDING TECHNOLOGY FOR NEW ENGINEERING CERAMICS AND METALS

Starting date: March 1988 ***Duration:*** 36 months

OBJECTIVES

The project has developed improved bonding techniques for joining the engineering ceramics SiC and Si_3N_4 to a number of industrial metals and alloys. The research has advanced prior knowledge on bonding these highly dissimilar materials by means of three parallel approaches involving the development of bonds via liquid phase (metallic and glass-ceramic) and via solid state metallic bonds. The principal technical problems addressed were: a) the transition between the metal and ceramic structures and b) the thermal expansion mismatch between ceramic and metal components.

ACHIEVEMENTS TO DATE

High strength joints of ceramic-to-ceramic and metal-to-metal have been achieved with glass-ceramic joining media. The development of graded expansion glass-ceramic joining media has enabled SiC-Nilo K joints to be achieved. Braze joints have been made of ceramic-to-metal with various ceramic and metal combinations and joint shear strengths up to 200 MPa, together with high tensile and bending strengths, have been achieved. Metallic interlayers such as Cu and Ni between ceramic and metal, to relieve expansion mismatch stress, have been shown to be advantageous. The joint strength decreased with rise in temperature in excess of 500°C. Using diffusion bonding techniques, high shear strengths of greater than 200 MPa, together with high tensile and bending strengths have been achieved for Si_3N_4-to-Nilo K combinations with Ni interlayers. Finite element analysis, using the GEC ALSTHOM MELISSA programme, has demonstrated the influence of the type and thickness of stress relieving interlayers and showed that peaked stress is in the ceramic near the interface. FEA results have been correlated with strength data.

KEYWORDS

Ceramic-to-metal; Joining; Glass-ceramic; Brazing; Diffusion bonding; Mathematical modelling; Multilayers

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Proposal no: P-2162

THE BRAZING OF NEWLY-DEVELOPED MECHANICALLY RESISTANT MATERIALS TO LOW-ALLOY-STEEL FOR INDUSTRIAL MACHINING

Starting date: March 1991 ***Duration:*** 36 months

OBJECTIVES

A bonding technique for thermally and mechanically highly stressed joints between cemented carbide with low content of Co-binder, silicon nitride or boron carbide and steel shall be provided. The hard materials will be brazed to tools for mechanical machining.

Suitable filler materials have to be developed which fulfil the objectives listed below:

- good wetting of newly developed cemented carbides, silicon nitride and boron carbide
- achieving shear strength of 200 MPa at room temperature
- the joints have to withstand service-temperatures of up to 600°C.

ACHIEVEMENTS TO DATE

The project has just started. Test specimens were fabricated and delivered to the partners. The characterization of materials and wettability tests on cemented carbide, silicon nitride and boron carbide were started.

KEYWORDS

Machining; Bonding; Brazes; Ceramics; Hard materials

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NEW BRAZE FILLER MATERIALS AND BRAZE TECHNIQUES FOR JOINING AUSTENITIC STEELS AND SUPERALLOYS WITH BETTER MECHANICAL AND CORROSION PROPERTIES

Starting date: July 1988 ***Duration:*** 48 months

OBJECTIVES

The aim of the project is to improve the efficiency of nickel-based filler metals by way of four specific objectives:

- characterization of the behaviour of the different families of filler materials especially with respect to Cr and other alloying elements in terms of microstructural composition, melting, wetting and flow behaviour and of brazed joints formed with a few selected workpiece materials
- development of a new brazing technique where the material surface is transformed into a braze by means of a boron and/or silicon coating
- codification of the brazing parameters for the optimum use of nickel-based filler metals and for the first time guidelines for the creation of new brazed joints, which are corrosion resistant in acqueous solutions
- economy through the development of brazes that melt at lower temperatures with equal or better properties.

ACHIEVEMENTS TO DATE

- thin layers of boron or silicon applied, by coatprocess, on different superalloys, and successful braze joints were made, which are 'hot-corrosion' resistant
- new, important, information has been obtained on the influence of alloying elements, with respect to braze-, mechanical- and corrosion properties
- new nickel-based braze filler metals have been developed with better and more predictible properties than the present commercially available brazes
- by optimization the braze temperatures of the new developed technique and filler metals are considerably lower than for the commercial brazes (upto 100°C).

KEYWORDS

Aeronautics/Aerospace; Food/Drink/Water; Coatings/Thin films; Powders; Solders/Brazes/Welding; Superalloys/Special alloys; Materials characterization/Testing

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Proposal no: P-2281

DEVELOPMENT OF NOVEL LOW MELTING POINT ALUMINIUM ALLOY BRAZES

Starting date: January 1990 ***Duration:*** 48 months

OBJECTIVES

There is an identified need to braze together components in a wider range of aluminium alloys than is currently possible. This arises from the low melting points of these alloys, relative to those of existing brazes, and restrictions imposed by the alternative joining methods. An example of the latter is mechanical fastening, where allowable geometries of components are limited and there are heavy penalties in terms of machining and assembly costs. Moreover, assurance on integrity and reliability can be difficult to establish. The aim of the project is to address this requirement by identifying and developing aluminium alloy brazes that melt below 500°C. There is evidence that such brazes are to be found in aluminium alloy systems containing silicon and germanium plus other elements. Joining processes based on selected compositions will be developed for use in industrial manufacturing. The ultimate goal of the project is to braze a range of representative components for airframe, aerospace and automotive applications that are difficult or impossible to braze at present. A successful outcome is likely to enable major improvements to be made to the design and performance of components and improve the cost-effectiveness of their manufacture. In consequence, this would raise the competitive edge of European manufacturing industry.

KEYWORDS

Electrical/Electronic industry; Aeronautics/Aerospace; Assembly/Joining; Solders/Brazes/Welding; Materials characterization/Testing

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Proposal no: BE-3082

DEVELOPMENT OF A MICRO JOINING TECHNIQUE WITH NON-PRECIOUS BONDING WIRES FOR INTERCONNECTING SEMICONDUCTOR DEVICES

Starting date: January 1989 ***Duration:*** 36 months

OBJECTIVES

The objective of this study is the development of micro welding techniques for interconnecting semiconductor devices with non-precious wires. In comparison with the present gold wire technique, the use of non-precious wire would reduce the cost of the interconnection substantially. Since high yield and reliability are required, detailed studies are necessary of both the materials used and the interconnecting process as well as the factors which influence the final assembled semiconductor device reliability. Using simplified screening tests, a selection of wires from copper, aluminium and/or alloys will be made and used to connect test chips with leadframe substrates. To achieve a controlled bond quality and in depth understanding of the basic correlation between process, material parameters and the final product properties, a number of investigations are performed. The intrinsic properties as well as functional requirements are derived from an extensive characterization of bonding wires, substrates and chip metallizations. Bondability tests with a monitoring of the relevant process parameters like bonding force, ultrasonic energy and temperature are presently running. Long-term reliability will be studied by the use of established, standardized tests to investigate environmental effects (package, temperature, humidity, bias). Detailed metallographic and chemical analysis will support the failure analysis in the reliability study of packaged devices.

KEYWORDS

Electrical/Electronic industry; Packaging; Assembly/Joining; Electrical; Solders/Brazes/Welding; Electronics; Research/Development

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SURFACE CONDITIONING OF ELECTRONIC COMPONENTS FOR CLEAN JOINING PROCESSES

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

General Objective:

To develop conditions of surface preparation for advanced techniques of soldering and adhering in electronic circuitry.

Field 1: Investigation by today's analytical means of the nature of surface films on the metallic surfaces of substrates and electronic components, in a produced condition and after special cleaning treatments (etching, etc.).

Field 2: Development of conditions for soldering without leaving residues, thus avoiding solvent cleaning afterwards (for both wave soldering and reflow soldering).

Field 3: Development of long-lasting electrical connections using conductive adhesives on cleaned surfaces.

Field 4: Development of feasible and rapid methods for the assessment of cleanliness of surfaces.

KEYWORDS

Materials processing; Electrical/Electronic industry; Assembly/Joining; Adhesives/Bonding; Solders/Brazes/Welding; Chemistry; Surface treatment technologies

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BASIC RESEARCH IN SOLDERING FOR SURFACE-MOUNTING TECHNOLOGY IN ELECTRONICS ASSEMBLY

Starting date: June 1989 ***Duration:*** 36 months

OBJECTIVES

The research programme is aimed to establish a relationship between the in-service reliability of surface mounted electronic assemblies and the degradation of the component solderability during storage prior to soldering. To establish this relationship the following tasks are being undertaken:

- a new instrument is to be designed and built for soldrability measurement of all package configurations of surface mounting components. The optimum measurement parameters of the instruments and the test procedures will be identified for each component type
- the mechanisms of natural and accelerated ageing of the various component metallizaton types will be investigated. A range of differing accellerated ageing procedures is then related to metallurgical changes which are in turn related to solderability changes
- surface mounted assemblies will be produced using both wave soldering and IR reflow soldering. The components used will have been subjected to a range of accelerated ageing procedures
- thermal shock testing and low-cycle thermal fatigue testing will be used as indicators of in-service reliability, enabling reliability to be related to solder fillet geomtry and in turn to component solderability.

ACHIEVEMENTS TO DATE

The solderability measurement instrument has been designed and built, ready for testing and a round-robin exercise. Our knowledge of the ageing mechanisms of different solderable surfaces has been considerably enhanced and their quantitative effect on solderability established. The surface mounted assemblies have all been built and are undergoing thermal shock and low cycle thermal fatigue testing.

KEYWORDS

Electronics; Surface Mount Assembly; Solderability; Reliabilty.

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JOINING TECHNIQUES FOR RELIABLE SURFACE MOUNTING OF MICRO - ELECTRONICS

Starting date: January 1989 ***Duration:*** 42months

OBJECTIVES

Modern electronic equipment frequently employs Surface Mount Technology to provide high packing density of components. This technology relies on solder connection for both electrical and mechanical support and the mechanical failure of these joints can give rise to reliability problems.

The objective of this project is to provide detailed knowledge of the reliability of electrical connections in surface mounted electronic assemblies, and thereby to enable connections of known and reproducible high reliabiility to be designed.

ACHIEVEMENTS TO DATE

Extensive investigations have been carried out into the mechanical properties of bulk solder. The properties measured include static, tensile and shear behaviour, low cycle fatigue, creep and anelasticity. These results are incorprated into a set of constitutive laws which are used to model the detailed mechanical properties of the solder joint.

Finite element analysis of the thermal and linear mechanical behaviour of populated SMT boards has been carried out. Non-linear finite element modelling is used to describe the mechanical behaviour and build up of damage within the solder joint.

Comprehensive testing of SMT boards is now producing practical failure data on a range of board and package types. This information will be used to validate the reliability model as it is developed.

The output from this programme will enable predictions to be made of the reliability of solder joints for specific combinations of board design, package and soldering process under design life ultimately bring benefits of increased cost-effectiveness and reliabilty to a wide range of electronic equipment employing Surface Mount Technology.

KEYWORDS

Solders; Reliability; Mathematical modelling; Surface Mount Technology.

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Proposal no: P-2309

LASER SOLDERING TECHNOLOGY OF S.M.D. ELECTRONIC ASSEMBLY FOR INTEGRATION ON PICK AND PLACEMENT MACHINES

Starting date: June 1990 ***Duration:*** 36 months

OBJECTIVES

- to develop a fully integrated surface mounting technology which is highly reliable and therefore cost effective. This is to be done by integration of the pick and placement and the laser soldering action in one process step (fault rates less than 100 ppm)
- to identify and optimize the parameters for the process of interconnecting surface mounted electronic component packages and printed circuit boards by means of a controlled laser soldering process at soldering rates which are compatible with pick and placement machines (placement rate of 6000 components per hour)
- to obtain a basic understanding of the physics and chemistry underlying the laser soldering process and to derive from the basic principles the limiting factors of laser soldering.

