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MEMORANDUM

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

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M E M O R A N D U M

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

The research proposals on iron and steel outlined in this memorandum have been selected from a total of 172 that were submitted to the Commission of the European Communities requesting aid under Article 55, 2 (c) of the ECSC treaty. After a detailed examination by the services of the Commission in collaboration with the Iron and Steel Technical Research Committee, 71 proposals have been selected as first priority and constitute the ECSC research programme in the steel sector for 1981.

In examining the aims of the proposals and assessing their significance to enhancing the competitiveness of the steel industry particular attention has been given to requests concerned with the reduction of operating and production costs (including energy saving and energy substitution), with increasing the quality of steel products and with improving the performance of steels in service.

The technical content of the proposed programme covers various aspects of the production, processing and properties of iron and steel with the level of funding distributed as follows : ironmaking (5%); steelmaking (31%); rolling mills and mechanical working (12.4%); measurements and analysis (13%); properties and service performance (34.2); plant availability (3.6%).

In the production and processing sector of the programme, the need to achieve greater efficiency and flexibility in energy utilisation is again a major theme. Two projects deal with the development of technology that will permit non-coking coals to be more widely used as an energy source and, thereby, reduce oil and gaseous fuel requirements. This work will cover the injection of powdered coal into the blast furnace and into a modified basic oxygen furnace; this latter research will enable scrap consumption in integrated steel plants to be increased which has important economic implications. Other studies include effort directed at increasing the efficiency of the blast furnace as well as improving the productivity of continuous casting installations and the quality of the cast product. Progress on this latter area will lead to the more effective exploitation of continuous casting with the obvious benefits this will have for metal yield, energy economy and working conditions. In an effort to reduce capital costs and extend flexibility, research is proposed also on the development of the horizontal continuous casting of thin sections.

In the field of rolling mill technology, the opportunity to reduce energy consumption is the aim of a major study on hot strip production by optimising production scheduling rather than maximising productivity. Investigations relating to a reduction of width variations and better control of flatness in the hot rolling of flat products are also proposed.

The projects on measurements and analysis are concerned with the development of new and improved methods of quality assessment, chemical analysis and process control; the search for more accurate methods of detecting surface and internal defects in rolled products and quantitatively their size and distribution remains a major objective in this programme.

Technological developments on the properties and utilisation of steel are being increasingly influenced by processing and fabrication costs, concern for energy, product reliability and safety as well as the growing emphasis on conservation. Against this background, research is proposed on new welding techniques on the fracture characteristics of structural steels and the effect of welds and on the improved corrosion resistance of steels while a study is proposed to evaluate the opportunities for steel in the development of new coal utilisation technologies. Also, an extension is requested of a large Community programme to investigate further the corrosion fatigue properties of steels for offshore structure applications. The initial work, which ended in 1980, provided a wealth of information which is proving to be of value to steel producers, designers and inspectors of these large and complex structures; however, gaps have appeared in the data which have called for further experimental work.

Valuable opportunities to achieve cost-savings in production can be gained by improving plant maintenance methods and reducing the costs of this essential activity. Consequently, a new section has been introduced in the programme dealing with this field and three proposals have been submitted covering problems of wear, abrasion and erosion of steelplant and equipment as well as improving the reliability of cranes.

The financial aid for the 71 research proposals presented below amount to a total of 19.364.000 ECU.

II. THE RESEARCH PROJECTS

II - 1. ORE REDUCTION

Blast furnace

Projects P 1023 and P 1047 form a supplement to the Community programme of research on the cohesive zone in blast furnace that was initiated last year. The work scheduled in connection with Project P 1023 is concerned in particular with research into the permeability of the "dead man" in respect both of gases and of liquid constituents such as slag and pig iron. In the context of Project P 1047, the local reduction conditions at the level of the blast-furnace bosh are to be simulated and investigated. The two projects complement each other in that the former is more concerned with the physical and technical flow aspects, while the latter concentrates on

the chemical aspects. Projet P 1069 can be regarded as a preliminary study for a Community programme scheduled for next year on the "injection of solid fuels into the blast furnace". In this project, the maximum permissible particle size of the coal for the injection operation is to be determined with the aim of keeping the crushing costs as low as possible.

