COMMISSION OF THE EUROPEAN COMMUNITIES

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M E M O R A N D U M

ON THE IMPLEMENTATION OF AN IRON AND STEEL RESEARCH PROGRAMME, WITH A VIEW TO OBTAINING FINANCIAL AID UNDER ARTICLE 55 (2) (c) OF THE ECSC TREATY

(presented by the Commission to the Council)

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OF THE
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I - I N T R O D U C T I O N

The ECSC iron and steel research programme for 1980 presented in this memorandum consists of projects that have been selected from a total of 150 proposals that were submitted to the Commission of the European Communities requesting aid under Article 55, 2(c) of the ECSC Treaty. After detailed examination by the services of the Commission in collaboration with the Iron and Steel Technical Research Committee, 75 proposals have been selected as first priority.

In examining the aims of the proposals and assessing their relevance to enhancing the competitiveness of the steel industry, particular attention was given to requests concerned with raising productivity and reducting production costs (including energy economy), with increasing the quality of steel products and with improving the performance of steels under service conditions. Within these major objectives for this collaborative scientific and technical effort, particular emphasis has been given to projects aimed at achieving progress of practical significance over the short-to-medium term.

The technical content of the proposed programme covers various aspects of iron and steelmaking technology with the level of funding distributed as follows : iron ores (1.6 %), ironmaking (30.0 %), steelmaking (19.3 %), rolling mills and mechanical working (6.8 %), measurements and analysis (9.3 %), properties and service performance of steels (29.8 %) and miscellaneous (3.2 %).

In the production and processing sector of the programme, major collaborative effort is proposed on blast furnace technology and on the casting and solidification of steel respectively. In the former area, 19 % of the total budget is directed at a detailed investigation of the reactions occuring in the cohesive (softening-melting) zone of the blast furnace; a better understanding of the flow and distribution of reducing gases in this region should permit improvements in the productivity by raising the chemical and thermal efficiency of existing blast furnace plant as well as aiding in the design of new equipment.

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The unprecedented growth in continuous casting potential within the Community, stimulated by the resulting energy saving over conventional methods (about 50 kg oil equivalent/tonne steel) is now expected to reach some 75 million tonnes in 1982. This expansion is calling for continuous technological effort to improve plant performance and product properties to which ECSC research is already making a significant contribution. Further majort effort (10 % of budget) is now proposed aimed at enhancing the surface and internal quality of slabs and billets as well as at increasing the flexibility of continuous casting plant.

In addition to the consequences that the above mentioned research will have on energy costs in steelmaking (now represents about 25 % of total costs), other projects dealing with energy utilisation and economy are to be found in the areas of the sintering of iron ores, gas utilisation and reheating furnaces for the hot rolling of ingots.

It should be noted also that further aid is requested to improve the efficiency and the safety of a new mining method for Lorraine ores; this research has obvious and important social implications.

Technological progress directed at improving the properties and thus the performance and safety of steel components and structures is vital in attempting to broaden the range of application of steel in engineering practice. Furthermore, the requirement for more sophisticated and more reliable products is essential to meet the growing competition with which Community steel producers are faced in world markets. To contribute to some of the pressing common research needs of the steel industry some 30 % of this programme is devoted to studies in the product-oriented sector.

Aspects of particular interest range from the weldability of steels and the resulting properties of welded joints to studies of corrosion behaviour and protection and the development and forming of high-strength sheet steels for the automobile industry. The second phase of a collective project aimed at the development of measuring techniques and collection of data for the traffic loading of steel bridges is also proposed; this project should permit safer and more economical structures to be designed particularly where steel and concrete are in close competition.

The proposals in the area of steel structures include an important technico-economic study designed to make a comparative evaluation of steel utilisation in construction in the Community, in North America and in Japan. This analysis should yield valuable information on the competitive position of the Community in this sector in addition to indicating where research and technological progress are needed to strengthen the position of Europe in an area where the potential for growth on a world-wide basis is considerable.

The financial aid for the 75 research proposals presented below amount to a total of 19.550.700 ECU. To this is added 510.000 ECU for ancillary costs and dissemination of information, giving a total financial commitment of 20.060.800 ECU.

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II - THE RESEARCH PROJECTS

II.1 - IRON MINES

Since 1975 the Commission has granted aid to several projects concerning long-wall advancing methods for ore winning. The tests carried out, difficulties encountered and experience gained have led to the definition of a winning method and types of cutting machinery and support systems to be used. The proposed project is an essential complement to previous research and is likely to produce a new method of winning siliceous and calcareous ores with a much higher productivity and greater safety than the traditional method now used.

- P 760 "Optimization of face-cutting machines"

The "long-wall", "short-wall" and "continuous miner" projects already carried out have shown that face-cutting is technically feasible and economically viable.

There are still two major problems concerning powered supports and the continuous miner.

The aim is to design prototypes of this new equipment in the light of the experience gained and to resume production tests with these prototypes.

Applicant : SAMIFER - Paris
Amount : 533 000 ECU
Duration : 1 1/2 years

II.2 - ORE REDUCTION

a) Sinter

The research aims are :

- to reduce energy consumption for sintering by improving the permeability of the sinter bed, which can be influenced by the order in which the raw materials are stocked in the blending beds

- to include sinter-bed permeability in the control of the sintering process, thus ensuring more uniform sinter quality and increased productivity.

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- P 824 "Reduction of energy consumption in a sinter plant, having regard to sinter quality, by controlling raw material stacking in the blending beds and varying the mixing process in a continuously adjustable combined mixing and balling drum"

First the adhesiveness of various ore mixtures under pressure will be determined in laboratory tests. The fines of various ores tend to form minipellets to a degree that depends on the order in which the various fines are added to the sinter mixture. If fines are eliminated, the sinter is more permeable and this means that less energy is required. The laboratory results will then be verified in the works.

Applicant : MANNESMAN HUETTENWERKE - Duisburg
Amount : 675 000 ECU
Duration : 3 years

- P 872 "On-line monitoring of the permeability of the sinter bed to reduce sinter variations and energy consumption"

The research will be carried out on an industrial sinter machine with a grate area of 400 M^2. The quantitative relations between the following operating parameters will be determined by mathematical and statistical methods : permeability, coke content, ignition conditions, sinter quality and productivity.

Then a mathematical model will be constructed for control purposes.

Applicant : ITALSIDER-Tarento in cooperation with CSM-Roma
Amount : 432 500 ECU
Duration : 2 years

b) Blast Furnace

Between early 1978 and mid-1979 the price index for coking coal rose by 17 points.

Over the same period the index for heavy fuel oil showed an increase of between 22 and 49 points, the amount varying from one country to another. These energy costs trends are reflected in the choice of this year's research projects. In seven of the eight projects energy saving and the reduction of energy costs head the list of research aims.

In one project an attempt will be made to replace oil in the blast furnace by waste coal, ballast coal and powdered lignite. Five projects concern research in the cohesive zone of the blast furnace. This zone is of vital importance for the uniformity of gas flow and hence for specific coke consumption. The aims of these coordinated projects are :

- to keep this cohesive zone as small as possible,
- to devise methods of determining the shape and position of this zone,
- to endeavour to control and influence this zone.

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Another project is designed to improve energy utilisation in the hot-blast stove. This is to be done by equalizing temperatures at the checkerwork, which will also improve service life.

The last project is designed to test new materials and new designs for staves so as to increase their service life.

- P 766 "Optimization of the thermal state of the tuyere zone in the blast furnace

The research will be carried out on a blast furnace with a hearth diameter of 9M and a capacity of about 2 400 tonnes of hematite pig iron a day.

Lignite and lean coal in the powdered form will be injected in turn. For each type of coal, the maximum amount accepted by the blast furnace will be determined together with the optimum degree of oxygen enrichment in the blast.

Each experimental period will last about two months so that mass and energy balances can be prepared.

Applicant : ARBED - Luxembourg
Amount : 954 000 ECU
Duration : 3 1/2 years

- P 780 "High-temperature reduction, softening and meltdown studies of burden materials"

It is first planned to carry out meltdown tests in an experimental furnace (up to 1500°C). By the addition of MgO to ore mixtures sinter and pellets the softening and meltdown temperature will be increased and as a result higher levels of indirect reduction will be achieved in the blast furnace. The influence of Al_2O_3, MnO and TiO_2 will also be examined.

In addition the influence of tramp elements (alkalis, zinc and sulphur) will be investigated.

Finally the results will be verified on an industrial blast furnace. It is planned to take samples from the blast furnace with a probe.

Applicant : BSC-London (Teesside Laboratories, Welsh Laboratories)
Amount : 509 500 ECU
Duration : 4 years

- P 821 "Influence of the form and position of the softening and meltdown zone on blast furnace performance"

The research will be carried out on industrial blast furnaces with hearth diameters of 8.75 and 9.0 M.

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The shape and position of the cohesive zone will be experimentally determined in the blast furnace by :

(a) indirect measurements such as :

- measurement of the thermal profile at the threat
- measurement of the gas profile at the threat and below the surface of the burden
- measurement of wall temperature
- measurement of pressure loss over the height of the blast furnace.

(b) direct measurements, such as :

- measurement of the temperature profile using descending temperature probes
- determination of a correlation between temperature profile measurements in the blast furnace and parallel measurements in the laboratory of the softening behaviour of burdens.

The programme of measurements on industrial blast furnace will be supplemented by research on an experimental blast furnace.

Finally an attempt will be made to control the shape and position of the cohesive zone from the outside on the basis of the research results.

Applicant : CRM - Liège
Amount : 506 500 ECU
Duration : 4 years

- P 826 "Control of gas flow in the solid, pasty and fluid areas of the furnace burden

Research will be carried out on five different blast furnaces with hearth diameters of 9.8 to 13.6 m in an attempt to achieve better gas flow (energy saving) and longer service life by optimum burden distribution. As well as the steelworks, two research centres are participating in the research. The following research programme is planned :

- measurements on various blast furnaces to determine gas flow, especially in the softening zone (for various burden materials)

- laboratory tests to determine the softening behaviour of burden materials and their mixtures (sinter, pellets, lump ores)

- effects of material properties on the softening front

- effect of burden material distribution on the softening zone and on gas flow in the charge

- influence of various operating parameters on the softening zone, such as blast speed and temperature, or the addition of oil and oxyge

- influence of blast furnace design on the shape of the softening zone depending on burden properties and burden material distribution

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- investigation of the influence of material properties, material distribution, design and gas flow on energy demand, refractory wear and service life of the blast furnace,

- evaluation of the various experimental results obtained in the laboratory and in practical operation and computerized compilation of these data.