ACHIEVEMENTS TO DATE

- laser types and modes have been evaluated
- commercial laser soldering pastes have been analysed
- process conditions for laser soldering with commercial solder pastes have been established
- different options for beam handling have been evaluated.

KEYWORDS

Electrical/Electronic industry; Assembly/Joining; Engineering (electrical); Solders/Brazes/Welding; Electronics; Laser technology/Power beams

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Proposal no: BE-3341

JOINING OF COPPER AND ALUMINIUM ALLOYS BY LASER (JOCAL)

Starting date: March 1990 ***Duration:*** 36 months

OBJECTIVES

Laser welding of copper, aluminium and their alloys is difficult, due to the high reflectivity for laser radiation, their high thermal conductivity, and the crack sensitivity of some of the alloys. In this project, laser welding, brazing, and soldering will be studied. This will be performed using alloys commonly used in the electrical, electronic, domestic appliances, and automobile industry. CO2 and Nd:YAG lasers will be used. The project will focus on the establishment of design rules for laser joining, and on the identification of methods for on-line control of the processes. Experiments will be supported by modelling Finally all the results will be collected in a database.

ACHIEVEMENTS TO DATE

Laser welding parameters, including the choice of the shielding gas, type of coating layers, laser intensity, and most suitable weld geometry, have been established for the following situations: CO2 seam welding of all alloys, Nd:YAG seam welding of copper alloys, and Nd:YAG spot welding of aluminium alloys. A control system for laser soldering and brazing has been developed and demonstrated. Conditions for laser soldering and brazing have been established, both experementally and by calculation. De-insulation of copper wire has been demonstrated. A start was made with the monitoring of weld quality by plume registration.

KEYWORDS

Joining; Process monitoring; Quality control; Non ferrous; Laser technology; Mathematical modelling; Research/Development

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HIGH POWER 15-20 KW CO_2-LASERS FOR MATERIALS PROCESSING

Starting date: January 1987 ***Duration:*** 51months

OBJECTIVES

The main objectives of the project are to establish the basic technology of two alternative approaches for the second generation of high power CO_2-lasers, namely: the turbulent axial flow DC-discharge (TAF) and the radiofrequency discharge (RF). Furthermore, the technical potential of the two approaches has to be evaluated with respect to essential criteria such as efficiency, beam quality, modes of operation and compactness. Finally, the validation of the results should lead to the design of a 15-20 KW laser for industrial application, especially for large area surface treatment.

ACHIEVEMENTS TO DATE

Two laser modules, one in the TAF and one in the RF-approach are fully operational at an output power of 10 kW. The RF-laser has also achieved 30 kW of peak power in the superpulse mode. Successful power extraction has been demonstrated with an aerodynamic window Good beam quality has beenobtained experimentally which compares favourably with the predictions of two different computer codes developed by each partner, respectively. In the present technology the TAF- approach is not scalable to powers well beyond 15kW. However, a medium frequency excitation scheme which has yet to be validated makes higher powers accessible. The power density in the RF-approach is already high (15 W/cm^3) and thus, scalabilty to powers well in excess of 15 or 20 kW will be achieved by appropriate combination of laser modules.

KEYWORDS

Laser technology/Power beams; Materials processing; Machine tool

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Proposal no: P-1354

LASER SHEET METAL WELDING

Starting date: September 1986 ***Duration:*** 48 months

OBJECTIVES

The aim of this project is to provide the automotive, aerospace and sheet metal industry with enhanced basic technology and systems knowledge in order to improve weld quality and laser system flexibility when welding complex shaped structural or non-structural ('shell') components. The research topics range from analysis of plasma and laser beam power distribution, welding coated and uncoated sheets with a variable gap and subsequent comparative mechanical, metallurgical and corrosion resistance tests. The filler metal technique will be adopted to achieve positive interaction with the variable gap parameter and the complex geometry of industrial components, while considering heterogeneous material welding. The project also includes development of sensors for focal position control. Flexible clamping systems are also to be designed and integrated with the supervisory systems. Aeronautic, aerospatial and automotive components will be welded following technological advances.

ACHIEVEMENTS TO DATE

Improvements in absorption of laser energy by the metal , the process has been monitored by optical beam switching and high speed cinematography. ▪ Diagnostic and control devices for the welding process have been tested, for integration in a production line. ▪ Fatigue resistance of laser non-through welds, for automotive applications. ▪ Zinc coated overlapping sheets have been satisfactorily welded by introducing a gap between rthem. ▪ In aluminium Al2219 and 6061 porosity still exists in the laser-produced weld bead. ▪ Welding Uranus 45 and Ti6Al4V gave satisfactory results. ▪ Rolling clamping devices have been designed and successful welding was obtained on relatively deformed sheets. ▪ Intermediate car door pillars with a shell structure have been laser welded, showing a very strong increase in rigidity and fatigue resistance compared with conventional spot welds. ▪ The aeronautic component 'capot échangeur' for the AIRBUS A320 in titanium has been laser welded, demonstrating the feasibility of annular spot welds; these should be regarded favourably for fatigue and thermal shock resitance. ▪ Aerospace cylindrical modules in Ti6Al4V, ϕ 500mm in diameter and 1.6mm thick, showed that laser welding results in a manufactured product with very low thermal distortions.

KEYWORDS Laser material processing; Laser technology/Power beams; Laser welding/Joining; Laser process sensors; Laser plasma

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PLUME EMISSION ANALYSIS UNDER "TIME RESOLVED SPECTROSCOPY" FOR LASER WELDING CONTROL

Starting date: December 1990 ***Duration:*** 36 months

OBJECTIVES

The aim of the project is to develop a system to provide real time control of the laser welding process of metals using simultaneous multichannel analysis of the plasma plume generated at the interaction point between CO2 laser beam and workpiece.

The research will develop by:

- analysis of the plasma generated during the welding process and collection of the spectra generated by optimized welding processes
- development of an autofocus system
- development of an on-line monitoring and alarm system
- building complete prototype testing system.

ACHIEVEMENTS TO DATE

- measurements with different metals, thickness-parameters, laser-power variation between 1.2 and 5.8 kW have been performed
- special analysis and processing software with a parameter library have been developed
- identification of significant parameters during welding for process control have been achieved
- prototype system development is in progress to be available by the end of 1991 to allow monitoring and alarm operation during welding.

KEYWORDS

Mechanical engineering/Machinery; Engineering (process); Quality control/ Inspection; Control systems; Sensors/Signal processing; Automation/CIM; Vision/Optical systems.

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Proposal no: BE-3042

SHEET-METAL WELDING WITH kW ND/YAG-LASERS FOR THE AUTOMOTIVE INDUSTRY

Starting date: October 1990 ***Duration:*** 36 months

OBJECTIVES

The objectives of the proposed project are to establish the principles and the underlying conditions for the industrial application of kW range solid-state lasers for welding thin sheet, to illustrate the possibilities and the limits for both the kW solid state laser and the optical fibre and to determine the prospects for the application of such systems.

For this purpose it will be necessary to carry out, evaluate and analyse welding of thin sheet. A detailed analysis of the interaction between beam and material is required in order to gain an understanding of the process. This understanding will permit the deduction of the basic conditions required for industrial thin sheet welding and will allow the development and testing of measures and methods for inspecting, controlling and regulating the process.

ACHIEVEMENTS TO DATE

- report on analysis of beam intensity distribution for fibre optics
- selection of the appropriate materials for fibre optic cables
- pulsed kW Nd:YAG Laser system for the work to be carried out
- first construction of an output housing with integral spacer sensor
- quality assessment using online process control during welding.

KEYWORDS

Laser technology; Automotive industry; Joining

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POWER SOLID STATE LASER WITH HIGH BEAM QUALITY BASED ON Co-DOPED LANTHANUM HEXA-ALUMINATE (LNA)

Starting date: November 1988 ***Duration:*** 36 months

The project aims to produce a power solid state laser in the range of 1 kW using an alternative material to YAC, the lanthanum-neodymium hexa-aluminate ($LaMgA_{11}1O_{19}$:Nd or LNA). The main objective of this research is to increase the yield of the laser by studying the effect of a sensitizer on the emission of the neodymium. Several possible sensitizers will be tried. A complete characterization of the material will be performed by measuring all the thermal, mechanical and optical parameters which are needed for the design of a high power and high-beam quality laser head. A predesign of the resonator will permit study of the flash pumping of the material for a CW, pulsed, switched laser emission. At the same time, the laser diode pumping will be studied with the small rods available at the beginning of the research. At the end of the project, two laser heads will be built in the range of 1 kW for the rod laser and in the range of 300 W for the slab laser.

ACHIEVEMENTS TO DATE

Processing of CrNd doped LNA rod of 7mm in diameter and 115mm in length along the A axis. Growth of LNA crystals of 30mm in diameter and 50mm in length along the C axis. Physical characterization of the properties of interest for laser action has been performed and CW and Q-switched laser action has been tested. Design of rod and slab resonator is completed.

KEYWORDS

Laser technology/Power beams; Optical materials.

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Contract no: RI1B-245
Proposal no: P-2112

IMPROVED PROCESSINGS CAPABILITY OF CW INDUSTRIAL CO_2 LASERS

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

The penetration of CO_2-laser technology in industry is conditioned by a profound understanding of underlying physical principles which determine the laser's machining capability. Besides aspects linked with the beam delivery system, this processing capability is mainly a function of the laser beam quality and the fluctuations. The excitation and de-excitation of the vibrational-rotational levels of the CO_2-molecule is extremely complex, since it is least to be considered as a 5 level system. This complexity is the origin of the lack of proper design and optimization criteria for the CO_2-laser, despite the rater elementary constituent parts of the laser itself.

The prime objective of the project is to enhance the materials processing capability of CW industrial gas lasers developing design criteria for achieving optimum flow and discharge conditions, which particular reference to FAF (fast axial flow) CO_2-lasers in the range between 1 and 5 kW, which represents the major sector of the industrial laser market.

The main areas of investigations will comprise plasma engineering and flow conditioning, with the aim of ensuring laser operation to the required standards of beam quality for various laser processing functions. Flow visualization and evaluation of plasma parameters, will be combined with computer modelling of the turbulent gas flow to elucidate key features, with particular emphasis on time dependent effects, e.g. laser/plasma fluctuations vs. turbulence. The sources of critical frequencies in the fluctuation spectra will be identified and, where possible, eliminated. This also includes the development of dedicated turboblowers with matched load lines.

Dedicated special diagnostic equipment such as ultrasonic laser beam analysis, intermode beating, laser plasma potential measurement, population density measurement, spatially resolved gain measurement and computational plasma simulation will be considered for these tasks. The results of the research will be validated in a representative device of 1 to 2 kW.

KEYWORDS

Processing (ceramic & glass); Research/Development; Materials processing

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Contract no: BREU-0516
Proposal no: BE-4266

LASER WELDING OF SUPERALLOYS AND OF TITANIUM ALLOYS

Starting date: 1991 ***Duration:*** —

OBJECTIVES

Nickel, cobalt, and iron-based superalloys are widely used in the aeronautical sector (jet engines, turbo propellers, helicopter turbines), they are also relevant to gas turbines for power stations and to chemical and nuclear reactors. They can be profitably welded by laser as preliminary research has shown.

The coordinated continuation of this research is urgent and will enable new competitive manufacturing processes and new product design, which laser technology has brought to other sectors, to be developed for this sector of European industry.

Traditional welding is difficult due to the material, the sometimes complicated shapes and heat induced deformations on the finished parts which cause costly and lengthy extra work.

Therefore the aim of this research is to give industry access to welding by CO_2 and Nd-YAG high power laser, with minimal deformation, also making use of fibre optics for hidden parts. The combined technique of laser cutting followed by welding, which is required in regenerating turbine engines (overhauling), will also be studied.