P 1023 : Investigations in the dead man and hearth of the blast furnace

A probe is to be constructed and tested which will make it possible to carry out core drilling into the centre of the blast furnace. It is then planned to inject marked substances at various points in order to determine the distribution rate. In addition, the force needed to insert the probe into the dead man is to be measured. Coke samples at various points from the periphery to the centre are to be removed and examined.

The investigations are to be carried out in a modern blast furnace loaded with high-grade ore and fitted with very efficient measuring devices.

Applicant : IRSID - St. Germain-en-Laye
Amount : 969.500 Ecu
Duration : 4 years

P 1047 : Effect of blast furnace burden distribution on radial reduction behaviour of iron-forming elements

Comparative investigations into the reaction kinetics of pasty or trickling iron-bearing constituents (sinter, pellets) and coke are to be carried out. The main objective here is to study the transport of C, S and Si from coke and slag into the metal. The ore/coke ratio is to be varied for this purpose within the range from 1 : 10 to 5 : 10 in order to simulate the conditions obtaining at the periphery and in the centre of the blast furnace. Further test parameters are degree of reduction and basicity of the ores.

It is planned to carry out laboratory tests on 500-g samples and smelting tests in the Tamman furnace on 10-kg samples.

Applicant : CSM - Roma
Amount : 390.000 Ecu
Duration : 2 years

P 1069 : Coal injection into the blast furnace

In this project, the intention is to determine the greatest particle size with which complete combustion can be achieved in the injection of coal dust into the blast furnace. Two test series are planned :

- (a) with a coal/oil slurry (40-70% coal),
- (b) with direct injection of coal (bituminous coal, anthracite).

The quantities injected are to be varied from 50 to 200 kg coal or slurry/tonne pig iron.

The work is to be carried out in a test furnace to be equipped with a blast furnace tuyere with a blast-air throughput of 50m³/minute.

Applicant : Estel-Hoogovens - Ijmuiden
Amount : 200.000 Ecu.
Duration : 1 year

II - 2. STEELMAKING

a) Casting and solidification

Approximately 31% of all the steel produced in the Community at the start of 1980 was continuously cast. Compared with Japan where the corresponding figure was 52%, this is very low. The Community lags behind Japan not only in capital investment but also in technology. In many cases the productivity of Japanese plants is better ; European firms are therefore buying Japanese know-how.

The research on continuous casting thus carries top priority. Four of the five proposed projects therefore relate directly to the improvement of continuous casting technology.

The following objectives are being pursued :

Project P 928 is concerned with the development of horizontal continuous casting. If success is achieved the capital cost of a continuous casting plant could be lowered by approximately 20%. In addition, steels which because of their strength at high temperatures can only be produced in the present state of the art by ingot casting (e.g. ledeburitic steels, tool steels etc.) could be made accessible to the continuous casting process. Projects P 982 and P 1055 are aimed at improving productivity and quality. Metallurgical and process technology measures which are important for the manufacture of products with better homogeneity and quality will be studied. Under project P 1055 an attempt will be made to produce a casting with stiffer solidification shell by means of modifications to the design of the mould. The aim of project P 1054 is to add certain easily oxidised alloying elements to the casting stream.

The work envisaged under project P 929 is aimed at improving the durability of slab-type ingot moulds, thereby lowering operating costs in ingot casting.

P 928 : Pilot plant process development for horizontal continuous casting of thin slabs

The purpose of a horizontal continuous casting process under development by the BSC is to cast slabs 500 mm wide and 75 mm thick (total 40 four-tonne casts). The research will concentrate on product quality. Some of the test casts will therefore be examined for structure, segregation and cleanness, others - after rolling - for their mechanical properties. Thus :

- the first five test casts will be carried out for machine commissioning,

- a further twenty test casts will be made to investigate the influence of casting rate (up to 20 m/min) and superheat on structure and segregation ;
- ten test casts will be made to investigate the influence of fluxes on cleanness and inclusions ;
- five test casts will be made to determine mechanical properties after rolling.

The steel grades involved are : C-Mn steels and low carbon Al-killed steels.