Applicant : VDEh-Düsseldorf (the following will cooperate in the research: Hoesch-Hüttenwerke AG, Dortmund; Mannesmann, Duisburg-Huckingen; Stahlwerke Peine Salzgitter AG, Salzgitter; Klöcknerwerke, Bremen; Thyssen AG, Duisburg-Schwelgern; RWTH, Aachen; Studiengesellschaft für Eisenerzaufbereitung, Liebenburg)
Amount : 3 557 500 ECU
Duration : 3 years

-P 853 "Blast furnace : consequences of charging on burden structure"

The flow of material through the furnace is to be investigated for various charging sequences with a view to the formation of the meltdown zone.

The research will be carried out on four blast furnaces of 8.5 m to 14.0 m hearth diameter. Three of these furnaces will be charged with high-grade ores and one with lean ores.

The shape and position of the meltdown zone will be determined experimentally during operation. Capsules with radioactive Xe will be inserted at various points in the blast furnace. These are embedded in materials that melt at given temperatures (700°C, 1050°C, 1250°C). The radioactive gas released is measured at the throat. Isotherms can be reconstructed from the space coordinates and the descent time.

At the same time the descent of the burden in the vicinity of the furnace wall will be monitored. This will be done by measuring the electrical resistance between ring electrodes installed one above the other in the furnace wall. The resistance changes depending on whether a "conductor" (coke) or a "non-conductor" (sinter, pellets, lump ore) is between the electrodes at any given moment. This method will first be tried out in model experiments.

Applicant : IRSID - St.German-en-Laye, in cooperation with SOLMER -Fos; USINOR - Dunkerque; SOLLA - Hayange
Amount : 1 209 000 ECU
Duration : 4 years

-P 878 "Influence of the chemical and physical properties and reduction conditions on the softening, meltdown and percolation of sinter at temperatures up to 1600°C"

This project consists of laboratory tests. First of all methods and equipment will be developed to investigate the behaviour of sinter at up to 1060°C.

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This will enable the meltdown and percolation behaviour to be included in the assessment of the sinter.

In the next stage the influence of chemical composition on softening and meltdown behaviour will be systematically investigated. It is planned to carry out tests on sinter in the basicity range 1.4 to 2.0 (CaO/SiO_2).

The influence of the following materials will also be investigated :

- FeO in the range 5.5 to 8.5%
- SiO_2 in the range 5.5 to 6.5%
- MgO in the range 0.8 to 1.5%
- Al_2O_3 in the range 1.5 to 2.5%

The third stage will be to investigate the influence of grain sizing on low temperature disintegration, particle sizes of 3 to 10 mm being examined.

The final stage will be the investigation of the influence of reduction conditions (gas composition).

In all about 25 types of experimental sinter and five to eight types of industrial sinter will be studied.

Applicant : CSM - Roma
Amount : 277 000 ECU
Duration : 4 years

- P 830 "Improvement of energy use by aerodynamic optimization of hot blast stoves"

An attempt will be made to improve flow processes, thus making heat exchange more uniform and enabling a better overall degree of efficiency to be obtained.

The work is to be carried out in close cooperation between the research institute and the user. The following programme is planned :

- collection and evaluation of operating results,
- analysis of the results with a view to heat exchange processes and the service life of refractory dome and checker bricks,
- aerodynamic tests on cold models in the laboratory, with simulation of the most significant areas of the hot blast stove (combustion chamber, dome, checkerwork, etc),
- tests of modern heating plant without combustion chamber,
- construction of digital mathematical models and numeric calculation of flow velocity and temperature fields,
- verification of the results and preparation of proposals for design and operation.

Applicant : VDEh/BFI - Düsseldorf
Total amount : 666 500 ECU
Duration : 3 years.

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- P 829 "Material selection and design of staves for blast furnaces"

The research will be carried out on a blast furnace equipped with staves. The following programme is planned :

- removal and examination of cast-iron staves from a 9.8 m blast furnace after 3 1/2 years in service,
- testing of cast alloy steel "cigar" type coolers in various areas of the blast furnace,
- manufacture of staves from cast alloy steel with subsequent testing in the laboratory and in service under various conditions,
- manufacture of special cooling plates and installation in the blast furnace,
- study of previous experience with staves taking into consideration on their design, cooling system and operation,
- improvement of shape with due allowance for the cooling system.

Applicant : HOESCH HUETTENWERKE AG - Dortmund
Amount : 963 500 ECU
Duration : 3 years

II.3 - STEELMAKING

a) Casting and solidification

Quality improvement and increased efficiency are aims common to all the eight projects described below, despite their different themes.

Three projects are concerned with the special problems of casting powders for continuous casting. Casting powders have several functions :

1. to protect the molten steel in the mould against reoxidation,
2. to provide thermal insulation of the molten steel and prevent solidification of the meniscus,
3. to absorb non-metallic inclusions from the steel,
4. to provide lubrication between the steel shell and the mould.

Consequently the casting powder resolidifying from the melt on the outer surface of the strand must meet very specific anti-friction requirements. Hitherto casting powders have been selected and used mainly on an empirical basis. In this programme an attempt will be made to establish a correlation between chemical composition and the basic physical properties on the one hand and the empirical data on the other.

One project is designed to improve the quality of large forging grade ingots (95-105 t), in particular specific consumption.

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Another relates to the continuous casting of long freezing range steels. Structural formation during solidification is to be improved by means of electromagnetic stirring.

A further project is designed to determine the permissible deformations in the bending of the strand before it is fully solidified (e.g. as it travels from the vertical to the horizontal position). If the shell is subjected to excessive tensile stress during bending, incipient cracks often form; these are visible in the finished product in the form of segregation crazing and cause problems during welding in particular. The tensile stress component during bending is to be reduced by compression of the strand in the longitudinal direction.

Two projects concern new developments. In the first, an attempt is to be made to carry out metallurgical after-treatment of the steel in the tundish. The main aim is to prevent reoxidation of the steel and also to control the casting temperature more accurately by means of plasma torch. The second aims to develop a direct strand reduction method for steel (billets and narrow strip). A preliminary study has indicated that direct strand reduction is technically feasible and economically viable. It is profitable for all rolled products that are produced in large batches.

- P 770 "Fundamental study of the behaviour of casting powders"

The following research is to be carried out in order to optimize the properties of casting powders for continuous casting :

- determination of viscosity, thermal conductivity and surface tension,
- determination of local heat transfer, thickness of the slag layer, gap formation and frictional forces between the steel shell and the mould,
- correlation of the above-mentioned physical parameters with the product surface quality,
- production of a mathematic model for the mould on the basis of these results.

Applicant : 1. IRSID - St.Germain-en-Laye
2. MPI - Düsseldorf
3. NPL - Teddington

Amount : 129 000 ECU (IRSID)
121 000 ECU (MPI)
122 500 ECU (NPL)

Duration : 2 years

- P 782 "Behaviour of mould fluxes during continuous casting"

This project will be carried out on an industrial plant equipped with an instrumented mould. Amongst other things, the results obtained in project P 770 will be tested under industrial conditions.

The first set of tests will assess :

- the effect of slag film thickness on friction,
- the tendency for slag rim formation.

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The plant performance will be assessed in terms of :

- operational factors during use,
- mould heat transfer,
- product surface quality.

Applicant : BSC - London
Amount : 112 500 ECU
Duration : 3 years.

- P 809 "Development of new casting powders for continuous casting"

Experiments on industrial plant and in the laboratory are planned under this project.

The friction between the strand and an oscillating mould will be monitored by an electronic instrument, the M L Tektor (mould lubrication quality detector), and then analysed. The signal from the M L Tektor can be used for overall quality assessment of casting powders as it gives an indication of strand lubrication. The aim is to find a correlation between the electronic signal from the measuring head and both the chemical and physical properties of the casting powder determined in the laboratory and product surface quality.

The tests will be carried out mainly on aluminium-killed steels for deep drawing sheet and steels for heavy plate.

Applicant : CRM - Liège
Amount : 256 000 ECU
Duration : 3 years

- P 831 "Development of insulating feeder heads to improve the quality of forging grade ingots"

If the top of an ingot solidifies too quickly both the segregation cone and the pipe will be excessive and therefore the yield will be poor.

The project aims to control solidification in the upper region of the ingot. The following research is planned :

- preparation of the thermal balance in the vicinity of the feeder head,
- development and testing of an insulating feeder head with cap,
- investigation of the influence of the insulating feeder head on ingot quality (10 ingots of 95-150 t in weight),
- investigation of a 95 t ingot by sawing it open vertically and horizontally and comparing it with a conventional ingot.

Finally economic comparisons will be made with other methods of producing large forging grade ingots such as the MHKW, ESU topping, ESU, BEST and TREST processes.

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Applicant : THYSSEN-HEINRICHSHUETTE - Hattingen
Amount : 365 500 ECU
Duration : 3 years

- P 784 "Control of solidification of long freezing range steels by electromagnetic stirring during continuous casting"

The research will be carried out in a pilot plant on high-carbon steels (C > 0.6%) and chromium steels type cord and ball bearing steels. The structure and segregation are to be controlled during solidification.

First an electromagnetic stirrer with a linear inductor will be tested. In the second stage an inductor capable of producing both linear and rotational bath movements will be tested. The combination of the two gives a helical stirring effect.

Both in-mould and below-mound stirring will be tested.