Industrial manufacturers representing diversified use of superalloys are cooperating in this project with research centres having experience in technological applications of high power lasers and laser system manufacturing.

KEYWORDS

Aeronautics/Aerospace; Energy/Power generation; Assembly/Joining; Solders/Brazes/Welding; Superalloys/Special alloys; Laser technology/Power beams

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Contract no: BREU-0518
Proposal no: BE-4096

HEAVY SECTION LASER WELDING

Starting date: October 1988 ***Duration:*** 48 months

OBJECTIVES

Welding metal sheets thicker than 10 mm by laser sources of power exceeding 10 kW is a research area of maximum interest for the European Community, due to the effect this technology can produce in several industrial sectors. This programme joins the European labs equipped with the lasers of highest power, has as its goals to determine the potential of laser technology in welding heavy sections, to gain insight in the complex interaction of high power laser beam with materials and to optimize the working conditions in order to offer the European industries the chance to exploit the advantages of laser in production. Therefore, this research will include a first analysis of the beam transport and focusing optics, and a deep analysis of the phenomena of interaction of the beam with metallic materials, as well as their modelling. Thus, control devices for shielding gas will be tested and improved in order to optimize the process, while different beam shaping systems and techniques for deep welding by narrow gap will be developed in order to increase the maximum welding thickness.

ACHIEVEMENTS TO DATE

Activity during the first years of the project concentrated on both the features of laser sources and laser-material interaction. The laser sources of the laboratories involved in the project (AVCO and UTIL) are currently being analysed in terms of total power, stability and spatial distribution, using both standard and specifically developed devices such as calorimetres and spatial analysers. The acoustic and optical signals of the plasma generated during the laser welding process have been studied under various conditions. Fast framing cameras visualized the plasma ignition cycles and the molten material motion; the thermal fields around the interaction area have been recorded using an infrared camera. The welding of precompetitive heavy section industrial mock-ups demonstrate the achievements.

KEYWORDS

Laser material processing; Laser technology/Power beams; Laser welding/Joining; Laser process sensors; Laser plasma

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Contract no: RI1B-199
Proposal no: P-2348

PLASMA AND LASER ENHANCED ARC WELDING FOR AUTOMATIC APPLICATIONS

Starting date: March 1990 ***Duration:*** 36 months

OBJECTIVES

- to study the underlying physical mechanisms of the welding arc
- investigate energy distribution and transfer between the arc and the weldpool for both partial penetration and keyhole geometries
- determine operating parameters for positional plasma keyhole welding
- examine the influence of laser beam enhancement on arc stability, weld quality and productivity
- determine the role of radiation on arc structure and energy transfer efficiency
- construct theoretical simulations of the arc welding process as a basis for future model development
- improve ignition behaviour and stability of the arc by using a laser beam as support
- determine operating parameters for positional laser enhanced arc welding
- prepare a laser enhanced arc welding facility, using a laser of a comparable low power (lower than 300W).

ACHIEVEMENTS TO DATE

- construction and test of the experimental equipment equipment for plasma-and laser-enhanced arc welding equipment
- analysis of the welding arc by distinct techniques
- model description of welding arc incl. nonequilibrium processes
- proof that plasma- and laser-beam-enhancement lead to significantly improved welding results.

KEYWORDS

Materials processing; Assembly/Joining; Ferrous; Automation; Laser technology; Mathematical modelling; Welding

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Contract no: BREU-0069
Proposal no: BE-3037

RELIABILITY AND REPRODUCIBILITY OF HIGH INTENSITY BEAM WELDING

Starting date: March 1989 ***Duration***: 42 months

OBJECTIVES

- to define optimised processing cycles and parameters of High Intensity Beam Welding - (HIBW) - Laser and Electron Beam - on main materials used in aircraft and energy industries and to establish repairing techniques for eventual defects in HIBW joints
- to establish an innovative ultrasonic method by Shear Horizontal plate modes for the inspection of HIBW joints - EMUS technique
- to establish correlations between welding cycles, NDT controls and mechanical performances of HIBW joints (fatigue and creep).

ACHIEVEMENTS TO DATE

- optimized laser and electron beam welding cyces have been established on all materials considered in the project (AISI 9310 and ASTM A335 steels, AA 6061 light alloy, ALLOY 80 superalloy)
- repairing techniques on defective joints (misaligned or damaged due to sharp laser stop) have been set up and properly defective joints have been produced for the NDT calibration
- the comparison of the EMUS results on a set of properly defective joints with conventional US NDT and destructive inspections has been started both on grinded and ungrinded specimens
- the activity on mechanical properties qualification of HIBW joints has been launched and the first fatigue curves are available: mechanical performances achieved by "different" kinds of beam joints, characterized by varying heat input and defectology will be finally compared.

KEYWORDS

Aeronautics/Aerospace; Energy/Power generation; Assembly/Joining; Prototyping; Superalloys/Special alloys; Instrumentatin/Measuring systems; Machine tools

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Proposal no: P-2232

IMPROVEMENTS TO LOW HEAT INPUT WELDING

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

The objective is to improve the technology, and hence European industrial exploitation, of low heat input welding by three significant, interlocking advances in weld properties, process sensors and expert systems.

Firstly, the weld properties work seeks to improve, inter alia, hardness and toughness (increasingly recognized as requiring urgent attention), where assessments will be made of local properties instead of the performance of structures in which they are incorporated.

Secondly, the sensor work involves novel research and development of ultrasonic equipment, capable of use on-line to measure the weld liquid/metal interface and thereby quantify weld size and penetration.

Thirdly, innovative work on an expert system will be carried out, incorporating rule-base information from the weld properties work with data input from the developed sensor systems. Finally, a demonstration of the complete adaptive weld quality control system will be set up by a group of partners collaborating at one of their premises.

Over the course of the programme, and in the context of laser welding, proposals and recommendations will be made regarding the drafting of new norms and standards; in the context of shipbuilding (identified here as a prime candidate for the technology) this will include Classification Society Rules. It may be noted that the collaboration has good vertical integration, from primary producers (steel) through welding process and sensor technologists to end-users in the shipbuilding, automotive, aerospace and electricity supply industries, thereby ensuring the overall project's immediate industrial relevance and routes for exploitation.

KEYWORDS

Shipbuilding; Assembly/Joining; Ferrous; Laser technology/Power beams; Research/Development

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Proposal no: BE-4331

ELECTRON BEAM WELDING ON LARGE THICKNESS STEEL FOR HEAVY INDUSTRY

Starting date: January 1989 ***Duration:*** 48 months

OBJECTIVES

The objectives of this project are as follows:

- determination and optimization of the EB welding parameters on very thick Cr-Mo steels, which are used in many industrial components, i.e.: pressure vessels, heat exchangers, gas and steam turbines, etc. Three EB equipments are involved in this project, to compare electron beam characteristics and weld qualities on four kinds of Cr-Lo steels: $2^1/_4$CrMo (plates and cast), 9% CrMo, 12% CrMo

The necessary steps to achieve these goals are:

- the relationship between beam characteristics, weld quality and occurrences of defects
- the optimization of welding conditions in partial and full penetrations (75 to 200 mm)
- the optimization of the welding procedure for a girth weld
- non destructive and destructive tests of the welds.

ACHIEVEMENTS TO DATE

The results of these tests will allow the performance of full scale mock-ups as a demonstration of the result validity and comparison with arc processes in quality and cost. This research will be the background of European Standards in quality of EB process and welding

KEYWORDS

Construction/Building/Civil engineering; Energy/Power generation; Assembly/Joining; Quality assurance; Metallic structural materials; Codes/ Standards

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Proposal no: P-2294

ANALYSIS OF BEAM/WORKPIECE INTERACTION APPLIED TO ELECTRON BEAM WELDING FOR INDUSTRIAL APPLICATION

Starting date: February 1991 ***Duration:*** 36 months

OBJECTIVES

The objectives of this project are:

- realisation of defined penetration geometries or weld forms by examination of the correlation between beam and weld geometry
- in accordance with this the selective, application specific development or improvement of beam generating systems
- development and application of the signal analysing methods that allows process observation and quality monitoring and hence detection of certain faults or their causes
- development of a computer-supported concept for efficient identification and optimization of appropriate process parameters
- Improvement of existing or development of new model concepts for energy conversion, dynamics of capillary action and heat flow with the aid of the results of the investigations.

ACHIEVEMENTS TO DATE

Development of a beam measurement system, which enables measurement of the geometry of electron beams up to a power level of 100 kW.

KEYWORDS

Imaging/Image processing; Laser technology/Power beams; Mathematical modelling; Sensors/Signal processing; Promotion/Technology transfer; Research/Development

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Proposal no: BE-3489

DEVELOPMENT OF A KNOWLEDGE-BASED CAD/CAM-SYSTEM FOR OFFLINE-PROGRAMMING OF RECURRING SENSOR-CONTROLLED WELDING PATTERNS

Starting date: January 1989 ***Duration:*** 48 months

OBJECTIVES

In this project a CAD/CAM-system is developed for knowledge-based offline programming of arc welding robots. This CAD/CAM-system is intended to support economic use of arc welding systems for medium and in particular very small lot sizes. The advantages of offline programming are enhanced here by a new concept. In contrast to other graphic offline programming systems offering the possibility of generating programmes interactively, this system eliminates unncessary user interaction during the generation of a robot programme by way of new numerical simulation techniques and the storage of welding and robot programming knowledge in the database of an expert system. With the robot programme in high level language a numerical simulation is started, which generates an optimized, collision-free path for the robot welding along the welding seams of the workpiece. The user may check the generated programme and the robot's movement by a graphic simulation system and, if desired, may change the programme according to any special user requirements. After the generation of an accurate, collison-free and corrected robot programme a compiler translates the programme from its independent form into a controller-dependent language of a robot manufacturer.

KEYWORDS

Shipbuilding; Assembly/Joining; Metallic structural materials; Automation/CIM; Robotics

PRIME PARTNER

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Contract no: RI1B-280
Proposal no: P-2322

ARC SENSORED ROBOT-WELDING OF 3-DIMENSIONAL SEAMS WITHOUT PROGRAMMING THE WELD PATH

Starting date: September 1990 ***Duration:*** 36 months

OBJECTIVES

The aim of the proposed project is the development of an arc sensored seam tracking system providing the following features:

- automatic height and side adjustment of the torch
- automatic adaptation of the torch orientation to the actual seam direction in 3 dimensions
- weldability of closed seams (orientation adjustment angle > 360°)
- welding speed is not affected by seam deviation
- automatic adaptation of welding and oscillation parameters for out-of-position welding
- weldability of continuous curved seams (with a certain radius, smallest possible, e. g. 20 mm) and non-continuous curved seams (sharp corners)
- reduction of seam programming to the teaching of start and final point.

ACHIEVEMENTS TO DATE

- construction of two microprocessor based control units which are suitable for the evaluation of non-continuous signals; the control units will be prepared for all software extensions that arise from the following stages of the project
- solution of interface problems between the newly developed sensor units and the robot controller
- adaptation of the robot coordinate systems to the requirements of the systems
- preparation of the robots for ARC sensored detection of the seam direction (adaptation of external oscillator and realisation of a constant wire feed system).

KEYWORDS

Robotics; Sensors/Signal processing

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Proposal no: BE-3490

FLEXIBOT PROJECT - FLEXIBLE MANUFACTURING SYSTEM INTEGRATING DIFFERENT WELDING TECHNOLOGIES AND OTHERS FOR SMALL-LOT AND VERY DIVERSIFIED PRODUCTION

Starting date: October 1991 ***Duration:*** 36 months

OBJECTIVES

This project starts from Bisiach and Carru's existing Mobile Gantry Robot. Their big, 3 polar-axes, hollow-head robot was originally devised for spot-welding, with a huge structure, a big operating volume (about 600m^3) and many specific features for this process. This is the most complex welding process, because of the high currents, magnetic field and loads of operating welding groups which are involved.