Applicant : BSC (Teeside Laboratories) - London
Amount : 723.500 Ecu
Duration : 3 years

P 929 : Establishment of design parameters for large slab-type ingot moulds

The various parameters for the production of slab-type ingot moulds - particularly modified graphite cast iron moulds - will be determined by measurement and calculation of temperatures and stresses under plant conditions. The temperatures will be measured by thermocouples, stresses will be determined by means of strain gauges and Thermovision equipment. Different mould design variants will be investigated. The abovementioned measurements will be supplemented by the metallographic examination of moulds withdrawn from service and by hot tensile tests at various temperatures. Stress and temperature distribution will then be described by the finite element method.

Applicant : BSC (Welsh Laboratories) - London
Amount : 229.000 Ecu
Duration : 2 years

P 928 : Influence of metallurgical and process engineering measures on solidification in the continuous casting of steel

This project comprises the following investigations :

- (a) process engineering measures for the improvement of continuous casting technology. In this connection, oxygen activity in billet and slab plants will be continuously monitored. The state of the mould will also be continuously monitored via the heat removed. A third measure will be to optimize the quantity of inert gas in shrouding tubes and immersion nozzles.
- (b) Metallurgical measures to influence solidification texture and technological properties. In this case the properties of flux powders will be determined in a testing procedure close to operating conditions with a temperature gradient. In addition, the interactions between deoxidation, steel composition, solidification cross section, cleanness and the technological properties of blooms and continuously cast billets on non-alloy and alloy special structural steels will be investigated. (Wire grades, case-hardening

steels, free cutting steels and quenching and tempering steels will also be covered by the research.)

- (c) Plant condition and solidification texture as parameters influencing internal defects in continuously cast slabs. The intention here is to determine interactions between the qualitative internal state of the casting and the mechanical condition of the plant. In addition the mechanism of crack formation (internal and external cracks) in continuous casting will be determined by simulation. The following steelworks and institutes are participating :

Estel-Hoesch AG, Dortmund
Krupp Stahl AG, Bochum
Krupp Südwestfalen AG, Siegen
Mannesmann-Forschungsinstitut GmbH, Duisburg
Stahlwerke Röckling Burbach GmbH, Völklingen
Thyssen AG, Duisburg
Hamburger Stahlwerke GmbH, Hamburg
Technische Hochschule Aachen, Aachen
Technische Universität Clausthal, Clausthal
Max-Planck Institut für Eisenforschung, Düsseldorf

Applicant : VDEh - Düsseldorf
Amount : 2.706.500 Ecu
Duration : 3 years

P 1054 : New methods of alloying steel in continuous casting

Within the context of an earlier project, a technology had been developed and tested by the applicant to reduce steel overheating in the mould by the addition of metal powder. Under this project, the iron powder will be replaced by alloying elements which will be added in the mould in a similar manner. Further additions of metal powder alloyed with Al, Ti and B will be made. The metering technique will be developed

- for casting with an open casting stream, and
- for casting with immersion nozzles.

The steel specimens will first be melted in a 200 kg induction furnace and subsequently in a 1.500 kg induction furnace at the CSM ; they will then be processed in the institute's pilot plants.

Applicant : CSM - Roma
Amount : 367.000 Ecu
Duration : 2 years

P 1055 : Corrugated-wall mould for the continuous casting of slabs

In order to improve the surface quality of continuously cast products - particularly with regard to the occurrence of surface cracks - a slab - type mould will be developed equipped with vertical corrugations. The risk of longitudinal cracks occurring is known to be particularly high in very low carbon steels or in stainless steels of type AISI 304, i.e. in steels with a high tendency to shrinkage. The design modification in the

mould will provide a solidification shell with a stiffening rib which will reduce susceptibility to cracking.

Applicant : CSM - Roma
Amount : 652.000 Ecu
Duration : 3 years

b) Steelworks - metallurgy

Projects P 975, P 1021 and P 1025 are aimed at improving the exchange of material between slag and metal in the basic oxygen converter to achieve better crude steel quality. In the context of projects 1021 and 1025, selected phases of the refining process such as silicon removal, desulphurization and dephosphorization will be separated in space and time. The efficiency rates of the individual processes will be increased thereby. In Project P 978 scrap or sponge iron will be melted in a converter with the use of solid coal fines as an energy carrier.

P 975 : Physical properties of slag used in basic oxygen steelmaking

The thermodynamic data of LD slags which have not yet been documented - viscosity, density, surface tension, conductivity, etc. - will be collated in a form in which they can be easily used by the steelmaker and will be published in the form of a handbook.