Applicant : BSC - London
Amount : 312 000 ECU
Duration : 3 years

- P 860 "Bending and straightening with liquid core"

The programme includes the following research in the laboratory, on models and in industrial practice :

(a) theoretical research in the microplactic range of the steel; determination of material coefficients up to temperatures immediately below the solidus;

(b) simulation tests on bending and straightening of strands in model tests with plasticine;

(c) industrial tests on billet and slab casting machines.

Applicant : IRSID - St.Germain-en-Laye, in cooperation with DILLINGER HUETTENWERKE - Dillingen, FORGES D'ALLEVARD - Cheylas, USINOR - Dunkerque.
Amount : 515 500 ECU
Duration : 3 years

- P 880 "Adaptation of the continuous casting tundish for after-treatment of steel"

The method will first be developed in the laboratory and then tried out in industrial practice.

(a) Testing of the after-treatment techniques in the laboratory. Deoxidation or desulphurization agents will be injected into the melt through a lance or added in the form of coated wires. The steel will be melted in a 1.5 t induction furnace.

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(b) The temperature in the tundish will be regulated by means of a plasma flame.

(c) To adapt the tundish to its new function flow research will be carried out on a cold model.

(d) It is also planned to conduct tests on the service life of the refractory materials, after which a pilot tundish will be built.

(e) Finally industrial tests will be carried out on a slab casting machine with charges of 20 to 50 t.

Applicant : CSM - Roma
Amount : 1 081 000 ECU
Duration : 4 years

- P 889 "Development of a direct strand reduction method for steel"

The research will be based on an earlier preliminary investigation on a modified Hazelett casting machine.

The work programme planned is as follows :

(a) research on the design of the casting machine,

(b) design and construction of the casting system,

(c) construction of the experimental plant (manufacture and assembly),

(d) casting tests (billets and strip),

(e) evaluation of the experimental results and technical and economic assessment.

This is a five-year research and development programme with a total expenditure of DM 12.65 million. The Steel Technical Research Committee approved the execution of the complete programme but suggested that the total budget be divided into three parts : for stages (a) and (b) DM 1.25 m; for stage (c) DM 7.2 m; for phases (d) and (e) DM 4.2 m.

The amount given below therefore covers only to the work outlined under (a) and (b) which is planned to take two years.

Applicant : KRUPP INDUSTRIE- UND STAHLBAU - Essen
Amount : 504 500 ECU
Duration : 2 years

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b) Oxygen Steelmaking

One project is designed to obtain greater homogeneity of the metal in the converter and to intensify the metal-slag reaction. This is to be done by injecting a gas (or gas mixture) through the bottom of the converter during refining, thus creating a stirring effect.

The second project aims to improve the making of tungsten-alloyed steels in the AOD converter. The tungsten is to be added in the form of scheelite, which has already proved successful in the electric arc furnace.

- P 787 "Bath stirring in basic oxygen steelmaking by gas injection through basal tuyeres"

The research is to be conducted on a 3-tonne experimental converter.

The following programme is planned :

- optimization of gas injection through the air/nitrogen and the oxygen/hydrocarbon tuyeres to improve the metallurgical process and obtain short operating cycles,
- determination of optimum oxygen distribution between the lance and tuyere,
- injection of desulphurizing and dephosphorizing agents,
- control of tuyere operation to reduce wear on the converter bottom,
- thermal process optimization in order to increase the use of scrap.

Application : BSC - London
Amount : 471 000 ECU
Duration : 3 years

- P 875 "Addition of alloy elements by means of ore in the AOD converter"

The research is to be carried out on an industrial converter. Steels containing 1 - 2.5% W will be melted. The following will be recorded for each melt :

- quantity of scheelite added and addition method,
- cooling effect,
- yield of alloying elements,
- consumption of energy and carrier gas,
- refining time,
- special features.

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The following laboratory tests will be carried out on each melt :

- hot working properties, segregation (macro and micro),
- mechanical properties,
- heat treatment.

Finally a technical and economic assessment of the method will be made.

Applicant : CERIMET - Torino
Amount : 268 500 ECU
Duration : 2 years

c) Refractories

In bottom-blown converters large concentrations of FeO form in the vicinity of the oxygen inlets and these are considered to be largely responsible for local wear at these points.

The project aims to give the converter bottom as long a service life as the general refractory lining. Hot and cold spraying methods to repair converter bottoms are to be tried out with this aim in view.

- P 858 "Repair of converter bottoms"

The spraying methods will first be tested on a 6-tonne experimental converter and then transferred to a 240 t industrial converter. Two methods will be tested :

1. the conventional method of spraying cold ceramic mixtures on to a base of slag, and
2. the hot spraying method in which the hot ceramic material is sprayed on by means of a plasma torch.

The preliminary basic research on the adhesion of the various mixtures will be carried out in an experimental furnace.

Applicant : IRSID - St. Germain-en-Laye
Amount : 743 000 ECU
Duration : 3 years

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d) Theoretical Metallurgy

The aim is to investigate the physical and chemical properties of slags :

1. Determination of phase diagrams and thermodynamic activities for complex system of blast furnace and steel furnace slags (quaternary and higher systems)

2. Determination of the properties of the interface between the metal and solid oxides.

- P 857 "Thermodynamic and kinetic data on various steelmaking materials (slags, inclusions)"

Research programme :

1. Experimental work on phase diagrams : determination of the tie-lines in the crystallization range of calcium silico-phosphates (LDAC slag) and melilith (blast furnace slag).

2. Determination of the activities of the slag components in the system : $CaO-Al_2O_3-SiO_2$ - MgO and $SiO_2-P_2O_5-CaO-MnO-FeO$.

3. Experimental work on the systems : iron-oxygen, aluminium oxide, calcium aluminates, hercynite (iron aluminate or chromite).

4. Experimental work on the systems Fe-O-S, CaO, MgO, Al_2O_3, SiO_2 and mullite with molten iron.

Applicant : IRSID - St. Germain-en-Laye
Amount : 302 500 ECU
Duration : 3 years

e) Energy

The two projects relating to steelworks energy supplies concern the improvement of efficiency and the extension of the uses of gas burners for charge materials.

- P 774 "Technical aspects of lean gas utilization in the iron and steel industry - Burner and combustion control investigations"

The aim is to develop burners capable of burning gases of different heat contents (blast furnace gases, coke-oven gas, LD gas, natural gas, propane gas). The necessary control systems are also to be developed.

First the limits on the mixing of gases from the user viewpoint will be determined. Then a series of burners will be developed that can be adapted to the necessary flexibility of the charge materials, making allowance for the type of flame.

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Mixtures of lean and rich gases will be systematically investigated, with either cold, pre-heated or oxygen-enriched air being used for combustion.

A combustion furnace will be instrumented to measure heat transfer.

Control systems will be developed for the best types of burners.

Adiabatic flame temperature, fuel quantities, oxygen quantities, wall temperature, waste gas temperature and, for safety reasons, the CO content in the waste gas will be taken into account for control purposes.

Applicant : International Flame Research Foundation - IJmuiden
Amount : 469 500 ECU
Duration : 3 years

- P 832 "Development of low-pulsation multi-fuel burners for large combustion chambers with a high energy efficiency"

The aim is to stabilize combustion processes in hot blast stoves.

The following research programme on multi-fuel burners is planned :

1. Collection and evaluation of analytical and service data.
2. Verification of measured data on hot and cold models.
3. Investigation of acoustic behaviour.
4. Hot model tests and industrial tests.
5. Constructive improvements to multi-fuel burners with a view to increasing efficiency.

Applicant : VDEh/BFI - Düsseldorf
Amount : 513 500 ECU
Duration : 3 years

II.4 - MECHANICAL WORKING

a) Reheating Furnaces

The main aim in the two projects described below is to control the reheating furnace to suit the product.

- P 881 "Operation of reheating furnaces to minimize energy consumption and scale formation with continuous recording of furnace atmosphere composition and temperature by laser spectroscopy"

The measurement system used to control the furnace is based on CARS (Coherent Antistokes Raman Scattering) and the differential absorption technique.

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This enables the contents of oxygen, CO_2, CO, H_2O, H_2 and the corresponding radicals, together with temperature between 1100 and 1800°K to be measured directly. As the degree of oxidation of the gas atmosphere varies with temperature, this direct measurement is of great importance.

First the spectroscopic system will be constructed in the laboratory and tried out. Then pilot experiments in an experimental furnace are planned to test the availability of the system.

Finally an industrial reheating furnace will be equipped with the system.

Applicant : CSM - Roma
Amount : 410 000 ECU
Duration : 2 1/2 years

- P 902 "Research on the closed-circuit control of a continuous annealing line by processing magnetic signals from the steel strip"

The research will be carried out on a continuous industrial line for the annealing of strip for tinplate manufacture.

Strip annealing will be controlled by means of the surface hardness (the HR 30 T value). The hardness will be measured indirectly via magnetic variables. The initial data for feed control will be the chemical and physical data on the strip that have to be input and the initial magnetic value.

The magnetic output value measured on-line will serve as a feedback for strip speed and temperature.

A mathematical model for the control system will be developed and will operate first as an open circuit and later as a closed-circuit control system.

Applicant : ITALSIDER - Genova
Amount : 246 500 ECU
Duration : 3 years

b) Hot Rolling

The aims of research on hot rolling are to improve the control models for various applications (flat products and sections). This should improve the efficiency of the rolling mills and reduce material losses. These losses (for heavy plate, for example) are around 8 to 15 % of ingot weight.

- P 793 "Three-dimensional model for metal flow under triaxial strain conditions"

Using finite element analysis, a three-dimensional model is to be developed for the prediction of the deformation, temperature and stress distributions in the workpiece during metal forming processes for the rolling of ingots and slabs. ./.

In the second stage a model for numerical solution will be constructed.

The model will be tested on a laboratory rolling mill. The tests will be carried out with plasticine.

The last stage consists of application to actual hot rolling processes.

Applicant : BSC - London
Amount : 308 500 ECU
Duration : 3 years

- P 833 "Research on material flow in grooved rolls to improve design methods and increase the efficiency of section rolling"

When grooved rolls are used it is not yet possible to calculate material flow in advance; it is determined experimentally by trial rolling. The principles for the mathematical description of material flow in grooved rolls will be established by experiment and research based on the theory of plasticity.