The basic robot already includes an automatic gun-changer and tools-magazine already planned for all necessary fluids (cooling-water, compressed-air, oil, electrics and electronic connections for sensors, secondary current, etc.).

The project aims at integrating other different technologies in the robot, to be used in the same work-station, with the same jigs in line with the total quality concept to transform the robot into a total flexibility poly-technological Universal Robotic Production Centre.

To do this, three possible end-users will collaborate for three years, with their experience in different welding technologies in relatively low and diversified car production-MECEDES ESPANA, PININFARINA and STEYR-DAIMLER-PUCH.

The planned technolgies for the project which are to be integrated in the robot are, among others:

- spot welding-direct/indirect, with gun (simple and multiple up to 4 guns), with tip (simple and double) in d.c. current, seam-roll welding, projection welding, MIG-welding, bolt-welding, rivetting and other operations with working elements for sheet-metalworking.

The advantages would be:

- a polytechnological robot system including several technologies in the same cycle and in the same work-station, ideal for small and medium-size production series
- increase in the quality of the final product as it can be produced in the same jig without removal (best geometry, space and time economy)
- reduction of production time, change-over of product model and programming
- extension of the client's potential market
- work ecology (no gas, heat and pollution for the operator
- off-line programing, increased safety and reduction of collision through errors
- increase in logistical flexibility, preventive and computer-aided maintenance.

KEYWORDS Automotive, Components & Parts; Assembly/Joining; Engineering (process); Manufacturing; Quality assurance; Automation/CIM; CAE/CAD/CAM systems

PRIME PARTNER

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Contract no:
Proposal no: BE-4159

PROCESS CONTROL FOR FLEXIBLE JOINING SYSTEMS

Starting date: August 1991 ***Duration:*** 36 months

OBJECTIVES

The project is primarily concerned with the establishment of the basic requirement for a feedback control system for the automatic and robotic MAG welding of sheet steel automotive components. However, some attention will be paid to other metallic materials and other welding and joining processes to define the limitations of the control system.

The exact requirements in terms of joint designs, joint quality and production rates will be defined and an appropriate monitoring system developed using state of the art sensors. Modelling will be used to identify critical parameters that need to be controlled. This work will lead to the definition of the requirements of a feedback control system after which a prototype system will be designed, built and tested under both laboratory and production conditions.

KEYWORDS

Welding; Automotive, Components & parts; Ferrous alloys; Control systems; Sensors/Signal processing; Monitors; Modelling

PRIME PARTNER

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Contract no: BREU-0415
Proposal no: BE-4006

DISSIMILAR METAL JOINING BY THE USE OF GRADED COMPOSITIONS

Starting date: August 1989 ***Duration:*** 48 months

OBJECTIVES

At present there are over 10 000 dissimilar welds operating in the creep range in the UK alone. These have a history of creep related failures arising from internal thermally induced stresses. This project aims at the development of an improved method for the production of these joints. This method requires the production of a transition piece having a composition which varies along its length. In effect this replaces the dissimilar weld with two similar welds at each end of the transition piece.

Three material combinations will be investigated 2 1/4Cr-316, mod 9Cr-316 and 2 1/4Cr-mod 9Cr. These will be fabricated using Hot Isostatic Pressing (HIP) and Vacuum Plasma Spraying. The technical and economic merits of the two fabrication routes will be compared. Trial joints in a number of designs of compositional gradient will be produced and subjected to uniaxial creep testing, Finite Element Modelling and corrosion testing. On the basis of this modelling and testing work optimized compostional gradients will be selected for each material combination. These will be subjected to long term uniaxial and biaxial creep testing.

By the end of this project there will be sufficient design data available for the rapid adoption of this technology for tube size joints in both the Power Generation and Petrochemical Industries.

KEYWORDS

Chemical/Petrochemical; Energy/Power generation; Design; Assembly/Joining; Multilayers/Multimaterials; Materials science; Powder metallurgy

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Proposal no: BE-4177

NEW POROUS SOLIDS - ORGANIC-INORGANIC PILLARED COMPOSITES

Starting date: September 1987 ***Duration:*** 36 months

OBJECTIVES

The preparation, characterization and pore properties of new porous materials prepared utilizing layered phosphates as the base materials and the concept of " pillaring". The latter involves insertion of cationic moieties followed by calcination giving rise to cross-linking in the materials, with consequent formation of pore structures with different geometries.

ACHIEVEMENTS TO DATE

Series of porous solids have been prepared with alumina- and chromia-pillars between phosphate layers, the cavities of which can indeed be manipulated by suitable choice of reaction conditions. Surface areas of 18-400 m^2g^{-1} have been obtained to date, in materials which can be modulated so as to be either crystalline or amorphous (whilst still being in many cases monopore). Thus, alumina- pillared series contain both wide pore -radius distributions (r_p = 11-50 Å) and others narrow ones : 10-25Å. Furthermore, series of materials can be manipulated to give free heights (as assessed by XRD) which can be rationally varied, between 5.5 and > 25 Å New methods have also been found for preparing starting Keggin-ion (and non Keggin-ion) clusters which can be generalised to smectite clays.

The materials selectively exchange transition metal ions, and absorb large organic molecules both in bulk and as adherent thermally stable films on metallic and vitreous surfaces. They also allow polymerisation of conducting organic "molecular wires" and supporting semi-conductor clusters to give quantum-well devices.

KEYWORDS

Pillared layered materials, Porosity; Films; Catalysis; Zeotypes; Phosphates.

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Proposal no: P-0837

COORDINATED EUROPEAN ACTIVITY ON PILLARED LAYERED STRUCTURES (CEA - PLS)

Starting date: July 1991 ***Duration:*** 48 months

OBJECTIVES

Pillared Layered Structures are nanocomposite materials prepared by linking molecules or colloids to a layered host. They exhibit a remarkably broad spectrum of structural, chemical, electronic, ionic, optical and magnetic properties, and provide supermesh host structures in which chemical reactions or physical processes can proceed under gas-phase conditions, but at liquid/solid state densities.They can be shaped as powders, pellets, supported or self-standing films, and can be dispersed in solid or liquid matrices.

Due to the equally broad spectrum of potential applications, including heterogeneous and homogeneous catalysis, separation technology, environmental applications, sensors, research on PLS is definitely pre-competitive.

ACHIEVEMENTS TO DATE

The CEA-PLS provides a forum for information exchange and cooperation in the field of PLS. In its present state, the CEA-PLS links twenty-three university or governmental groups and ten industrial groups, from seven European countries.

KEYWORDS

Multilayers/Multimaterials; Catalysts; Coatings/Thin films; Powders; Nanocomposite materials; Waste treatment/Containment; Particle technology

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Contract no: BREU-0462
Proposal no: BE-4275

SYNTHESIS, CHARACTERIZATION AND EVALUATION OF MULTI-LAYERED AND PILLARED MATERIALS FOR PROCESS CHEMISTRY AND THE ENVIRONMENT

Starting date: August 1991 ***Duration:*** 48 months

OBJECTIVES

The overall objectives of this project are to develop processes for the reproducible and predictable preparation of pillared layered and multi-layered materials of regular interlayer spacings having desirable physical and chemical properties for use in process chemistry and environmental applications, to scale-up these preparations and to thoroughly evaluate the technology in a laboratory pilot scale plant for the process under consideration. The aim is to build a model of the structures and associated properties and therefore be able to predict performance.

The project will develop processes for the preparation of pillared layered stuctures and multi-layered materials of regular interlayer spacings, having desirable and predictable chemical properties. If successful this will generate several materials with a wide range of possible applications, including improved chemical synthesis and environmental protection. Materials will initially be prepared as powders or pellets by different methods in each laboratory and tested using an agreed range of reactions and characterization techniques, while successful materials will be scaled-up for further testing. The work will be divided into five tasks covering the preparation and selection of materials, evaluation, characterization and optimization of active site, scale-up of preparations, the assessment of performance at the laboratory pilot scale and project management.

The partners in this proposal are two users of catalyst/absorbent technology supported by one materials supplier, one research and development organisation and two universities. The structure of the project is vertically integrated and the applications being addressed are of a multi-sectorial nature. The partners possess the required skills and facilities to carry out this work in a complementary fashion.

KEYWORDS

Chemical / Petrochemical; Engineering (chemical); Multilayers / Multi-materials; Ceramics / Glasses; Materials characterization / Testing; Research /Development; Chemistry.

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HETERO- AND HOMOGENEOUSLY CATALYSED ELECTRO-CHEMICAL GAS PURIFICATION FOR SO_2 AND NOx REMOVAL

Starting date: September 1988 ***Duration:*** 48 months

OBJECTIVES

Due to stringent legal regulations for environmental protection and pollution control there is a high demand for the purification of off-gases from power stations, heating combustion units and chemical plants producing such wastes. It is the objective of this project to develop the scientific and engineering fundamentals of SO2 and NOx removal as the bases of new electrochemical gas purification techniques.

ACHIEVEMENTS TO DATE

- theoretical complications of the possible electrochemical reactions for SO_2 and NO_x conversion have been performed
- gas / liquid absorbtion of SO_2 and NO_x in different aqueous solutions has been carried out
- microkinetic data has been determined for the anodic oxidation of SO_2 on Pt, graphite and PbO_2 and for th ecathodic regeneration of $S_2O_4^{2-}$ from SO_3^{2-} on lead electrodes
- two different process schemes have been developed:

(i) an anter cell process with Ce^{3+}/Ce^{4+} as redox mediator

(ii) a combined process with direct SO_2 oxidation in a PbO_2 packed bed cell and homogeneous reduction of NO_x with electrochemically formed $S_2O_4^{2-}$.

In pilot studies both processes will be tested for industrial applications.

KEYWORDS

Chemical engineering; Waste treatment; Gases; Environment

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Proposal no: P-2026

NEW ZEOLITE-BASED SHAPE-SELECTIVE CATALYSTS FOR THE PRODUCTION OF SPECIALITY CHEMICALS FROM NATURAL FEEDSTOCKS VIA CO-METATHESIS

Starting date: September 1988 ***Duration:*** 48 months

Co-metathesis of naturally available and renewable feedstocks as fats, fatty acid esters and derived products with light olefins from petrochemical origin will be used to produce catalytically a whole family of speciality chemicals, which via other routes cannot as easily be made or cannot be made at all. To be able to do this in an economic and competitive way, more active, selective and cheaper catalysts than the presently used ones must be developed. Once these catalysts are available for a few very specific co-metathesis reactions, they will be suitable for process development in a whole range of conversions. The fundamental knowledge to achieve this goal is sound and solid, but much progress beyond this state of the arts is needed before new processes are available. This will require a considerable amount of research, focusing mainly on catalyst improvement, by changing the support acidity and shape-selectivity and studying the catalyst activation chemistry.

KEYWORDS

Catalysts/Zeolites; Ceramics/Glasses

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MATERIALS HAVING NOVEL STRUCTURE FACTORS FOR CATALYSIS OF HYDROCARBON TRANSFORMATIONS AND DEVELOPMENT OF SELECTIVE PROCESSES

Starting date: July 1991 ***Duration:*** 48 months

OBJECTIVES

New catalysts are necessary to improve the selectivity and activity of many vital industrial catalytic processes. In addition to the driving force deriving from better use of feedstocks and raw materials-particularly important where these are petroleum based-there is also a strong environmental need to eliminate unwanted side reactions, which can yield hazardous by-products, and also to improve the problems which may derive from the present disposal residues.