Applicant : NPL - Teddington
Amount : 103.500 Ecu
Duration : 2 years

P 978 : Development of the Klöckner steelmaking process. Construction and operation of a prototype

The separate process stages of preheating and melting of scrap (or sponge iron), afterburning of refining gases and injection of solid carbon carriers will be combined in a single reaction vessel. For this purpose, a 125-tonne prototype plant will first be built. The construction of the plant does not form part of the research project. After its completion, tests are planned in which a liquid sump of molten iron will be charged. Subsequently only solid iron-bearing materials will be charged; these will be heated by natural gas/oil-oxygen burners in a preheating phase. When a liquid metal bath has formed, the system will be switched to carbon injection. Investigations will extend to the metallurgy of the process, energy consumption, refractory wear, process control and ergonomic problems.

Applicant : Klöckner Werke AG - Duisburg
Amount : 2.467.500 Ecu
Duration : 2 years

P 1021 : Low-slag refining in the LD converter

The hot metal will be pretreated between blast furnace and converter so that refinement in the converter can take place with smaller quantities of slag. The following advantages are expected from this: increase in production,

Lower material input and material losses, less refractory wear and better process control.

The following variants will be investigated :

- silicon removal in the LD converter (normal operation)
- silicon removal in the torpedo ladle or charging ladle
- silicon removal in the tapping launder
- dephosphorization and desulphurization of the hot metal after silicon removal in the ladle.

The individual variants will then be investigated for their economic efficiency. The tests will be conducted during normal operation.

Applicant : Krupp Stahl AG - Bochum
Amount : 966.500 Ecu
Duration : 3 years

P 1025 : Pre-refining of haematite pig iron

The programmes for this project and the preceding one (P 1021) are coordinated with one another.

The various possibilities of pre-refinement will be tested and assessed in laboratory and in semi-industrial trials. These tests should enable :

- the additives to be selected,
- their quantities to be determined,
- equilibria to be determined,
- temperature influences to be determined,
- refractories to be selected and
- the temperature balance to be drawn up

Applicant : Insid, St. Germain-en-Laye
Amount : 741.000 Ecu
Duration : 3 years

c) Steelworks - technology

The only project in this sector is P 933. Its aim is to develop an easily installed auxiliary heating system for electric arc furnaces. The advantages expected from this form of auxiliary heating are :

- a reduction in noise levels,
- greater electrical stability,
- lower electrode consumption.

P 933 : The use of plasma guns for auxiliary heating in an electric arc furnace

The oil burners used for auxiliary heating, will be replaced by plasma guns; one of these is to be mounted initially for trials in a 500 kg experimental furnace.

The schedule for the test programme is as follows :

- selection of plasma gun (output approx. 1.400 kW)
- melting tests with various types of scrap
- measurement of electrical and heat transfer efficiency
- repetition of tests in a larger electric furnace operated with one central electrode
- technical and financial assessment for installing plasma guns in UHP furnaces

Applicant : BSC (Sheffield Laboratories) - London
Amount : 274.500 Ecu
Duration : 2 years

d) Refractories

P 1053 is the only application concerned with this field. The use of CaO bricks as a refractory material has not hitherto been possible owing to their intensely hygroscopic behaviour. The applicant has succeeded in producing a stabilized CaO sinter which does not possess this undesirable property. The aim of the project is to test a CaO lining of this type in an industrial refractory system.

P 1053 : Use of calcium oxide as a refractory material for the lining of ladles for refining outside the steel furnace

Refractory bricks will be produced from a stabilized CaO sinter. The material will be compacted into bricks using tar as a binder. A ladle will be lined with these bricks and tested. It is hoped in particular to be able to reduce exogenous inclusions of the MgO-Al₂O₃ spinel type.

Applicant : CSM - Roma
Amount : 473.000 Ecu
Duration : 2 years

e) Theoretical steelmaking

Deoxidization and desulphurization with Ca have taken on increasing importance in recent years. In particular, Ca is being used to an increasing extent in the production of free cutting steels. While a number of techniques have been developed, concerned specifically with the aspect of alloying, there remain considerable gaps in the basic thermodynamic science.