The three-dimensional velocity fields calculated will be verified experimentally in the model.

In particular, the influence of longitudinal forces and variations in them (in tandem mills) on the flow of material and the cross-sectional tolerances will also be investigated.

Applicant : VDEh/BFI-Düssleodrf
Amount : 536 500 ECU
Duration 3 1/2 years

- P 862 "Monitoring of the ends in the rolling of thick plates"

Themain aims of the project are to improve material yields and obtain more accurate dimensions. A rolling programme will be developed that enables stock input to be reduced, the optimum reduction per pass to be determined and an optimum rolling schedule for heavy plate (rolling in longitudinal and transverse directions) to be established.
1150 kg of stock is used to produce 1 tonne of heavy plate in Europe, but only 1080 kg in Japan.

It is planned to carry out theoretical research that will later be varified in model tests with plasticine.

Applicant : 1. IRSID - St. German-en-Laye
2. ECOLE DES MINES - Paris
Amount : 347 000 ECU
Duration : 3 years

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c) Miscellaneous

Tungsten carbide rolls are already being used in the finishing stands in rod mills because of their good wear resistance. These rolls are now to be used in intermediate stands for the first time. The results can also be extrapolated to billet mills.

- P 767 "Tungsten carbide rolling mill rolls"

The experiments will be carried out on a Morgan mill. 360 mm rolls with tungsten carbide are to be installed on 4 three-line intermediate stands. The main problem is the cooling of the rolls. Because of the lower rolling speed in the intermediate stands the rolls have to be equipped with a special cooling system.

The experimental parameters are :

- testing of various types of carbide
- testing of various pass forms and cooling systems
- testing of various steel grades and rolling temperatures.

Applicant : ARBED - Luxembourg
Amount : 380 000 ECU
Duration : 2 1/2 years

II.5 - MEASUREMENTS AND ANALYSES

The major part of the research proposed in this area is concerned with methods of inspecting and assessing the surface quality of semi-finished steel products. The continuing effort being made in this area is in response to the changes in customer requirements which have obliged steelmakers to improve as-rolled surface quality and to adopt a more quantitative approach to the assessment of defects in semi-finished products. An important feature of this proposed work is the attention devoted to the development of hot inspection techniques which should lead to the more continuous processing of steel which has important implications for energy saving.

The second major theme relates to techniques of measurements covering flaw detection and growth in engineering structures, non-destructive determination of internal stresses in components and the detailed chemical analysis of steel microstructures.

- P 773 "Classification of round bar surface quality directly from a mill cooling bank"

The research is designed to develop non-destructive testing techniques for internal and surface testing of steel (without cooling) at temperatures up to 500°C.

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An ultrasonic inspection unit will be constructed for in-line installation. Round bars from 100 to 270mm in diameter will be tested in theworks and difficulties caused by temperature and product speed will be examined.

These tests will be followed by a study to develop the computer control of the test system to ensure that the bars are collected together, transported and processed in the most efficient manner.

Applicant : ROUND OAK STEELWORKS - Brierley Hill
Amount : 595 500 ECU
Duration : 4 years

- P 786 "Surface inspection of continuously cast billets"

The aim is to find a reliable surface inspection method in order to establish suitable means of in-line inspection for continuously cast billet production.

The initial experiments will be on cold billets but they will be extended to warm (up to 500°C) billets later.

Four methods will be tested and the results obtained compared in order to make a final choice : eddy current, flux leakage, ultrasonic and optical/infra-red techniques.

Applicant : BSC - London
Amount : 384 500 ECU
Duration : 3 years

- P 817 "Development of an industrial gauge for hot detection of surface defects on beams"

The research is designed to develop a method of hot surface inspection for beams. It will make use of a system for the observation and detection of surface defects based on the development of a camera with photodiode devices.

Once the method has been developed an industrial prototype will be produced for continuous operation on the delivery side of a beam mill. The beam surface temperature range will be between 500°C and 1 150°C.

The defects to be detected will be surface cracks and flaws of small dimensions (not less than 1 cm^2).

Applicant : CRM - Liège
Amount : 434 500 ECU
Duration : 3 years

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- P 852 "Acoustic emission monitoring of steels and structures"

The enormous potential of acoustic emission inspection techniques for steels is gradually but very slowly being utilized. The project aims to define and implement an acoustic emission method for the examination of "calm" (low-emission) materials.

The points to be elucidated are :

- which steels are emitters and which are calm,
- how the metallurgical structure and production operation influence emission behaviour,
- how emission behaviour varies with conditions (dimensions or geometry of parts or test structures),
- maximum useful detection capacity.

To allow for the effects of variations in steel composition and in the production process on emission behaviour, three groups of steels will be studied : carbon manganese, micro-alloyed and high-strength low-alloy steels.

Applicants : 1. DANISH WELDING INSTITUTE - Glostrup
2. RIS NATIONAL LABORATORY - Ris
3. CSM - Roma
Amount : 654 000 ECU
Duration : 3 years

- P 864 "Ultrasonic detection of inclusions in sheet"

The programme consists of researching and developing a 100% contactless in-line inspection technique based on an electromagnetic-acoustic probe. The aim is to improve the quality of sheet produced from ingots or made by continuous casting.

The project may be divided into three separate parts :

1. laboratory studies : characterization of defects detected, identification of the defects by destructive testing;
2. study and construction of an electromagnetic-acoustic head, industrial feasibility;
3. industrial tests : construction of a prototype unit and installation on an industrial site for works testing.

Applicant : IRSID- St. German-en-Laye
Amount : 515 500 ECU
Duration : 3 years

- P 900 "Improvement of quantitative micro-analysis of light elements in steel"

To improve the monitoring of steelmaking by process control and assessment, the project is designed to develop and improve a microprobe for quantitative determination of inclusions, precipitates, segregations and phase transformations. ./.

The method studied will be based on the "Parobek"and Brown" quantitative analysis method, using the general equation for the distribution in depth of x-ray sources as a function of composition, energy and absorption of electrons.

Determination will relate mainly to boron, carbon, nitrogen and oxygen.

Applicant : TNO- Apeldorn; MANNESMANN WERKE AG - Duisburg
Amount : 182 500 ECU
Duration : 2 years

- P 904 "Non-destructive evaluation of residual stresses in steel"

This project is a complement to ECSC contracts (Agreements No. 7210GA120 - 7210GA810) that is necessary in order to reach conclusions that can be used by industry.

The method devised and developed uses non-destructive testing by two techniques : ultrasonic (Harwell) and magnetic (IZFP).

Applicants : AERE - Harwell
Amount : 260 000 ECU
Duration : 3 years

II.6 - PROPERTIES AND SERVICE PERFORMANCE

The continuous effort devoted to research into the service properties and behaviour of steels must be aimed at the technical promotion of steel products, aided by a reduction in costs.

To promote steel it must be possible to offer the user the most suitable grade, quality and type of long or flat product for his needs. This calls for continuous contacts between producers and users to find the optimum solution in each specific case. This concept of optimization applies in all areas - lightweight structures, heavy pipelines, pressurized containers for the petrochemical industry or generating stations and even turbines; it gains added significance with the current tendency to increase dimensions so as to economize by benefiting from the scale effect. Inevitably this tendency must be accompanied by an increase in the safety of structures and plant, calling in turn for a more comprehensive knowledge of the material and its conditions of use.

Consequently great importance must be attached to the homogeneity of products and invariability of their properties which facilitate fabricating operations (such as forming and welding) and to component reliability and durability : the concept of performance over time has come to the fore.

Associated with this concept is the cost-quality ratio, for which the best compromise must be sought :

- by increasing the reliability and precision, and hence the profitability, of production plant (automation, plant control) to obtain more homogeneous production and closer dimensional tolerances; ./.

- by joining in the worldwide effort to save energy through greater efficiency of machines, process automation, reduction in component weight, a better surface finish (resistance to environmental conditions) and also by developing techniques that allow reduced consumption or replacement of the most costly alloying elements;

- by constantly urging rational product use, i.e. optimization in combination with other materials. This is an excellent method of promotion as it provides an opportunity of demonstrating the intrinsic qualities of steel such as strength/weight ratio, flexibility of use, maintenance of mechanical properties.

a) Weldability

- P 758 "Research to obtain greater economy in the welding of high-strength steels"

In the present state of the art in the welding of steels, the risk of cold cracking when high-strength steels are welded causes problems because of the difficulty in giving manufacturers sufficiently simple and economic fabricating directives to encourage the use of such steels.

Consequently it is necessary to establish the limits to the use of the criterion for high-strength steels when welding the first run without pre-heating and to investigate the conditions for multi-run welding involving temperature monitoring but having the advantages of both safety and ease of welding.

These investigations are to be carried out on steels E 460 to E 690 in medium thicknesses of between 16 and 30 mm; the restraint intensity of standard connections and the properties of the filler metal will be taken into consideration.

The aim is to define, for high-strength steels (types E 460, E 550, E 690) of medium thickness, the least restrictive welding conditions possible, on the basis of the criteria of the implant crack test, restraint intensity and thickness of the connection.

A better knowledge of the weldability of high-strength steels should make it possible to relax the requirements on welding conditions, in particular as regards pre- and postheating. At technical level, this will simplify operations, thus saving costs, and will improve working conditions and hence quality. Consequently the results should increase the possible uses of high-strength steel in welded structures.

Applicant : INSTITUT DE SOUDURE - Paris
Amount : 103 500 ECU
Duration : 2 years

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- P 759 "Evaluation of the strength of spot-welded assemblies with a view to the drawing-up of design rules"

Lightweight structural steelwork (in particular three-dimensional frameworks) is a potential field of application for spot welding that is not yet exploited. It should be possible to use this assembly technique to produce more cheaply in the workshop standard prefabricated elements for subsequent assembly on site by other methods.

In structural steelwork the thickness used amount to several millimetres and the assumed stresses are quasi-static.

There are no design codes for determination of the optimum configurations of assemblies.