The concept to be followed in this project will be to design novel microporous materials where greater control will be obtained over the two key factors in catalysis - the strength and nature of the active sites and the geometric structural factors, which between them dictate activity and selectivity. Advances in synthetic procedures for microporous materials have been recently achieved by one of the partners and these will be explored further and also applied to the preparations of a wide range of novel materials.

Catalytic performance of these new products will be examined in industrial processes of hydrocarbon transformations (as fluid catalytic cracking and hydrocracking) and other catalytic reactions. Promising materials will be developed to pilot scale preparation level and formulated into finished catalysts for testing under conditions which relate to commercial practise.

KEYWORDS

Chemical/Petrochemical; Catalysts/Zeolites; Hydrocarbons/Petrochemicals; Catalytic process

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Contract no: BREU-0532
Proposal no: BE-4633

DEVELOPMENT AND OPTIMIZATION OF CU BASED CATALYTIC MATERIALS FOR THE SIMULTANEOUS REMOVAL OF SOX AND NOX FROM FLUE GASES

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

The general objectives of the project are: 1) to develop improved and more reliable Cu-oxide based catalytic materials for simultaneous removal of SO_2 and NO_x from flue gas, and 2) to develop the process itself from the lab-scale testing (as in previous BRITE project) to the pilot-plant proof of concept unit.

Improved catalytic materials will be able to operate effectively in extended operations over multiple cycles of reaction and regeneration, in the presence of variable, real gas compositions (derived from the combustion of fuel oil with about 2% S), and solid transport conditions as those prevailing in the pilot-plant unit. Removal of SO_2 and NO_x higher than 90% for, at least, 100 cycles of reaction-regeneration is expected.

The principle points of the project are:

1) Sorbent - catalyst testing during extended operations over multiple cycles of reaction and regeneration, in presence of real flue gas and under realistic attrition conditions.

2) Evalution and identification of the nature of changes in the attrition resistance during Life-Cycle Test.

3) Development of improved methodologies of preparation of these catalytic materials.

KEYWORDS

Catalysts; Flue gas clean-up; De SO_x; De NO_x

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THE DEVELOPMENT OF VALIDATED PREDICTIVE MODELS FOR OPTIMAL DESIGN OF MULTIPHASE CHEMICAL PROCESSES

Starting date: September 1991 ***Duration:*** 48 months

OBJECTIVES

The project envisages the optimal design of multiphase processes. The objective is the development of computer simulation packages which allow detailed predictions on the preparation and behaviour of dispersions and chemical reactions in two phase systems. These processes play essential roles in the pharmaceutical, biotechnology, food, detergent, oil, chemical and polymer manufacturing industries.

To arrive at predictive models three interrelated classes of studies will be performed.

Firstly, the detailed physics of the processes will be modelled at a microscopic level. For the emulsification process droplet/bubble break-up and droplet/bubble merging (coalescence) are the primary issues. Mass transfer of a component from a phase to the interface or from one phase to the other phase are fully taken into account. An extensive experimental programme is proposed to support the theoretical modelling.

Secondly, two phase turbulent flows in reactors will be modelled, taking into account reactor type, geometry, impeller type and rotational speed. The studies comprise: the physics of two-phase turbulence, development of reliable and efficient mathematical algorithms and experimental verification of the turbulence modelling.

Thirdly, the two classes of models mentioned above will be combined to investigate the interaction of local hydrodynamics and microscopic processes. The procedures developed will be implemented in a flexible user-friendly computational package which can cope with a large variety of reactor geometries.

KEYWORDS

Chemical/Petrochemical; Food/Drink/Water; Processing (food, non-rigid); Pharmaceuticals; Polymers; Materials science; Manufacturing

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CARBONYLATION REACTIONS OF INDUSTRIAL INTEREST CATALYZED BY SUPPORTED METALS

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

The main objective concerns the production of higher carboxylic acids by catalytic carbonylation of methanol in the presence of supported Rh.

Direct conversion of synthesis gas to chemicals is not presently commercialized in any homogeneously catalyzed process. On the other hand, the heterogeneously the catalyzed Fischer-Tropsch reaction converts synthesis gas directly to mixtures of variously functionalized compounds. With the notable exception of methanol synthesis however, such heterogeneously catalyzed processes have thus so far been rather nonselective to discourage further application.

As a result of this project, a new preparative route to short-chain alyphatic carboxylic acids may be developed where the products are optionally based upon syngas feedstocks alone. Alternatively by conventional esterification and hydrogenolysis of the reaction mixtures containing variable blends of acids and alcohols may be obtained which are useful as octane boosters.

The first year will be devoted to the development of innovative techniques for supportig Rh, to the chemical and physical characterization of the catalysts and to batch catalytic tests under various conditions. In the second year optimization will be performed through kinetic modelling while investigating on the esterification of reaction mixtures obtained and their hydrogenation to alcohols to assess their potential as octane boosters. The third year will study the transposition as a continuous process of the optimum conditions identified in batches while evaluating the recovery of the metal from the reaction and the economic potential of the defined process.

KEYWORDS

Chemistry; Catalysts/Zeolites; Recovery/Recycling; Engineering (chemical); Chemical/Petrochemical

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Proposal no: BE-4561

CO-ORDINATED ACTIVITY IN PROCESS TOMOGRAPHY FOR IMPROVING THE DESIGN AND OPERATION OF INDUSTRIAL PROCESSES

Starting date: August 1991 ***Duration:*** 48 months

OBJECTIVES

Process tomography is aimed to solve the need for general detailed knowledge of the boundaries between various fluid and solid components in physical systems. In recent years several groups in various countries have developed novel techniques for tomographically imaging systems ranging from process pipelines and reactors to geological strata. Collaborating groups in the UK and several other countries have developed the subject of 'process tomography' to satisfy the great industrial need for non-intrusive measurements of common boundaries in multi-phase flow, process mixing, etc.

The enabling skills of process tomography are sensors, random data analysis, digital signal processing, and the use of array processors. Closely related application skills are process technology, fluid dynamics, and computer-aided design. This interdisciplinary subject is now a major research topic for sixty workers, mostly in EC universities, and eleven workers in EC industry. Based on four previous meetings of UK workers, this co-ordinated activity has three aims:

1) to hold annual meetings of workers from all the EC organisations in order to promote scientific discussion and future applications 2) to prepare an annual report of progress in process tomography 3) to support a database of EC and international progress in process tomography.

KEYWORDS Chemical/Petrochemical process; Imaging; Mathematical modelling

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Proposal no: BE-4015

CATALYTIC MEMBRANE REACTORS: APPLICATION TO FINE CHEMICAL SYNTHESIS

Starting date: September 1991 ***Duration:*** 36 months

OBJECTIVES

The overall objective of the project is the implementation of a new type of catalytic process (i.e. catalysts + reactors) for fine chemicals synthesis. These new catalytic systems will involve inorganic membranes with controlled pore size which will act classically as a separator of the reactants and products but also as a support of the catalysts.

High performances in activity and selectivity are expected owing to the control by the membrane of the circulation of the partners of the reaction, which implies preparation of membranes with small pores (1nm or less).

The project originates from the association of laboratories involved in complementary disciplines related to membrane science, heterogeneous catalysis and chemical engineering.

Inorganic membranes will be prepared and the active phase deposited inside. Catalysts will be tested in model reactions chosen as representative of fine chemicals syntheses. Membrane and catalyst characterizations will be performed before and after use. Modelling of the membrane will provide a better description of the work of catalytic membrane reactors.

KEYWORDS

Chemical/Petrochemical; Engineering (chemical); Engineering (process); Catalysts/Zeolites; Chemistry; Membrane/Separation technology

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SEPARATION OF AQUEOUS ORGANIC ACIDIC MIXTURES BY PERVAPORATION

Starting date: May 1988 ***Duration:*** 48 months

OBJECTIVES

The manufacture of carboxylic acids and their esters is of major importance to the European chemical industry. The objective of this research is to develop acid resistant pervaporation membranes for dewatering aqueous organic acids or esters.

ACHIEVEMENTS TO DATE

Fundamental research has been carried out to select a suitable polymer and develop a better understanding of the pervaporation process. Membranes have been developed which achieve fluxes within the original target range for acetic acid and ethyl acetate. Economic evaluations have been carried out which indicate the pervaporation technology appears more attractive than conventional distillation technology in certain applications. On the basis of studies performed to date, the more attractive applications are the ability of the membrane to produce a reject water stream with low levels of organic residue is very important. Experimental work with formic acid dehydration has shown that selectively and flux are both lower than corresponding values for acetic acid.

KEYWORDS

Membrane/Seperation technology

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Proposal no: P-2079

DEVELOPMENT OF NEW PERVAPORATION MEMBRANES AND PROCESSES TO SEPARATE ALCOHOLS/ETHERS/HYDROCARBON MIXTURES

Starting date: April 1991 ***Duration:*** 36 months

OBJECTIVES

The overall objective of this project is to improve, by pervaporation integration, the separation sequences of the production processes of both main ethers: MTBE and ETBE. We shall mainly try to work out the problems relative to ETBE production; these problems seem to be the most difficult to work out and the least studied to date.

Therefore, the main purpose of this project is to design and develop new pervaporation membranes for alcohol extraction (methanol/ethanol) from hydrocarbons (C_4 fraction) and/or from ethers (MTBE/ETBE). It will bring about a major innovation in pervaporation field, by extending this technology, hitherto limited to the separations of water/organic compound mixtures, to organic/organic type separations.

It is based on three complementary lines:

1) Development of new membranes specific to alcohol/ether and/or alcohol/hydrocarbon separations.

2) Design improvement and cost reduction of the pervaporation units.

3) Definition of optimal separation processes.

KEYWORDS

Pervaporation; Membranes; Alcohol; Ether; Hydrocarbon; Methanol; Ethanol.

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ACIDS RECOVERY BY MEMBRANE TECHNOLOGY NEW MEMBRANES AND PROCESS OPTIMISATION

Starting date: October 1991 ***Duration:*** 45 months

OBJECTIVES

The aim of the project is to develop new electrodialysis and electro-electrodialysis membranes and the necessary associated industrial equipments, adapted to the concentration of acids and their separation from metallic cations. The membranes will be achieved by radiochemical grafting technology and the equipments improved to allow operations in contact with agressive industrial fluids.

KEYWORDS

Membrane/Separation technology; Chemical/Petrochemical; Engineering (chemical); Recovery/Recycling; Ecology/Environment; Waste/Effluents; Polymers

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Contract no: BREU-0497
Proposal no: BE-4535

DEVELOPMENT OF MEMBRANE PROCESSES FOR THE OLIVE OIL AND OTHER VEGETABLE OIL INDUSTRIES

Starting date: March 1989 ***Duration:*** 39 months

OBJECTIVES

The aim of the proposed research project is to set up integrated methods, based on the use of membrane technologies, for treating olive oil waste water. Laboratory and pilot test will be performed with the following objectives:

- to develop treatment methods for reducing the organic load of the olive oil waste water
- to develop and/or optimize ultrafiltration, nanofiltration, microfiltration and reverse osmosis membranes and spiral wound modules, according to specific needs
- to set up pretreatment methods and/or in-service devices for overcoming membrane fouling and clogging
- to study the possibility of recovering natural pigmental and antioxidant components and/or energy from the concentrate.

ACHIEVEMENTS TO DATE

- technical and economic evaluation of the olive oil waste water treatment
- characterization of the olive- oil waste water
- development and characterization of R.O. and U.F. tubular and spiral wound modules
- development of physical and physical-chemical methods to reduce the membrane fouling and to clean fouled membranes
- selection of experimental conditions to recover natural antioxidant products from the UF/RO concentrate
- planning of experimental plants for pilot tests.