P 981 : Optimization of desulphurization and inclusion formation in the calcium treatment of steel melts

Thermodynamic data for reactions between Ca, O and S in non-alloy and alloy steels which have not yet been determined will be documented with the aim of optimizing the Ca treatment of steel. The following studies are planned for this purpose :

- determination of Ca solubility in pure iron at different pressures
- determination of Ca solubility in Fe alloys (C, Si, Mn, Cr? Ni, Al)

- Investigation of the reactions of $Ca + O$ ($Ca + S$) in pure iron and Cr-Ni alloys.

The studies will be conducted in the laboratories of the MPI.

Applicant : VDEh - Düsseldorf
Amount : 237.500 Ecu
Duration : 3 years

II - 3. MECHANICAL WORKING

a) Hot rolling mills-long products

The aim of Project P 936 is to study the individual factors responsible for the occurrence of end splitting in the rolling of free cutting steels.

The aim of Project P 984 is to increase rolling speeds on wire mills rolling medium and high alloy steels by improving the temperature control concept.

P 936 : The cause of end splitting during the rolling of free cutting steels

To begin with all factors which influence these special rolling defects, such as reheating conditions, stocksection size, roll and stock water cooling, reduction sequence and interpass delays will be studied. In this first phase, the tests will be carried out on an experimental mill using normal commercial steels.

The special influences of alloying elements (sulphur, lead, bismuth) and special casting and solidification conditions will then be investigated.

Studies will be conducted in parallel on hot workability. Finally a model will be developed to describe the local stress and strain distribution patterns in the roll gap under different stock/reduction sequences.

Applicant : BSC (Sheffield Laboratories) - London
Amount : 267.500 Ecu
Duration : 2 years

P 984 : Rolling of high alloy steels on wire mills at higher rolling speeds

Formability, temperature conductivity, heat transfer values, recrystallization behaviour and resistance to deformation will be determined for various groups of special steels. These data will then be used to derive.

- cooling conditions during rolling (phase of cooling and cooling line length),
- rolling speeds, and
- position and length of temperature equalizing lines.

It will then be possible to achieve a better definition of the distances between stands and the length of cooling lines required for new rolling mills..

The temperature control concepts developed will be tested operationally on the special steel mills of Thyssen Edelstahlwerke and Krupp Südwestfalen.

Applicant : BFI - Düsseldorf
Amount : 549.000 Ecu
Duration : 3 1/2 years

b) Hot rolling mills - flat products

Rolling sequences and rolling programmes are normally geared to maximum production. Under project 963, programmes will be organized to ensure minimum energy consumption. This will enable energy costs to be kept to the lowest possible levels, particularly when the mill is not being used to full capacity.

The aim of the three other projects is to secure improvements in process control. Under Project P 1030, a closed-circuit control system will be developed to improve flatness control of hot-rolled wide strip. Flatness measurement, roll deflection, roll separating force and the flatness values of the preceding stand will be included in the control circuit. The main objective of Project P 1032 is to reduce width fluctuations on roughing trains. This will reduce material losses caused by overwidths. Under Project P 1056 an attempt will be made to include structural transformation phenomena in the control of the rolling process and in this manner to secure optimum material properties in the mill products.

P 963 : Crisis pacing method for a wide strip mill

Optimum holding times in soaking pits will be coordinated with optimum material temperatures in primary and finishing mills in such a way as to secure minimum energy consumption.

For this purposes a process control programme will be developed to cover the following data :

- thickness, width and weight of the slab and grade of steel;
- the data for the finished product (thickness, width, shape, final rolling temperature and coiling temperature of hot strip);
- the costs per unit of electrical and thermal energy;
- any bottlenecks in soaking pits, primary mill and finishing mill.

Two pairs of data will be combined in each case, e.g. slab thickness, strip thickness and minimum temperature interval.

Applicant : CRM - Liège
Amount : 922.000 Ecu
Duration : 4 years

P 1030 : Flatness control on the hot strip mill

To begin with it is intended to develop a theoretical model for flatness in which the roll profile, roll separating force and back-up roll bending will be taken into account. With the aid of this model, flatness will be

monitored and controlled in line in the transverse direction. A flatness-measuring instrument fitted six metres after the last rolling stand will be used for measurement sensing.

In the industrial part of the research, the effect of back-up roll bending on the rolling stand will also be investigated. It is expected in addition that the tests will show at which stand (the last or last but one) it would be most appropriate to install a back-up roll bending control device.