Such design codes can only be produced on the basis of experimental data on the behaviour of real or simulated assemblies.

It is therefore necessary to undertake a series of tests to establish a collection of results providing qualitative information on the mechanisms of multi-joint assemblies and the values of limit loads that can be withstood by such assemblies.

Applicant : INSTITUT DE SOUDURE - Paris
Amount : 103 500 ECU
Duration : 2 years

- P 815 "Risk of cold under-bead cracking and the welding of branches on gas pipelines"

The first aim is to establish sufficiently general laws to allow the results obtained on implants under standard conditions to be transferred to other situations, thus enabling the results to be applied more precisely to industrial assemblies.

The second aim is to predict the risk of cold cracking in the case of hot tapping, i.e. welding a branch on to a main pipeline without interrupting the flow of the fluid transported.

The steels studied will be of grades X70 and X80; an attempt will be made to ascertain any restrictions to be observed by steelmakers in the development of these grades.

Applicant : CRM - Liège
Amount : 546 500 ECU
Duration : 3 years

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- P 841 "Fracture behaviour of thick-walled joints welded by various methods - Influence of bead width and stress-relieving"

Stress-relieving treatments are used in an attempt to prevent stresses in thick-walled welded structures of high-strength steel grades. It has been known for some time that the annealing of alloy steels may lead not only to embrittlement caused by the temperature and by precipitation but also to embrittlement and cracking by elongation due to stress-relieving. It thus appears that the embrittlement phenomenon is also influenced, possibly even to a predominant extent, by the micro-structure and not only by the stress state.

The tests on an ordinary material (22 NiMoCr 37) will be carried out on test pieces of various dimensions (250 to 1 000 mm) with or without stress-relieving.

Applicant : VDEh/Staatliche Materialprüfungsanstalt, Stuttgart University
Amount : 565 000 ECU
Duration : 3 years

- P 866 "Weldability of quenched and tempered steels obtained by direct quenching"

The production of high-quality steel by high-temperature thermo-mechanical treatments, in particular direct quenching followed by annealing, not only saves energy (by an amount equivalent to the heating of plate in the conventional process) but also saves raw materials (high-quality sheet with low alloy content).

The low content of these steels makes them by definition suitable for welding. It is important to demonstrate this and in particular to see how the overall behaviour of the weld is affected.

The development of these steels is dependent on a knowledge of the appropriate conditions for their fabrication. It is therefore useful to study the welding behaviour of these steels for the following applications :

- abrasion-resistant plate
- plate for welded tubes
- heavy plate

The grades studied will be :

- E 690 in thickness of 8 - 30 mm
- E 550 in thickness of 12 - 22 mm
- E 460 in thickness of 30 - 50 mm

Applicant : IRSID - St. German-en-Laye
Amount : 344 000 ECU
Duration : 3 years

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b) Corrosion and Surface Protection

- P 810 "Gas-metal reaction during basic annealing - Influence on sheet surface cleanness"

The concept of the "surface cleanness" of annealed and skin-passed sheet is becoming increasingly important, particularly in the car-making sector. The corrosion resistance of phosphated, painted sheet has been shown to be closely related to the amount of residual carbon in the outer surface of the annealed, skin-passed sheet.

The removal of residual hydrocarbons from cold-rolled steel depends on a large number of parameters.

Knowledge of the way in which the major parameters operate is an essential precondition for any improvement of product quality.

The research is intended to define the state of the "chemical micro-reactor" represented by the interstices of a coil undergoing annealing, by measuring changes in gas composition over a period of time and by describing the surface chemistry of the sheet at the start and end of process annealing. Since laboratory simulation tests are not representative, research must be conducted on actual coils in an industrial furnace.

Applicant : CRM - Liège
Amount : 409 500 ECU
Duration : 3 years

- P 873 "Study of the phosphate coating and corrosion behaviour of cold-rolled products of high strength low-alloy steel"

This research forms part of the study of steel surfaces in relation to their susceptibility to phosphating and therefore to the corrosion resistance of the steels in question.

The current tendency to use HSLA steels mainly in response to the problems of reducing the weight and increasing the solidity of motor vehicle bodies, has revealed a number of major problems relating to corrosion behaviour beneath paint after phosphating and painting.

The research is designed to establish a relationship between the surface composition of certain low-alloy steels, produced either experimentally or commercially, and susceptibility to phosphating, either by means of laboratory tests or by the use of a pilot phosphating line. The results obtained will be evaluated using only phosphated samples or phosphated and painted samples.

Applicant : ITALSIDER - Genova
Amount : 173 000 ECU
Duration : 2 years

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- P 883 "Neutral electrolytic pickling process for ordinary and low-alloy sheet. Process development on a pilot line to optimize the surface quality characteristics of products for various applications"

Earlier research has made it possible to define the mechanisms of the electrochemical reactions which form the basis of the neutral electrolytic pickling of sodium sulphate (NEP), to establish the effect on the process of the various operating parameters, and to clarify the mechanisms influencing the morphology and nature of the mill scale.

Future prospects for the development of NEP seem favourable in view of current improvements in the working environment and the quality of rolled products. The adoption of this process to replace the hydrochloric and sulphuric acid processes would remove all the pollution problems which typify such pickling systems and would also entail a drastic reduction in maintenance costs in respect of corrosion.

It is proposed to conduct experimental research with the following objectives :

1. Development of NEP, particularly the final stages of the process for the production of cold-rolled carbon steel and low-alloy silicon steel, which have optimum surfaces as regards rust resistance and suitability for the successive operations which make up the process cycle.

2. Study of electrolytic treatments processes in a neutral sodium sulphate solution for the improvement of the surface quality of cold-rolled carbon steel from the standpoint of susceptibility to phosphating, painting and corrosion resistance when painted.

Applicant : CSM - Roma
Amount : 346 000 ECU
Duration : 2 1/2 years

- P 885 "Cladding of Zn-Al Alloys. Development of the cladding process on a pilot plant"

Consideration has recently been given to the possibility of coating steel with Zn-Al alloys having a high Al content; depending on the composition of the coating it would, in theory, be possible to give such steel a range of properties varying from something fairly close to those of the zincate to something fairly close to those of the aluminate.

The basic objective of an initial research programme was the acquisition of scientific information and laboratory-scale technical know-how.

It is proposed to check the technical feasibility of the coating process on a continuous line, using alloys selected during the initial research programme, and to extend study of the service properties of products including field tests. The pilot plant will make it possible to optimize the process parameters under dynamic conditions in order to transfer the process to the industrial scale.

Applicant : CSM - Roma
Amount : 311 500 ECU
Duration : 3 years

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- P 901 "Research on the corrosion behaviour of low-alloy steels under atmospheric and offshore conditions"

The literature contains a large number of reports and publications concerning the significance of alloying elements in low-alloy steels used in offshore technology and in the atmosphere (different climates). The information is mainly based on laboratory investigations (circuits or artificial seawater) and the results, which are promising in some cases, must be tested in practice before the steels are used in operational conditions. This is the aim of the present project, which uses suitable commercially available steels as a basis for the examination of a number of alloys that can be expected to be characterized by adequate resistance in seawater and/or the atmosphere, low manufacturing and processing costs, good mechanical properties and a wide range of application.

An additional important factor is that some of the steels examined could also be used as evaporator casings for marine desalination plants.

Since the research will be conducted on existing test rigs, the costs incurred will be relatively slight.

Applicant : VDEh - Düsseldorf
Amount : 103 500 ECU
Duration : 3 years

c) Forming

- P 813 "High strength multiphase steels for various types of flat products"

Since the sixties, the need for increased mechanical strength in general steels has grown considerably in the various fields in which they are used. Automobile manufacturers are particularly interested in this since this is one of the ways in which they can improve safety and reduce the weight of vehicles. Unfortunately, of course, as a general rule an increase in strength means a loss in ductility and it is, therefore, necessary to find an economic compromise between these two properties.

It is with this in mind that the concept of using a biphase structure comprising principally granular ferrite and martensite, what is known as dual phase (DP) or multiphase steel, came into being.

It is then possible to obtain, after annealing a steel with 0.2% yield limit which is low but which, nevertheless, improves considerably following deformation of 2 to 5% as often occurs in industrial practice. This produces, after forming, a high strength steel.

In order to solve the problems raised such as the elongation limit and dispersion of properties over the length of the coil, a detailed study on the mechanisms of multiphase microstructure formation and their behaviour during plastic def mation is essential.

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Applicant : CRM - Liège
Amount : 372 500 ECU
Duration : 3 years

- P 814 "Deep-drawing of very high strength steel sheets"

In order to meet current safety and economic requirements, users of sheet steel, and automobile manufacturers in particular, are increasingly interested in the possibilities of reducing weight. The motor car industry would, therefore, like to see the development of the following three grades : 500 MPa, 650 MPa, 1030 MPa. A better knowledge of the behaviour of these steels, especially during deep-drawing processes is required. We therefore propose to study, as a priority, the general suitability of these products for forming by concentrating on the forming of folds and on the spring-back effect. Special attention will be paid to the influence of tools on performance in deep-drawing. The properties of the final products such as stiffness, sound deadening and impact strength will be studied.

Applicant : CRM - Liège
Amount : 449 500 ECU
Duration : 3 years

d) Constructional Steels

- P 750, 765, 771, 778, 850, 903 "Measurement and interpretation of dynamic loads on bridges"

This programme is the second phase which had originally been planned in a study started at the end of 1975, the first phase of which is nearing completion. The aim of the research is to become more familiar with the service conditions of steel bridges in order to improve the computer codes and, by using standard fatigue calculations for bridges, to make them more competitive in an area where concrete bridges have gained supremecy. To date, 11 road bridges and 3 rail bridges have been instrumented for the measurement of traffic conditions (frequency, composition) and the results have been analysed.

Before drawing conclusions, and thence by simulation, developing a calculation method which will enable the various types of bridges to be matched properly to the various configurations and use conditions, measurements of the operating conditions of such bridges have to be more closely defined and refined, i.e. special effects resulting from congested traffic, holiday traffic. During the simulation exercise, it was found that this was only valid if the parameters were known for a recording period which corresponded to a minimum number of axle crossings as well as the distribution of the corresponding stresses.