KEYWORDS

Food/Drink/Water; Design; Disposal/Dismanteling/Demolition; Recovery/recycling; Waste treatment; Ecology/Environment; Membrane separation technology

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Proposal no: P-2033

MICROPOROUS CARBON MEMBRANE FOR GAS SEPARATION

Starting date: 1991-1992 ***Duration:*** 42 months

OBJECTIVES

A novel route to produce mechanically, thermally and chemically stable microporous carbon membranes has now been discovered that is based on proprietary porous polymer precursors. Initial tests have shown the simple thick film tubular membranes to have the potential for two types of separation. Simple molecular sieving has been demonstrated by separating hydrogen from hydrocarbons at high temperatures whilst C1-C5 hydrocarbons have been separated using novel mechanism that relies on condensation of the gases in the carbon micropores at temperatures well above the gases critical temperatures.

The aim of the proposed project is to extend the current simpler tubular membrane technology to multichannel monolithic membranes in modular form and to confirm their process viability in demonstration facilities located on refinery/petrochemical process plant. This will require the development of an understanding of the separation mechanism for these novel membranes, methods for producing the optimum pore structures for the different separations and new process routes for producing the monoliths and significantly thinner membrane layers inside the monolith channels.

If successful the membrane modules should fine rapid commercial application by retrotting to a wide variety of existing processes. In addition it is anticipated that they could be used in a wide variety of novel grass routes applications in the environmental and process field at a later date.

KEYWORDS

Chemical/Petrochemical; Carbons/Graphite; Membrane/Separation technology; Research/Development.

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CROSS-FLOW MICROFILTRATION AS AN EMERGING TECHNIQUE FOR INDUSTRIAL SEPARATION – DEVELOPMENT OF A NEW GENERATION OF HIGH FLUX MEMBRANES AND MODULES ALLOWING FOULING CONTROL WITH A HIGH DEGREE OF MASS TRANSFER

Starting date: February 1989 ***Duration:*** 36 months

OBJECTIVES

A large variety of separation techniques can be achieved by membranes. The far more developed technologies (reverse osmosis, ultrafiltration) use devices where the fluid flow is tangential to the membrane in order to limit the accumulation of species on the membrane and reduce the decay of performance. Usually, microfiltration is used in 'dead-end' techniques where the fluid flow is perpendicular to the membrane. This restricts microfiltration to analytical uses or filtration of liquids with a very low content in suspended material. Considering the need of the bio-industries to find an alternative for the configuration and drawing on their experience in membranes and bio-products, the partners will conduct research in order to produce:

- a range of microfiltration membranes enduring repeated steam sterilisation and showing a high resistance to fouling
- modules designed for high performance microfiltration with the capacity to be an interesting alternative to centrifugation in the bio- and pharmaceutical industries.

ACHIEVEMENTS TO DATE

- microfiltration membranes were successfully grafted with various anionic and cationic species as well as polyvinil alcohol
- polyesters and polyether-sulfone were selected as non woven for supports of steam sterilizable membranes
- extensive test of characterization were carried out on grafted membranes. Significant improvements were obtained in methodologies of characterization (fouling by proteins, tests of rejection)
- industrial englobulin precipitated serum was used to characterize the positive effect of grafting on the flux of proteins permeating through microfiltration membranes
- a lab test apparatus was designed for characterization of MF membranes. The design is the basis for the development of a pilot plant system.

KEYWORDS Membrane/Technology separation

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USE OF BACTERIA IMMOBILIZED ON AQUATEXTILES OR COMPOSITE MEMBRANES FOR EXTRACTION OF METALS AND MICROPOLLUTANTS

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

Examination of technical literature reveals a potential use of combined water purification via physical, chemical and biological processes integrating the most recent techniques. The main goal of this research, concerning topics no 4.3.3 and 4.4.4 of the Brite programme, is to set up new multisectorial and cost effective, biological and membrane processes. The originality of the approach consists of proposing new separation techniques which can easily be integrated in reaction systems and improve mass transfer while limiting the clogging and/or contamination risks. Technological progress is based on: the use of bacterial species capable of assimilating heavy metals and degrading the micropollutants present in industrial effluents of various origins; dyeing plants, surface treatments, non-ferrous metals, rainwater, lixiviation extracts in released products, etc...

The efficiency of aquatextile and composite membranes integrated in type reactions: sedimentation on fibrous matrix, tangential filtration, absorption-filtration on a mobile membrane, flat sheet membrane and tubular membranes.

KEYWORDS

Construction/Building/Civil engineering; Textile/Clothing; Waste treatment/Containment; Textiles; Ecology/Environment; Promotion/Technology transfer; Research/Development

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Contract no: BREU-0084
Proposal no: BE-3517

ENZYME CONFINEMENT IN LIQUID DETERGENTS

Starting date: January 1990 ***Duration:*** 24 months

OBJECTIVES

The specific goal of the project is to develop materials to protect enzymes against the hostile components in modern heavy duty liquid detergents. The protected enzyme must be released in an active form, during the first minute of the wash cycle.

ACHIEVEMENTS TO DATE

The four year project consists of 5 distinct steps.

- step 1 and step 2 were addressed during 1990. Step 1 concerned Preliminary Screening of Materials and Methods. Step 2 concerned Development of Materials and Processes. The project is slightly ahead of the plan
- work in the first year of the project involved a survey of encapsulation and entrapment techniques. Several processes, leading to the development of a number of theoretical confinement models, were identified
- the theoretical aspects of membrane formation, diffusion and solubility of detergent components have been investigated in detail. This has lead to construction of equipment for experimental investigation of diffusion and solubility
- the market has been surveyed in order to determine the composition of the liquid household detergents. This knowledge is used to produce liquid detergents for experimental purposes
- the materials identified have been tested together with the enzymes for compatibility. Formulated enzymes have also been tested for their influence on the confinement materials and processes. No major difficulties have been seen

KEYWORDS

Other manufacturing industries; Polymers; Enzymes; Detergent

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BULK PRODUCTION OF PARTICLES BY ATOMISATION – STUDY OF DROP INTERACTION, SIZE DISTRIBUTIONS AND SPRAY STRUCTURES WITH LASER TECHNIQUES. COMPARISON WITH PREDICTIONS OF MATHEMATICAL MODELS

Starting date: May 1987 ***Duration:*** 48 months

OBJECTIVES

This project is a study of industrial spray atomisation systems with the objectives of developing a computational model of the spray dryer process and validating the model with laser based measurements on industrial plant.

ACHIEVEMENTS TO DATE

The project finished after 48 months on 30th April 1991. The objective of developing and validating a computational model capable of simulating spray gas mixing in industrial spray dryers was achieved. During development the model was adapted to five different dryer geometries. Two types of laser based instruments were adapted for use inside the hot dusty environment of industrial spray dryers. Comparisons between the predictions of the model and measurements have been made on five spray dryers using industrial feedstocks. The comparisons were used to adjust the model such that good agreement can now be achieved between predictions and experiment if certain features of the model are operated in an appropriate way. The ability of the model to give such agreements over a wide range of dryer types gives considerable confidence in its predictive capability.

This project has resulted in a major step forward in the state of the art of spray dryer modelling. The benefits which will result include the ability to test new operational procedures and new feedstocks for spray dryers using a validated computational code.

KEYWORDS

Mathematical modelling; Instruments/Sensors; Particle Technology; Powders

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Proposal no: P-1202

CONTROL OF SUSPENSION POLYMERIZATION REACTIONS FOR PRODUCTION OF POROUS MICROPARTICLES OF DESIRABLE PROPERTIES

Starting date: August 1987 ***Duration:*** 48 months

OBJECTIVES

Problems related to the formation, structure, suspension stability, modelling and control of molecular and morphological properties of polymer microparticles are investigated. These problems are examined in relation to the suspension polymerization of vinyl chloride and the slurry/precipitation polymerization of acrylonitrile-based copolymers. The specific objectives of the programme are:

- development of detailed comprehesive process models for the suspension homo- and co-polymerization of vinyl chloride and acrylonitrile-based copolymers
- development of microscopic particle mordphology models
- development of macroscopic particle morphology models
- design and construction of all necessary experimental facilities (bench-scale reactors, pilot-scale reactor)
- experimental verification of the theoretical results
- development of improved computer-based analytical techniques for on-line and off-line characterization of molecular and morpholgical properties of polymer particles.

ACHIEVEMENTS TO DATE

To date the following results have been obtained:

- a detailed kinetic model for the suspension and bulk polymerization of VCM
- mathematical models describing the aggregation phenomena in VCM polymerization
- a generalized model for prediction of particle size distribution in agitated vessels
- comprehensive kinetic models for linear and branched copolymers
- design and construction of bench-scale and pilot-plant reactors
- development of necessary computer-based methods for the characterization of particulate polymers
- an experimental investigation of acrylonitrile polymerization using redox free radical initiation
- modelling of primary particle formation in slurry polymerization of acrylonitrile
- experimental evaluation of molecular and morphological properties of particulate polymers.

KEYWORDS Polymers; Particle technology; Mathematical modelling; CAM systems

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Proposal no: P-1560

REAL TIME MANUFACTURE PROCESS CONTROL FOR CRYSTALLINE MICROPARTICLES (COMIPA)

Starting date: 1991 ***Duration:*** 36 months

OBJECTIVES

Fine inorganic chemicals are generally obtained by precipitation or crystallization. There is a real need for a better control of reactive precipitation, because the main physico-chemical properties (purity, size, shape) are determined during this key step of the process. For instance, narrow crystal size distribution is required for high technology applications (e.g. micro electronics, ceramics, reinforcement) so that currently cheap products (like calcium carbonate) could reach another class of high market value materials.

The project is aimed at developing a new crystallization process for controlling the production of tailored particles. Two basic concepts are proposed to reach this objective: controlled release of reactants (via decomplexation reactions), and process control with a model-based software (derived from predictive numerical simulation).

This methodology will be designed and validated for calcium oxalate or calcium carbonate productions, these compounds being representative of classes of crystalline micro-particles. The proposed concepts are likely to be adapted to other precipitation products, such as SiO, BaCO, Y2O, ZrO, TiO for ceramics and electronics.

KEYWORDS

Materials science; Chemical; Process/ Product monitoring; Engineering (chemical); Particle technology; Mathematical modelling; Control systems

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Proposal no: BE-4429

COST EFFECTIVE LASER SYNTHESIZED NANOSCALE POWDERS AND CASES OF THERMOMECHANICAL APPLICATION

Starting date: July 1991 ***Duration:*** 48 months

OBJECTIVES

The development of laser synthesized nonoscale ceramic powders is restricted by the high cost of the chemical precursors and the lack of industrial application to justify such high quality materials.

The goal of this project is to develop a European industry for nanoscale powders based on innovative answers to these restrictions:

- firstly in using cost effective precursors, a new concept of synthesis reactor and an advanced laser technology
- secondly in developing two original application fields:
  - tools made from sintered cermets for wear and mechanical properties
  - electrochemical composite coatings for which nanoscale SiCN and TiB_2 ceramic reinforcement enhance erosion and wear resistance.

Having the advantage of the availability of large quantities of such powders, their sintering behaviour will be with a view to the conventional applications in the field of ceramics.

KEYWORDS

Ceramics/Glasses; Powders; Nanotechnology; Powder metallurgy; Surface treatment technologies; Laser technology/Power beams; Aeronautics/ Aerospace

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Proposal no: BE-4236

THE PLASMA ARC SYNTHESIS OF ULTRAFINE ALUMINIUM NITRIDE POWDER

Starting date: February 1988 ***Duration:*** 36 months

OBJECTIVES

Tetronics (TRD) and GH Industries (GH), in consultation with the other partners, the University of Limoges (ULIM), decided on the design and construction of a five piece modular reactor to be sited at TRD's premises. GH fabricated the reactor modules and shipped the units over to England in August 1989.