Applicant : Irsid - St. Germain-en-Laye
Amount : 498.500 Ecu
Duration : 3 years

P 1032 : Width control in the roughing stand of the strip mill

Width fluctuation in primary mills will be analysed to provide a better understanding of the phenomenon. For this purpose :

- theoretical and experimental studies will be carried out on malfunctions in vertical stands ;
- a rolling model will be developed for vertical and horizontal stands taking into account temperature gradients in the slab and tensile stresses between successive stands ;
- the model will be verified in a simulation plant using plasticine ;
- the results will be compared with those from operational tests ;
- the model will be tested in an industrial plant.

Applicant : Irsid - St. Germain-en-Laye
Amount : 690.500 Ecu
Duration : 4 years

P 1056 : Sheet mill microstructural phenomena control system

The kinetics of microstructural transformations will be studied in a new control model to be developed. The research will be divided into the following stages :

- development of the "microstructure" model ;
- inclusion of the microstructure model ;
- in a normal rolling model ;
- on line tests in operation.

The tests will be carried out on two grades of steel (C-Mn steels and Nb or V micro-alloy steels). The model will provide quantitative data on the connection between microstructure parameters and rolling parameters (time, temperature, degree of reduction etc.).

The laboratory rolling tests and hot tests in the laboratory will be carried out at the CSM; the operational tests at Italsider in Taranto.

Applicant : CSM - Roma
Amount : 517.500 Ecu
Duration : 3 years

c) Rolling mills -various

The aim of projects P 925, P 940 and P 1007 is to reduce roll wear and hence increase service life.

Various production and operating parameters having a direct influence on roll wear will be investigated and quantified. In addition, an attempt will be made to resurface rolls by means of the plasma clad-welding process and to enable them to be recycled.

Apart from on-line inspection, the on-line improvement of possible surface defects is one of the principal requirements for a hot connection between continuous casting plant and rolling mill. Trials on the latter will be carried out under Project P 938.

P 925 : The influence of manufacturing variables on the wear characteristics of hardened steel rolls

Investigations will be carried out to determine the influence of variables during the manufacture of hardened rolls :

- (a) on the surface finish imparted by grinding and grit blasting and
- (b) the rate at which the finish is lost or changed during use.

The factors to be evaluated are : hardness, alloy content, microsegregation, retained austenite, carbides crystal orientation, hardening method and heat treatment.

The study will be carried out on test products from 20 kg casts.

Applicant : Brown Firth Research Laboratories - Sheffield
Amount : 356.000 Ecu
Duration : 3 years

P 940 : The use of hi-chrome rolls in cold tandem and temper mills

The research programmes for Projects P 925 and P 940 have been coordinated with one another.

The aim of the research is to obtain the maximum benefit from and to quantify the advantages of hi-chrome rolls for the production of cold rolled narrow strip.

- (a) In the processing of the rolls particular attention will be devoted to the study of the parameters governing final roll surface texture. These parameters are :

- for the grinding of the rolls : rotation speed, speed of traverse and type of grinding wheel etc.
- for shot blasting : shot size, hardness, roll rotation, etc.

- (b) In the operation of the rolls, roll speed, reduction, ingoing and out-going strip textures will be logged. Relationships will be sought between roll roughness on the one hand and strip texture and roll durability on the other hand.

Conventional and hi-chrome rolls will be compared. The operational tests will be carried out in the last stand on a five-stand tandem mill and in a temper mill.

Applicant : BSC (Welsh Laboratories) - London
Amount : 202.000 Ecu
Duration : 2 years

P 1007 : Cladding of rolling mill rolls by plasma arc welding

Ni-Cr-B-Si alloys will be deposited on rolls with the aid of a plasma arc welding machine. The choice of the welding process will make it possible to deposit the layers with sufficient evenness to obviate the need for any subsequent treatment.

Rolls for the following plant will be treated in this way :

- intermediate stands for heavy beams
- finishing stands for narrow strip.

The welding parameters, dilution of weld metal by the base metal and the granulometru of carbides will be investigated.

Finally, wear measurements will be carried out on the clad rolls.

Applicant : Arbed - Luxembourg
Amount : 435.000 Ecu
Duration : 3 years

P 938 : Metallurgical study of in-line hot scarfing

A method of surface improvement of rolled products billets in in-line operation will be developed.