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Project No.	Applicant	Amount in ECU	Duration (years)
750	Liège University	53 500	2
765	Pise University	65 000	2
771	Laboratoire des Ponts et Chaussées - Paris	91 500	2
778	Transport Road Research Laboratory - Crowthorne	70 000	2
850	Laboratorium für Betriebs-festigkeit - Darmstadt	121 500	2
903	Stichting Staalcentrum Nederland - Amsterdam	109 500	2

- P 868 "Study of the fatigue behaviour of welds"

This proposal deals with the use of austenitic stainless welding metal on basic low alloy steel materials such as are frequently encountered in large boiler production.

The complexity and dimensions of these products require the assembly of multiple elements which must normally combine resistance to mechanical and thermal stresses with corrosion resistance.

Furthermore, the possibility of substituting a low alloy for a stainless steel wherever the use of the latter is not essential would permit major savings in raw materials.

Moreover, the use of high elasticity grades in this type of weld could lead to beneficial solutions which could encourage the use of these grades of steel.

The main aim of the proposed study is to identify the fatigue characteristics of the most common heterogeneous welds and hence to obtain data for a better definition of their service properties.

The types of weld to be considered are :

- weld using a mild steel with an austenitic stainless steel;
- weld using a high elastic limit steel with an austenitic steel after buttering of the low alloy steel;
- weld using an austenitic electrode for elements of high grade steel.

Applicants : IRSID - St. German-en-Laye
CREUSOT-LOIRE - Firminy
Amount : 293 000 ECU
Duration : 3 years

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- P 891 "Evaluation of the fatigue strength of welded, bolted and riveted connections in high strength low-alloy steel"

In industry there is a strong tendency to use higher yield strength materials. In general, it is true to say that the use of high strength materials means reduced energy consumption and reduced weight (i.e. space craft, bridges) and/or more economic production and greater efficiency in service. In structural steels this tendency is very strong. Type FeE240 steel, which was formerly very common, has been extensively replaced by FeE355 steel, which allows a 50% increase in static design level.

This steel is, generally speaking, the highest grade plain carbon steel which can be easily welded.

Because of technical difficulties in the welding process for higher steel grades, other methods are used :

- bolted connections, notably using pre-tensioned H.T. bolts,
- riveted connections, although riveting is currently often regarded as out-of-date.

The greatest disadvantage of connections in shear by bolts and rivets is that, in order to achieve a fairly even load distribution, the tolerance of the pitch of the hole has to be very narrow. With bolt connections, this drawback is overcome by the use of high-strength, pre-tensioned bolts. The shear forces are then transmitted by friction between the plate surfaces.

The aim of the research is to evaluate the fatigue strength (constant and variable amplitude) of different types of connection (welds, bolts, rivets) in HSLA steel comparable to FeE560.

Applicant : STICHTING STAALCENTRUM NEDERLAND - Amsterdam with participation by the following laboratories :

University of Technology - Eindhoven,

DAF Trucks - Eindhoven,

Nederlandse Schroefboutenfabriek N.V. - Helmond,

Hoogovens - IJmuiden.

Amount : 200 000 ECU
Duration : 3 years

e) Fracture Mechanisms

- P 844 "Research into the influence of size on the working stress of notched specimens resembling structural members with varying material toughness"

The effect of the size of notched structural members is to increase the stress due to clamping, possibly to reduce the deformation capacity and to increase the probability of the formation of weak points.

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Whereas it is relatively simple to determine the initiation of plastic deformation with the aid of the yield point given by a monoaxial tensile test, such a precise criterion does not exist for the ultimate stress (crack type and orientation).

Two materials will be tested, one with high toughness properties and the other with low toughness properties. The deformation before fracture will be determined and, in relation with this deformation, the ultimate stress will be measured with very large specimens and specimens of decreasing size down to the sizes commonly used for determining material properties.

Applicant : VDEh - Düssledorf (Staatliche Materialprüfungsanstalt, Universität Stuttgart)
Amount : 356 500 ECU
Duration : 3 years

- P 884 "Influence of microstructure and grain boundary segregation on the fracture toughness of Ni-Cr-Mo-V steels for low pressure rotors"

The trend in the design of rotating machines for energy production is increasingly to use criteria that are no longer so extensively (or exclusively) based on mechanical strength, but also (and especially take) into account fracture toughness. These criteria are obviously determined in relation to the real service conditions of the various components of the machine, which operate in temperature ranges that involve widely-differing fracture mechanisms.

The research work will, broadly speaking, involve the following : fracture toughness will be studied (in the static and/or dynamic modes) at temperatures approaching ambient temperature in generators; the deterioration of these properties in low-pressure rotors as a result of being maintained under isothermal conditions at 350°C will be predicted; and the extent of damage due to creep and resistance to low-cycle fatigue at high temperature will be assessed in high-pressure rotors.

Applicant : CSM - Roma
Amount : 313 500 ECU
Duration : 3 years

f) High Temperature Steels

- P 757 "Effect of periods at maximum and minimum strain values and of various strain levels on cumulative low-cycle fatigue damage in a 2 1/4 Cr 1 Mo ferritic steel at high temperature"

Electricity generating, chemical and petrochemical plant components are subjected to thermal transients during startup and shutdown and under the steady-state conditions corresponding to normal operation at high temperature. As a result, low-cycle plastic fatigue, creep and/or stress relief can be observed in these components.

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The aim of this research is to conduct tests that, taking into account both the various mechanisms governing damage of this type and the properties of the material under conditions similar to those of actual service, make it possible to establish the relationship between stress relief and low-cycle fatigue by analysing the various laws of cumulative damage.

Applicant : ISTITUTO RICERCHE BREDA - Milano
Amount : 190 500 ECU
Duration : 2 years

- P 848 "Research into the tendency to work hardening in heat-resistant steels at elevated temperatures and its significance in the specification of safe working stresses for structural components with local stress concentration"

The scheduled tests are intended to demonstrate that steels which, over certain temperature ranges, have a fairly short stress/elongation proportionality limit followed by significant hardening can be used with properties based on a higher limit of elongation in strength calculations. Both the effect of previous work-hardening at a lower temperature and the displacement of stresses in components subjected to maximum stresses must be taken into consideration.

The behaviour of the material at different temperatures has to be studied with the usual method (tensile tests and impact tests). The final tests will be conducted on small (impact test) and large (400 x 80 mm cross-section) specimens.

Applicant : VDEh - Düsseldorf(Staatliche Materialprüfungsanstalt, Universität Stuttgart)
Amount : 244 500 ECU
Duration : 3 years

- P 869 "Influence of forming on heavy plate properties"

The aim of this proposed research project is to supplement the incomplete information available on the cold forming of heavy plates by studying the precise metallurgical consequences of forming deformation followed by welding.

The research will be conducted on a fine-grained annealed carbon-manganese steel and low-alloy chromium-molybdenum and manganese-molybdenum-vanadium steels.

The fact that these steels are widely used for the fabrication of pressure vessels means that this project will have relatively wide applications. In addition, it will be possible to transpose much of the information obtained to a wide number of similar steel grades.

This study will make it possible to determine how production methods can be simplified by avoiding energy- and time-consuming treatments while ensuring that the finished product offers properties that are commensurate with the desired safety levels.

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Applicants : IRSID - St. Germain-en-Laye
CREUSOT-LOIRE - Le Creusot
Amount : 350 000 ECU
Duration : 3 years

g) Light Structures

- P 776 "Study of connections between steel structures and horizontal or vertical masonry components"

One of the main obstacles to the use of metal structures in civil and industrial engineering is the difficulty in ensuring a satisfactory connection between the metal structures and the horizontal or vertical components made from conventional masonry materials. The aim of the proposed study is to supply designers and constructors with all the necessary technical details for solving their specific problems and, to bring about a greater penetration of the very important building construction market. Either because designers do not know how to calculate metal structures correctly or because the engineers and building workers find difficulty in adopting the assembly techniques on the building site, prestressed masonry elements are often selected in order to avoid the problem of assembling heterogeneous materials.

Applicant : CISIA - Milano
Amount : 35 000 ECU
Duration : 2 years

- P 798 "Relationship between design of precoated steel cladding and its environmental behaviour in service"

This project aims to increase the market for pre-coated steel products by developing data leading to their more effective utilisation in service. The data derived from this work will also help steelmakers and coil coaters wishing to improve the properties of their products.

The overall general objective is to obtain a better understanding to the effect of design factors arising in current building practice on the behaviour of pre-coated steel-based products when exposed outdoors. It is intended that the results from this work should influence the way in which precoated products are used in the future so as to minimise the possibility of premature failure caused by their misuse.

The specific objects are :

a) to inspect steel cladding on buildings in service in order to examine phenomenologically the modes of ultimate breakdown actually occuring in a variety of outdoor climates and their relationship to design.

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b) To expose specially designed profiled specimens of a selection of pre-coated products to a variety of climatic conditions for approximately three years, to examine them in the laboratory for symptoms of incipient breakdown of the kinds observed in the inspection of buildings.

c) To use relevant accelerated performance tests in combination with modification of the natural microclimate in such a way as to exaggerate its more aggressive characteristics and so to give early results.

d) To conduct relevant laboratory measurements, mainly in order to specify the initial properties of the actual samples of coating systems under observation, but also paying initial attention to causes of breakdown.

Applicant : BSC - London (Shotwick Research laboratory)
Amount : 382 000 ECU
Duration : 4 years

- P 801 "Development of recommendations for the design of welded joints between steel structural hollow sections or between steel structural hollow sections and H sections"

Steel structural hollow sections (SHS) have an essential role to play in improving the aesthetics and economics of construction, particularly in steel.

The use of steel SHS in construction has increased considerably in recent years even against a general decline in building activity. In many cases SHS have opened up new opportunities for steel that would otherwise be in other materials such as concrete or wood. An example of this is the use of concrete filled SHS columns in buildings that would traditionally be in reinforced concrete. This trend will encourage the use of steel products generally by leading the way to more steel intensive solutions.