ACHIEVEMENTS TO DATE

Both the modular reactor and a smaller test unit at ULIM have produced aluminium nitride powders; initial tests at TRD using a twin plasma torch, configured to run argon (anode) and nitrogen (cathode), while ULIM ran on straight single transferred plasma using nitrogen. Primary aluminium was found in the TRD powders but not in those produced by ULIM. A nitrogen anode torch has been developed at TRD to eliminate argon and hence free aluminium in the modular reactor. Tests have been recorded on video at both test unit locations. Vaporisations is thought to occur at the surfaces of the massive aluminium nitride structure (mushroom) growing from the aluminium melt. The twin arc system does not require the use of an aluminium anode return. The model for the nucleation and growth of AlN is being developed at ULIM.

Typical powder sizes of nominally 135nm have been produced with Aluminium Nitride contents up to 99%. At ULIM and TRD the twin torch configuration installed in the modular reactor demonstrates a basis for the productioin of nano-sized powders.

KEYWORDS

Materials processing; Processing (minerals & metals); Processing (ceramics & glass); Ceramics/Glasses; Composites (ceramic matrix); Composites (metal matrix); Particle technology

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Contract no: RI1B-188
Proposal no: P-2145

POWDER FORMATION IN LOW PRESSURE, LOW TEMPERATURE PLASMAS

Starting date: July 1991 ***Duration:*** 24 months

OBJECTIVES

The research project has three scientific and technical objectives:

- The development of in -situ plasma diagnostics of powders associated with some ex-situ characterization
- fundamental understanding of the kinetics of formation and dynamics of trapping of powders in plasmas of reactive gases (hydrides: Si_4, NH_3 and fluorides: CF_4, CF_2Cl_2, SF_6)
- development of costless monitoring methods and guidelines for operation of discharge reactors either for minimizing particulate contamination in plasma-surface processing or for optimizing powder size and yield.

ACHIEVEMENTS TO DATE

Several in-situ diagnostics have ben implemented on five RF (13.56 MHz) and VHF (~100MHz) discharge reactors:

- Laser Mie scattering of powders (size 0.1-> 10μm) calibrated by ex-situ measurements by electron microscopy
- emission spectroscopy (spatially and time-resolved) and RF discharge current and power measurements
- laser photodetachment of negative ions and negatively charged particulates or powders
- in-situ ellipsometry on the surface of a material to analyse the contamination by powders.

The basis of the control of powder size and yield is to operate RF discharges in a pulsed-mode (100Hz-10kHz) to allow detrapping of negatively charged particulates.

KEYWORDS

Materials processing; Coatings/Thin films; Gases; Powders; Chemistry; Particle technology; Research/Development

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Contract no: BREU-0411
Proposal no: BE-4529

PREPARATION OF REACTIVE PREMULLITE, MULLITE AND SIALON POWDERS

Starting date: March 1989 ***Duration:*** 48 months

OBJECTIVES

The general objective of this work is to convert selected (mainly Spanish) natural clay minerals into reactive premullite, mullite and Sialon sinterable powders, particularly suited for advanced ceramics applications. Starting from low cost raw materials, this research intends to achieve a satisfactory purification degree by thermal treatment in order to transform that purified material into good reactive pre-mullite and mullite powders, in a flexible process which allows the use of mineral feeds with different degrees of homogeneity. It is finally intended to obtain Sialon powders by carbothermal gas-solid nitridation of the pre-mullite, in the best conditions to ensure the reproducibility of results.

ACHIEVEMENTS TO DATE

During the first two years of the project most of the scheduled tasks have been performed at laboratory scale.

Planned taskds such as thermal and chemical treatments to prepare premullites with different Al_2O_3/SiO_2 ratios, reduction of impurities of the kaolins, preparation and characterizatrion of mullite and premullite powders, synthesis of sialon powders from prelmullites and sintering and properties of the of resulting mullite and sialon powders were studied.

Therefore the manufacture of suitable premullites at 1-5 kg scale from adequate natural raw materials (kaolins) and their subsequent transformatiobn into good quality high surface area ß-sialon and mullites seems feasible.

However, it seems advisable to place all the emphasis on the mullite dimension of the project aimed at preparing very reactive premullite and mullite powders.

KEYWORDS

Materials processing; Processing (minerals); Ceramics; Powders; Premullite/ Mulllite; Sialon.

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Proposal no: P-2024

POWDER METALLURGY OF MULTIPHASE ALLOYS OF REFRACTORY METALS BY USING SINTERACTIVE COMPOSITE POWDERS

Starting date: March 1988 ***Duration:*** 42 months

OBJECTIVES

A special technique in metal powder manufacture is used to produce improved refractory metal alloys. These tungsten- and molybdenum-based materials have to meet high demands not only on mechanical properties, but also on homogeneity, thermal and electric conductivity, and burn-off resistance; it is therefore important to combine all the requested characteristics in an optimal way. The technological basis for this project is a Dornier-developed method for the production of metallic alloy powders, the so-called reaction spray process (RSV). The powders manufactured according to this process are characterized by extremely high homogeneity and sinter activity. Powder production and powder processing on a laboratory scale are to be performed by Dornier, while the manufacture of samples and their application testing are to be undertaken by the partner company. The selection of the material systems and material optimization are to be coordinated with the partner's activities.

ACHIEVEMENTS TO DATE

Reduction of tungsten-copper-oxide powder is carried out in a rotary tube furnace. Batch size was increased from about 0.5kg to 2.5-3kg. Oxide content in the metallic powder is in the range of 0.1 to 0.5 %

WCu alloys containing 50% and 25% copper respectively can be sintered to specimens showing a density between 95% and 98% of theoretical density, depending on the size of the specimen.

KEYWORDS

Materials processing; Metallic structural materials; Powders; Refractories; Powder metallurgy

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Proposal no: P-2237

NEW CONTROLLED SINTERING PROCESS FOR MASS PRODUCTION OF ADVANCED PM STEELS

Starting date: February 1990 ***Duration:*** 36 months

OBJECTIVES

Through the knowledge of the thermo-chemical processes and physico-chemical reactions which take place inside industrial sintering furnaces, of the nature of gas circulation and of the application of computerized regulation and control processes in steel sintering operations it will be possible to achieve the following objectives:

(i) Carbon content: to within ± 0.05%C for three different carbon content levels in 0.2% C, 0.5% C, 0.8% C. This precision will be achieved with conventional existing techniques for production of sintered steels.

(ii) Microstructure: the carbon content must be homogenous throughout the entire pieces, the carbon content variations in each piece being to within ± 0.05% C, and the structure must be free from intergranular cementite.

(iii) Dimensional precision: must comply to ISO standard IT8 with the aim of avoiding calibrating operations after sintering.

(iv) Specifications for the construction of new furnaces in order to achieve points (i), (ii) and (iii).

KEYWORDS

Automotive, components & parts; Assembly/Joining; Processing (minerals & metals); Components (metal matrix); Metallic structural minerals;Materials science; Powder metallurgy

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Proposal no: BE-3104

SINTERING OF HIGH SPEED STEELS CONTAINING CERAMIC OR METAL COATED CERAMIC POWDERS FOR WEAR AND FATIGUE RESISTANT COMPONENTS

Starting date: March 1988 ***Duration:*** 48 months

OBJECTIVES

This project involves the utilization of metal- or ceramic-coated cheap ceramic powders (TiC and Al_2O_3 in particular) for incorporation in high speed steel (HSS) matrices. Concurrent objectives are low (liquid phase) sintering temperaures, below 1180°C, high density, stregth, toughness, and corrosion resistance. The existence of a suitable metal layer on ceramic powder should minimize die wear, improve sintering charcteristics of the ceramic/metal composite and inhibit dissolution of the ceramic in the metal. Promising candidates chosen for further evaluation and prototype fabrication and testing.

ACHIEVEMENTS TO DATE

A modified CVD process using a fluidized bed and electrodeless process were developed during the project for the coating of powders, respectively with ceramic and metals. The coating thickness and microstructure were characterized and its influence studied in laboratory scale sintering and wetting testing. In parallel, a model of sintering mechanisms of Cu-P modified HSS was established. Sintered HSS with coated and uncoated ceramic additions were mechanically tested. For example, Ti-N coated Al_2O_3 addition led to a transverse rupture strength better than that given by uncoated Al_2O_3. Frettting fatigue is used in addition to pin-on-disc and bench-motor testing to feature the role of ceramic/matrix interfaces.

KEYWORDS

High speed steel; Composite; Sintering; Wear; Ceramic; Coating; CVD

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Proposal no: P-2408

DEVELOPMENT OF POWDER METALLURGY PROCESSING ROUTES FOR THE PRODUCTION OF MAIN LINE BEARINGS FOR AERO-GAS TURBINE ENGINES

Starting date: December 1986 ***Duration:*** 48 months

OBJECTIVES

Powder processing is an attractive alternative to casting and hot-working for production of the mainline bearings for gas turbines owing to a fine microstructure, a uniform distribution of fine carbides and an improved homogeneity. Two commercial high speed steels, Ti and M 50 are considered processed along various routes.

ACHIEVEMENTS TO DATE

For Ti a satisfactory process route has been developed on the laboratory scale and validated on the 300kg scale relying on water atomization (with filtering of liquid metal and magnetic separation of non metalic inclusions) and vacuum sintering to >96% t.d. HIPping or hot working. For M50 nitrogen atomization (600kg) HIP route is the only viable route. Both materials exhibit the fine microstructure expected from powder metallurgy. For Ti the carbide size may be adjusted between 1 and 5 μm. Levels of static mechanical properties equal or superior to those of optimized reference materials have been measured in bend testing (3 or 4 point) and the interaction of carbides with cracking has been studied on the various materials. The inclusion contents of the conventional materials can be matched by both P.M. routes and the performance of the fully densified P.M. high speed steels with an optimized microstructure under fatigue and also under rolling contact fatigue conditions is encouraging.
Qualifications bench tests are underway for M50 aero-gas turbine engine bearings and the manufacturing of bearing rings is under way for Ti.

KEYWORDS

Materials processing; Processing (minerals & metals); Powders; Metallic structural materials; Materials characterization/Testing; Powder metallurgy; Aeronautics/Aerospace.

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Proposal no: P-1350

THE APPLICATION OF THE "GRADED STRUCTURES" CONCEPT AS A MEANS OF IMPROVING THE PERFORMANCE OF ENGINEERING COMPONENTS

Starting date: August 1991 ***Duration:*** 30 months

OBJECTIVES

This proposal seeks to apply the "Graded Structures" concept to engineering components, required to perform in environments which no single material is capable of satisfying. Specifically, it involves the engineering of composite multi-layer structures to enable the utilization of the wear and/or heat resistance of ceramics and cermets and the toughness of metallic alloys. Combination of carbide cermets with tool steels and oxides or borides with nickel base alloys will initially be investigated.

Along with the applied technological aspects of the research a fundamental approach will be adopted to facilitate the engineering of interfaces in order to overcome joining problems associated with the physical and chemical incompatibilities between dissimilar materials.

Powder metallurgical techniques will be applied to fabricate "graded" components, including hot isostatic pressing, uniaxial hot pressing, injection moulding and tape casting. The structures produced will be assessed metallographically and the microstructure and physical properties obtained will be correlated against the fabrication techniques employed.

KEYWORDS

Materials processing; Graded structure; Diffusion bonding; Composites (metal matrix); Multilayers/Multimaterials; Powders; Forming/Shaping/Casting

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Proposal no: P-4324

DESIGN OF NEW HIGH-SPEED STEELS WITH IMPROVED SINTERABILITY AND MECHANICAL PROPERTIES (CADOSTS)

Starting date: June1990 ***Duration:*** 48 months

OBJECTIVES

A three-phase region, austenite plus carbide(s) plus liquid, is essential to the successful supersolidus sintering of several standard high-speed steels: T1, M3/2, T42. Until now only determination of sintering curves can identify the sintering gate and the effect of compositional variations on sinterability. The major objectives are to design alloys having the attributes of high-speed steels by phase diagram computations, which can be:

- sintered to full density
- with a wide sintering gate
- of different, possibly leaner, compositions to existing materials
- which sinter at temperatures possibly as low as 1150°C.

It is also proposed to develop richer alloys which cannot be processed by conventional means.

ACHIEVEMENTS TO DATE

Water-atomized powders subsequently processed to near full density include ASP60 type and carbon enriched T1 alloys with extended sintering gates (up to 50°C) and lower processing temperatures (down 1240°C). Microstructures and crystallization paths of these and a number of model quaternary systems were determined; metallographic (scanning electron and optical) observations were supplemented by X-ray and DTA studies. Phase diagrams for C-Fe-Mo, C-Fe-Mo-Cr, C-Fe-W and C-Fe-W-Cr systems have been recalculated (CALPHAD) for 4wt%Cr and varying contents of Mo and W in the temperature range 800-1900C. Differences between theoretical calculations and experimental observations relating to the liquidus temperature were frequently 10°C or less.

KEYWORDS Powder metallurgy; Ferrous; Materials processing; Powder atomisation; Automotive, components & parts; Materials characterisation /Testing; Computer-aided alloy design

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DEVELOPMENT OF P/M COMPOSITES AND APPLICATION TO LUBRICATED TRIBOLOGICAL SYSTEMS

Starting date: December 1988 ***Duration:*** 36 months

OBJECTIVES

Known P/M techniques are well developed to produce flat friction surfaces but some optimal mechanical solutions, such as tapered or drum forms for clutches and brakes, are not obtainable with conventional P/M. The project aims at developing a process with the following advantages: 1) non flat surfaces are possible, 2) optimal combination of matrix material and friction modifier additives is obtained by powder mixing, 3) favourable process energy consumption, 4) process well suited to mass production.

The overall research programme should provide improved functional performance at reduced cost. The project includes tribological testing and study of the friction phenomena with surface microanalysis techniques. A functional prototype is going to be designed and tested.

ACHIEVEMENTS TO DATE

A process for coating surfaces by powder techniques has been developed. An understanding of factors controlling friction in lubricated systems has been obtained. Tribological properties of conventional materials have been developed. Protoypes manufactured according to new P/M process are being tested.

KEYWORDS

Automotive, components & parts; Manufacturing; Metallic structural materials; Powders; Powder metallurgy; Tribology

PRIME PARTNER

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Contract no: RI1B-279
Proposal no: P-2090

COMPOSITES POWDER METALLURGY MATERIALS FOR OPERATIONS UNDER POOR/NON LUBRICATING CONDITIONS IN HEAVY DUTY DIESEL ENGINES

Starting date: September 1991 ***Duration:*** 48 months

OBJECTIVES

Reciprocating engine emissions are of increasing public concern, eg solid exhaust particulates from diesel engines are deemed to be carcinogens. Up to 60% of the particulates emitted originate from uncontrolled combustion of lube oil. To reduce this signifincatly a new philosophy of engine design, "the clean car", is required. Much reduced or no lubrication of valve train components, such as rocker arms, valve giodes and valve seats is now proposed. There are presently no materials available which could reliably operate in the severe tribological conditions at temperatures up to 600°C.

The objective of this project is to develop solid state lubricant/hard ceramic phase/strong metallic matrix composite materials by powder metallurgy (PM) methods. Conventional or modified PM techniques will be applied to newly-developed fine particle powders including special agglomeration techniques. Up to 15 vol % solid state lubricant dispersed in a high strength matrix is aimed for.

The research programme is formulated jointly between a powder producer, three PM part manufacturers, a diesel engine/truck producer and an academic reserach group. The aim is, in the long term engine test, to achieve a reduction of particulate emissions by 0.03 gm/HP.hr for the whole useful engine life of 500,000 km. According to diesel engine experts such a value cannot be attained solely by reducing the piston-cylinder running clearances, increasing tightness of valve stem seals and improvements in engine management systems, but necessitates reduction or elimination of valve train lubrication, which in turn requires the development of new composite materials for the components.

KEYWORDS

Automative, Components & Parts; Composites; Powder metallurgy; Materials science

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Contract no: BREU-0439
Proposal no: BE-4028

NOVEL BETA SILICON CARBIDE POWDERS AND DERIVED HIGH PERFORMANCE CERAMICS

Starting date: July 1990 ***Duration:***36 months

OBJECTIVES

The overall aim is to establish an economic source of reliable high quality beta silicon carbide powders in Europe. Lonza will develop the manufacture of powders by the carbothermic reduction of silica. Process options will include the addition of sintering aids to ensure their effective dispersion and agglomeration of the powder for forming by pressing. Cerex will transfer from the laboratory to the pilot scale a novel process in which silicon tetrachloride vapour is injected into a solution of calcium carbide in molten calcium chloride at 900°C to form finely divided silicon carbide powder. These processes will be characterized and optimized for processing into components by T & N Technology supported by CEIT. Correlations will be established between the chemical and physical characteristics of the powders, the structural features of the derived ceramics and the behaviour of components in demanding applications in the process, aerospace and electronics industries.

ACHIEVEMENTS TO DATE

Pilot scale plants for powder production are now under construction. Powder samples are under evaluation.

KEYWORDS

Materials processing; Ceramics; Powders; Chemistry; Materials characterization/Testing; Research/Development; Silicon carbide

PRIME PARTNER

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Contract no: BREU-0132
Proposal no: BE-3005

SYNTHESIS AND PROCESSING OF FINE GRAIN ALUMINIUM NITRIDE POWDERS

Starting date: 1990 ***Duration:*** 36 months

OBJECTIVES

The aim of this project is:

- to find methods of synthesizing AlN powders with flexible controlled properties according to the end uses of the material (mechanical and electrical)
- to study the effect of powder characteristics on shaping and densification behaviour
- to establish correlations between powder characteristics and AlN ceramic materials, which are the key to industrial application development.

ACHIEVEMENTS TO DATE

- synthesis of the first samples of AlN powder by carbo-nitridation and by chemical vapour deposition
- tape casting of commercial AlN powders
- sintering and characterisation of commercial AlN powders by hot pressing and conventional sintering.

KEYWORDS

Aluminium nitride; Ceramics; Powder processing; Powder synthesis

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Contract no: BREU-0055
Proposal no: BE-3150

DEVELOPMENT OF A TWIN D.C. PLASMA ARC FOR THE PRODUCTION OF ULTRA-FINE CERAMIC POWDERS, THEIR EVALUATION AND PROCESSING

Starting date: August 1991 ***Duration:*** 36 months

OBJECTIVES

The consortium will develop and optimize the technology to exploit the special D.C. characteristics of the twin and multiple plasma systems for vaporising ceramic materials and their precursors. This permits the laboratory scale production of nanometer dimension ceramic particles and of thin films of material either on larger particles within the plasma jet, or on extended external surfaces. This project will provide a range of materials for evaluation. Ultra-fine and coated powders will be characterized, and their sintering behaviour evaluated. Nanometer coatings will be evaluated for microstructure and mechanical properties. This programme is a direct development project first introduced at BRITE 1 (1987) and using the same team.

KEYWORDS

Materials processing; Composites (ceramic matrix); Processing (minerals & metals); Composites (metal matrix); Processing (ceramic & glass); Particle technology; Ceramics/Glasses

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Contract no: BREU-0479
Proposal no: BE-4624

POWDER PROCESSING – MORPHOLOGICAL AND CHEMICAL COMPATIBILITY OF METALLIC AND CERAMIC PARTICLES.

Starting date: January 1990 ***Duration:*** 36 months

OBJECTIVES

Single-function ceramic electronic components have now reached the smallest size compatible with surface mounting technology and remaining the bulky part of electronic system. The next innovative step will be to integrate in the same package complementary materials to produce sophisticated ceramic/metal chips combining several electrical functions. The present project concerns the critical problems related to this step: powder processing, materials, compatibility and interfaces structure.

ACHIEVEMENTS TO DATE

- A passive integrated multicomponent has been realized.

For this component, processes have been adapted in order to reduce thermo-mechanical stresses in the chip and to take into account the specificity of the product. A post fired resistive ink compatible with the dielectric substrat has been developed. Chemistry of interfaces has been characterized (diffusion, reaction).

Conduction mechanisms in this new material have been identified.

- Stability at high temperature of resistive oxides have been studied, some of them under specific conditions of process could be co-fired with the dialectric substrat.

- The ferrite powder preparation has been studied in order to get a co-processable material. A solid state route with the use of specific additive and an hydrothermal route have been studied. Physical and electrical characteristics of the powder have been evaluated.

KEYWORDS

Electrical/Electronic industry; Ceramics/Glasses; Magnetic; Dielectrics/ Ferroelectrics; Powders; Passive integrated components

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Contract no: BREU-0051
Proposal no: BE-3387

SOLUTION OF ELECTROSTATIC PROBLEMS IN POWDER HANDLING AND PROCESSING

Starting date: 1991-1992 ***Duration:*** 36 months

OBJECTIVES

Electrostatic charges are the cause of problems in many industries where powdered materials are manufactured or processed. Electrostatic hazards are now well understood, but powder handling and processing problems still occur which can reduce quality and productivity, leading to inferior products and higher costs.

At the root of these difficulties is a lack of understanding of their cause and a lack of appropriate solutions. By focusing attention on specific powder manufacturing difficulties of one of the partners, the group will :

- Quantify electrostatic problems on plant after adapting and developing suitable multifunction measuring instrumentation
- compare various charge control techniques, establish their limitations, make improvements and develop a prototype neutralizer specifically for powders
- check the efficiency of these improved charge control techniques both in the laboratory and on site
- give the basis for developing a feedback specific neutralizer.

KEYWORDS

Chemical/Petrochemical; Engineering (chemical); Electrical; Powders; Particle technology; Electrostatic.

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Contract no:
Proposal no: BE-4538

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indicating which of the above activities are of particular interest to you.

European Communities – Commission

EUR 14042 – BRITE/EURAM Programme – Synopses of Current Projects, 1990-1991

Luxembourg: Office for Official Publications of the European Communities

1991 – cii + 536 pp. – 15.0 x 21.0 cm

Industrial processes series

ISBN 92-826-3350-0

Catalogue number: CD-NA-14042-EN-C

Price (excluding VAT) in Luxembourg: ECU 42.50

This book describes the research projects selected for support under the 1990 round of the European Community's BRITE/EURAM research and technological development programme, and gives updated synopses of the projects running under the two previous EC programmes covering research in industrial technologies (BRITE) and research in advanced materials (EURAM). For each of the 530 projects, there is a summary of the objectives and the achievements to date, the starting date and duration of the project, the contact address, telephone, fax and telex of the main contractor, the contact person at the main contractor, and a list of the other major contractors, subcontractors and sponsors involved in the project.

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This second edition of *BRITE/EURAM – Synopses of current projects* collects the latest progress and contact information for the 530 research projects running during 1991, resulting from the 1989 and 1990 calls for proposals under BRITE/EURAM, and its predecessors BRITE and EURAM. Over 1989-92 BRITE/EURAM is active in promoting new industrially oriented research in the programme's five major technical areas:

1. Advanced materials technologies
2. Design methodology and assurance for products and processes
3. Application of manufacturing technologies
4. Technologies for manufacturing processes
5. Specific activities related to aeronautics.

The BRITE/EURAM programme is open to all industrial enterprises, universities, research institutes, and other interested organizations in the EC and EFTA countries. The follow-up programme, "Industrial and Materials Technologies" (BRITE-EURAM II), will run from 1991 to 1994.
Future editions of this publication will include descriptions of projects funded under BRITE-EURAM II. Calls for proposals under this new programme are expected in 1991 and in 1992.

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