Light SHS trusses are also the most serious competitor to wood in applications such as roof trusses for housing.

The lack of comprehensive design recommendations in some areas of SHS applications have proved to be a severe handicap to the continuing development of the market. This is particularly so in the field of welded lattice girder construction where the particular properties of SHS can be used to their best advantage.

The objectives of the study are to provide comprehensive recommendations for the design of welded joints in SHS or SHS and H sections which will form a basis for European recommendations and Euronorms which will thereby overcome the need for special testing to demonstrate joint performance which is so often necessary at present.

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Applicants	Amount ECU	Duration (years)
BSC - London, Tubes Division Research Centre - Corby	156 000	3
DALMINE/ITALSIDER - Bergamo	160 000	3
MANNESMANN - Düsseldorf	101 000	3
ESTEL - IJmuiden	141 000	3
COMETUBE - Paris	52 000	3

- P 887 "Comparative technical and economic study of structural steelworks in the European Community, in North America and in Japan"

The European metal construction industry which has been a traditional client of the steel industry is in a serious crisis involving increasingly frequent plant shutdowns with all the social consequences that this entails.

This situation is very worrying not only for the industry itself but also for its main supplier, the iron and steel industry, which is trying to find suitable ways to develop the use of its products in this field.

By acting in good time, it is still possible to halt this dramatic turn in events. The example of North America and Japan where the metal construction industry if still flourishing shows that the crisis now being experienced by this sector in Europe is largely attributable to an industrial structure which has not adapted itself sufficiently to the increase in salary costs by a corresponding increase in productivity.

To determine the full extent of this problem, an objective comparative study on the metal construction industry is necessary which will examine the way this industry operates in the Community as compared with similar industries in North America and Japan.

This technical and economic study aims to compare the situation regarding the metal construction industry in the European Community, the United States and Japan, to identify the strong and weak points of the European industry and, on the basis of this analysis, to define the remedies to be applied and strategies to be adopted at industrial, technological, R&D and marketing level.

Ultimately, the results of this comparative study should help to restore conditions for encouraging sales of European steel and develop new steel user outlets in the area of steel construction.

Applicant : CBLIA - Bruxelles
Amount : 335 000 ECU
Duration : 2 years

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h) Alloy and Special Steels

- P 761 "Case-hardening steels with grain size control using high-temperature thermo-chemical treatment"

The current trend in heat treatment by means of cementation is to raise the process temperature (up to 1050°C) with the aim of considerably reducing the duration of the treatment.

One of the major metallurgical problems connected with this trend is the dimensional stability of the austenite grain.

Normally, austenite grain size is controlled by means of controlled addition of aluminium. However, to be able to do this at high temperature the additions necessary are such as to impair hot ductility, especially in resulphurized steels.

The elements traditionally used as alternative or joint additives to aluminium for grain refinement are Nb, V and Ti, but so far their use has been examined mainly for structural steels and hardly at all for heat-treated steels.

This project is aimed at developing case-hardening steels which can guarantee enough grain size stability at high temperature without having any drawbacks either at the fabrication stage (hot embrittlement) or in use (static and fatigue strength and toughness).

Applicant : BREDA SIDERURGICA - Milano
Participating laboratories : BREDA SIDERURGICA -
NAZIONALE COGNE - Aosta
CSM - Roma
CRM - Torino

Amount : 259 500 ECU
Duration : 3 years

- P 772 "Study and development of materials and fabrication processes to improve the performance of equipment for the hot shaping of steels"

In addition to high temperatures, equipment used in the hot shaping of metals are subjected to particularly high service stresses as well as a rapid influx of intense heat which must be dissipated after each cycle to avoid overheating.

The heating and cooling cycles produce stresses which reduce the strength of the equipment and may induce dangerous cracking. For this reason the use of equipment for the hot shaping of metals requires the use of a given type of special alloy steel which has certain basic strength properties after special heat treatment. The aim of the research is to re-examine existing materials and to study and develop new materials, and to determine which heat and surface treatment methods produce the best wear resistance in equipment used for the hot shaping of metals in the steel industry.

Applicant : DALMINE - Milano
Amount : 458 500 ECU
Duration : 3 years

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- P 802 "Conservation of strategic alloying elements - Selection and heat treatment of alloy steels"

The supply of alloying elements to the steel industry has been subject to continual disruptions. These have arisen from national or international crises and also from problems associated with the production of an individual element. After each interruption, there has been an adjustment in the pattern of use of alloying additions and this is reflected in various national steel specifications.

Although there have already been extensive reductions in alloy contents, such that steels introduced some years ago as "economy measures" are now widely established, there is room still for further optimization. Two factors aid this optimization. The first is the availability of more efficient heat treatment procedures and the second is the ability of modern steelmaking practice to provide accurate compositional control.

The research project has two main objectives :

1. To examine systematically the properties obtainable from individual classes of heat treated steels, to define the regions of overlap in hardenability and properties between the compositional variants.

2. To study systematically the response of the major alloy steel types to variations in heat treatment.

Applicant : BSC - London (Sheffield Laboratories)
Amount : 257 000 ECU
Duration : 3 years

- P 820 "Influence of chemical composition and other factors on the forgeability of cold-heading quality steels"

This proposal intends to improve the quality and suitability of steel rod and wire for cold forging. The majority of thin steel is converted to industrial fasteners of all types. High standards are essential for this type of steel since the European market for cold forging quality steels is under pressure from outside the ECSC (lower price, higher quality). Another source of pressure is the import of finished fasteners. As this flow increases, and it is already over 50% of the market in certain localized areas, there is a corresponding loss of steel supply market for the ECSC producers.

It is proposed to study the influence of fine structure and composition on forgeability by closely monitored off-line forging trials on experimental coils with different distributions of sulphide inclusions and nitrides. This study will involve a finite element simulation of the forming of a standard bolt cheesehead. The mathematical models will be validated by laboratory measurements and tool load measurements in forging trials.

Applicant : GUEST, KEEN & NETTLEFOLD LTD - Wolverhampton
Amount : 262 500 ECU
Duration : 3 years

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- P 882 "Free-cutting graphite steels"

Steels to be worked at high speed on automatic machines for the mass production of bolts, screws and small metal parts are currently produced with the addition of special elements such as Pb, S, Te, Se, etc.

The substitution of these inclusions by spheroidal graphite particles may give considerable advantages over conventional free-cutting steels, in particular :

a) improved workability, hot plasticity and directionality;

b) improved environmental conditions when working lead-containing steel.

The aim of the research is :

- to identify classes of graphite steel with good workability which can be substituted for current lead-containing types;

- to explore the various aspects of the fabrication cycle and heat treatment with the aim of attaining the service properties required.

Applicant : CSM - Roma
Amount : 389 500 ECU
Duration : 3 years

- P 894 "The influence of texture on the fatigue properties of HSLA steels"

The ever-increasing demand for high-srength low-C plate and strip and the need to optimize the use of current products may be met by steels with properties which are improved by controlled hot rolling processes which can give steels with high performance.

Reference to the applications of HSLA steels in the transport sector shows the particular importance of resistance to dynamic stresses both in the nominally elastic phase and in the plastic phase (fatigue behaviour).

The lack of data available at present on the possible correlation between texture and fatigue in steel means that this field of research has very interesting prospects.

Applicant : CENTRO RICERCHE FIAT - Torino
Amount : 329 000 ECU
Duration : 3 years

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II.7 - MISCELLANEOUS

- p 754 "Technical steel literature"

This is an extension of previous agreements granting ASELT financial aid for the translation into Community languages of documents of interest to the steel industry published in "difficult" languages (especially Japanese and Russian).

Applicant : ASELT - Luxembourg
Amount : 125 000 ECU
Duration : 1 year

- P 851 "Research into steelworks slag, especially its use in road construction"

This coordinated programme is a follow-up to the work done under Agreements 7210-XA during which it emerged that free lime and free MgO contents presented a major problem.

The aims of the present programme are :

- to study the parameters affecting free lime and MgO formation in the converter and after casting;
- to develop a method of ensuring the stability of the physico-chemical and mechanical properties of slag;
- to study volumetric stability of slag and examine conditions for treatment prior to use;
- to study the mechanical properties of slag by comparison with conventional materials to encourage its use in road construction.

Applicants : FORSCHUNGGEMEINSCHAFT EISENHUETTENSCHLACKE - Duisburg
USINOR - Paris
CRM - Liège
BCS - London
Amount : 833 000 ECU
Duration : 3 years (prolongation from 1.7.1980)

Annex

SUMMARY TABLE

Project N°	Title of the research	Proposed research			Financial aid	
		by	Duration (years)	Amount ECU (7.12.79)	%	Amount ECU (7.12.79)
	IRON MINES					
760	Optimization of face-cutting machines	Samifer	1 1/2	533.000	60	319.800
	ORE REDUCTION					
	a) Sinter					
824	Reduction of energy consumption in a sinter plant, having regard to sinter quality, by controlling raw material stacking in the blending beds and varying the mixing process in a continuously adjustable combined mixing and balling drum	Mannesmann	3	675.000	60	405.000
872	On-line monitoring of the permeability of the sinter bed to reduce sinter variations and energy consumption	Italsider (+CSM)	2	432.500	60	259.500
	b) Blast furnace					
766	Optimization of the thermal state of the tuyere zone in the blast furnace	Arbed	3 1/2	954.000	60	572.400
780	High-temperature reduction, softening and meltdown studies of burden materials	BSC	4	509.500	60	305.700
821	Influence of the form and position of the softening and meltdown zone on the blast furnace performance	CRM	4	506.500	60	303.900

Project N°	Title of the research	Proposed research			Financial aid	
		by	Duration (years)	Amount ECU (7.12.79)	%	Amount ECU (7.12.79)
826	Control of gas flow in the solid, pasty and fluid areas of the furnace burden	VDEh (et al.)	3	3.557.500	60	2.134.500
829	Material selection and design of staves for blast furnaces	Hoesch	3	963.500	60	578.100
830	Improvement of energy use by aerodynamic optimization of hot blast stoves	VDEh/BFI	3	666.500	60	399.900
853	Blast furnace: consequences of charging on burden structure	IRSID (et al.)	4	1.209.000	60	735.400
878	Influence of the chemical and physical properties and reduction conditions on the softening, meltdown and percolation of sinter at temperatures up to 1600 ° C	CSM	4	277.000	60	166.200
	STEELMAKING					
	a) Casting and Solidification					
770	Fundamental study of the behaviour of casting powders	(IRSID (MPI (NPL	((2 (	129.000 121.000 122.500	60 60 60	77.400 72.600 73.500
782	Behaviour of mould fluxes during continuous casting	BSC	3	112.500	60	67.500
784	Control of solidification of long freezing range steels by electromagnetic stirring during continuous casting	BSC	3	312.000	60	187.200
809	Development of new casting powders for continuous casting	CRM	3	256.000	60	153.600
831	Development of insulating feeder heads to improve the quality of forging grade ingots	Thyssen	3	365.500	60	219.300
860	Bending and straightening with liquid core	IRSID (et al.)	3	515.500	60	309.300
880	Adaptation of the continuous casting tundish for after-treatment of steel	CSM	4	1.081.000	60	648.600

Project N°	Title of the research	Proposed research			Financial aid	
		by	Duration (years)	Amount ECU (7.12.79)	%	Amount ECU (7.12.79)
889	Development of a direct strand reduction method for steel	Krupp	2	504.500	60	302.700
	b) Oxygen steelmaking					
787	Bath stirring in basic oxygen steelmaking by gas injection through basal tuyeres	BSC	3	471.000	60	282.600
875	Addition of alloy elements by means of ore in the AOD converter	Cerimet	2	268.500	60	161.100
	c) Refractories					
858	Repair of converter bottoms	IRSID	3	743.000	60	445.800
	d) Theoretical metallurgy					
857	Thermodynamic and kinetic data on various steelmaking materials (slags, inclusions)	IRSID	3	302.500	60	181.500
	e) Energy in steelindustry					
774	Technical aspects of lean gas utilization in the iron and steel industry, burner and combustion control investigations	IFRF	3	469.500	60	281.700
832	Development of low-pulsation multi-fuel burners for large combustion chambers with a high energy efficiency	BFI	3	513.500	60	308.100
	MECHANICAL WORKING					
767	Tungsten carbide rolling mill rolls	Arbed	2 1/2	380.000	60	228.000
793	Three-dimensional model for metal flow under triaxial strain conditions	BSC	3	308.500	60	185.100
833	Research on material flow in grooved rolls to improve design methods and increase the efficiency of section rolling	BFI	3 1/2	536.500	60	321.900

Project N°	Title of the research	Proposed research			Financial aid	
		by	Duration (years)	Amount ECU (7.12.79)	%	Amount ECU (7.12.79)
862	Monitoring of the ends in the rolling of thick plates	IRSID (+Ec.Mines)	3	347.000	60	208 200
881	Operation of reheating furnaces to minimize energy consumption and scale formation with continuous recording of furnace atmosphere composition and temperature by laser spectroscopy	CSM	2 1/2	410.000	60	246.000
902	Research on the closed-circuit control of a continuous annealing line by processing magnetic signals from the steel strip	Italsider	3	246.500	60	147.900
	MEASUREMENTS AND ANALYSIS					
773	Classification of round bar surface quality directly from a mill cooling bank	Round Oak	4	595.500	60	357.300
786	Surface inspection of continuously cast billets	BSC	3	384.500	60	230.700
817	Development of an industrial gauge for hot detection of surface defects on beams	CRM	3	434.500	60	260.700
852	Acoustic emission monitoring of steels and structures	(Risø	)	180.000	60	108.000
		(CSM	)3	294.000	60	176.400
		(Dan.Wel.In.	)	180.000	60	108.000
864	Ultrasonic detection of inclusions in sheet	IRSID	3	515.500	60	309.300
900	Improvement of quantitative micro-analysis of light elements in steel	(TNO	)2	109.500	60	65.700
		(Mannesmann	)	73.000	60	43.800
904	Non-destructive evaluation of residual stresses in steel	AERE	3	260.000	60	156.000
	PROPERTIES AND SERVICE PERFORMANCE					
	a) Weldability					
758	Research to obtain greater economy in the welding of high-strength steels	Inst.Soud.	2	103.500	60	62.100

Project N°	Title of the research	Proposed research			Financial aid	
		by	Duration (years)	Amount ECU (7.12.79)	%	Amount ECU (7.12.79)
759	Evaluation of the strength of spot-welded assemblies with a view to the drawing-up of design rules	Inst.Soud.	2	103.500	60	62.100
815	Risk of cold under-bead cracking and the welding of branches on gas pipelines	CRM	3	546.500	60	327.900
841	Fracture behaviour of thick-walled joints welded by various methods - Influence of bead width and stress-relieving	VDEh (+Univ.Stutt.)	3	565.000	60	339.000
866	Weldability of quenched and tempered steels obtained by direct quenching	IRSID	3	344.000	60	206.400
	b) Corrosion and surface protection					
810	Gas-metal reaction during basic annealing: influence on sheet surface cleanness	CRM	3	409.500	60	245.700
873	Study of the phosphate coating and corrosion behaviour of cold-rolled products of high strength low-alloy steel	Italsider	2	173.000	60	103.800
883	Neutral electrolytic pickling process for ordinary and low-alloy sheet. Process development on a pilot line to optimize the surface quality characteristics of products for various applications	CSM	2 1/2	346.000	60	207.600
885	Cladding of Zn-Al alloys. Development of the cladding process on a pilot line	CSM	3	311.500	60	186.900
901	Research on the corrosion behaviour of low-alloy steels under atmospheric and offshore conditions	VDEh	3	103.500	60	62.100
	c) Forming					
813	High strength multiphase steels for various types of flat products	CRM	3	372.500	60	223.500

Project N°	Title of the research	Proposed research			Financial aid	
		by	Duration (years)	Amount ECU (7.12.79)	%	Amount ECU (7.12.79)
814	Deep-drawing of very high strength steel sheets	CRM	3	449.500	60	269.700
	d) Constructional steels					
750	Measurement and interpretation of dynamic loads on bridges	Univ.Liège	2	53.500	60	32.100
765	"	Univ.Pisa	2	65.000	60	39.000
771	"	Lab.P.etCh.	2	91.500	60	54.900
778	"	T.R.R.Lab.	2	70.000	60	42.000
850	"	Lab.Bet.f.	2	121.500	60	72.900
868	Study on the fatigue behaviour of welds	)IRSID)Creusot-L.	)3)	146.500 146.500	60 60	87.900 87.900
891	Evaluation of the fatigue strength of welded, bolted and riveted connections in high strength low-alloy steel	S.S.N. (et al.)	3	200.000	60	120.000
903	Measurement and interpretation of dynamic loads on bridges	S.S.N.	2	109.500	60	65.700
	e) Fracture mechanisms					
844	Research into the influence of size on the working stress of notched specimens resembling structural members with varying material toughness	VDEh (+Univ.Stutt.)	3	356.500	60	213.900
884	Influence of microstructure and grain boundary segregation on the fracture toughness of Ni-Cr-Mo-V steels for low pressure rotors	CSM	3	313.500	60	188.100
	f) High temperature steels					
757	Effect of periods at maximum and minimum strain valves and of various strain levels on cumulative low-cycle fatigue damage in a 2 1/4 Cr 1 Mo ferritic steel at high temperature	I.R.Breda	2	190.500	60	114.300

Project N°	Title of the research	Proposed research			Financial aid	
		by	Duration (years)	Amount ECU (7.12.79)	%	Amount ECU (7.12.79)
848	Research into the tendency to work hardening in heat-resistant steels at elevated temperatures and its significance in the specification of safe working stresses for structural components with local stress concentration	VDEh (+Univ.Stutt.)	3	244.500	60	146.700
869	Influence of the forming on heavy plate properties	IRSID / Creusot-L.	3	350.000	60	210.000
	g) Light structures					
776	Study of connections between steel structures and horizontal or vertical masonry components	CISIA	2	35.000	60	21.000
798	Relationship between design of precoated steel cladding and its environmental behaviour in service	BSC	4	382.000	60	229.200
801	Development of recommendations for the design of welded joints between steel structural hollow sections or between steel structural hollow sections and H sections	BSC	3	156.000	60	93.600
		Dalmine		160.000		96.000
		Mannesmann		101.000		60.600
		Estel		141.000		84.600
		Cometube		52.000		31.200
887	Comparative technical and economic study of structural steelwork in the European Community, in North America and in Japan	CBLIA	2	335.000	80	268.000
	h) Alloy and special steels					
761	Case-hardening steels with grain size control using high-temperature thermo-chemical treatment	Breda Sid. (et al.)	3	259.500	60	155.700
772	Study and development of materials and fabrication processes to improve the performance of equipment for the hot shaping of steels	Dalmine	3	458.500	60	275.100
802	Conservation of strategic alloying elements selection and heat treatment of alloy steels	BSC	3	257.000	60	154.200

Project N°	Title of the research	Proposed research			Financial aid	
		by	Duration (years)	Amount ECU (7.12.79)	%	Amount ECU (7.12.79)
820	Influence of the chemical composition and other factors on the forgeability of cold-heading quality steels	GKN	3	262.500	60	157.500
882	Free-cutting graphite steels	CSM	3	389.500	60	233.700
894	The influence of texture on the fatigue properties of HSLA steels	Fiat	3	329.000	60	197.400
	MISCELLANEOUS					
754	Technical steel literature	Aselt	1	125.000	100	125.000
851	Research into steelworks slag, especially its use in road construction	(FEhS (Usinor (CRM (BSC	)))3)	250.000 250.000 81.000 252.000	60 60 60 60	150.000 150.000 48.600 151.200
	Sub-Total			32.389.500		19.550.700
	Ancillary costs and dissemination of information					510.100
	TOTAL			32.389.500		20.060.800