The research will cover the effects of :

- carbon content ;
- the various alloying constituents ;
- low melting constituents (particularly in free-cutting steels).

The method will take into account the liquidus and solidus lines of the steel concerned together with the viscosity and the reaction products formed.

The tests will be carried out on a pilot plant. In view of the rate of traverse of the stock (approximately 100 mm/sec) automatic recording of the operation will be necessary.

The investigation will be based on billets of 100x100 mm² section.

Applicant : BSC (Sheffield Laboratories) - London
Amount : 302.500 Ecu
Duration : 3 years

II - 4. MEASUREMENTS AND ANALYSES

The overriding aims of the great majority of the projects submitted are to improve quality and to increase profitability. One of the most important aspects in an integrated production complex is to reduce costs, while at the same time improving the quality of the product, either by a wide variety of analyses or by means of non-destructive tests. This entails systematized control at each stage of the steel production process or, alternatively, automation. Furthermore, the constant activity in this sector is the result of the development of ever stricter standards and specifications. However, it is now noticeable that advances in the processes for the continuous casting of steel, for example, are accompanied by changes in the criteria governing the internal constitution of iron and steel products, and this services to illustrate the desirability of a number of the research projects concentrating on these aspects.

Another aspect to be considered concerns the need for high-speed analyses (quantitative determination of a greater number of elements) in an extremely diversified range of materials, as a result of the ever increasing demand for high-quality and high-purity steels and, above all, for the recycling of raw materials. Work of this kind is planned under a number of projects, in order to meet the demand.

In the final analysis, it should be borne in mind that non-destructive testing is an important and booming area of activity the economic impact of which cannot be neglected. For example, in the field of radiography (X, γ) digital methods under investigation will ensure that a greater number of higher-quality tests can be carried out more economically and more quickly.

P 906 : Analysis of trace elements in iron and steel materials by direct flameless atomic absorption on solid samples

The aim of this research is to study the feasibility of atomic absorption spectrometry with a heat-atomization source (graphite furnace) for the direct determination of solid samples. The elements considered will be atomizable and present in steels, alloys, ferro-alloys and, as a general rule, all materials relevant to the iron and steel industry.

This work is a sequel to earlier research, where a basic framework was established under Contracts 7210-GA/315 and GA/407. These coordinated activities will be conducted jointly by three laboratories :

- Arbed, Luxembourg ;
- CSM, Rome ;
- Creusot-Loire, Unieux.

Applicants : Creusot-Loire - Unieux
 CSM - Roma
 Arbed - Luxembourg

Amount : 297.000 Ecu
Duration : 2 years

P 907 : Quantitative assessment of X-ray control methods in steel metallurgy by the digital processing of radiographs

Industrial radiography is a technique which is taking on an increasing importance in steel and product quality control.

The proposed research will be carried out in four laboratories with a view to determining the use of methods of digital processing and shape identification by X- and γ -rays, in order to remove the subjective element associated with visual testing (essential conditions for the development of the complete automation stage in this control process).

The field of application covers three distinct aspects :

- 1) radiography (X-rays);
- 2) Co^{60} and Ir^{192} γ -radiography;
- 3) autoradiography.

Thick test-pieces will be used : forging ingots containing defects (artificial and natural) or sections of slabs or blooms labelled with a radioisotope (antiradiography). The digital methods developed in this way will ensure that a greater number of higher-quality tests can be carried out more economically and more quickly.

Applicants : Insa - Lyon
 Creusot-Loire - Le Creusot
 Framatome - Châlon s/Saône
 Insid - St. Germain-en-Laye

Amount : 565.500 Ecu
Duration : 3 years

P 920 : Study of the solidification structure of slabs using ultrasonic methods

In the case of continuous casting plants, the need for immediate process control by testing the structure of the semis (ingots, slabs, billets) calls for an appropriate form of test. The elaboration of such a test is the object of the proposed research. Research and development aimed at evolving a method and the accompanying equipment will demonstrate the potential for studying solidification structures by ultrasonic techniques and comprehensive computer-processing. This research will cover two stages :

- 1) Laboratory studies to verify the usefulness of this new method on the basis of conventional macrographic comparisons. Tests for "on-line" use.
Programme for the computer-processing of the data recorded.
- 2) In-situ study of 150 sections of miscellaneous cast slabs (50x250x 2000 mm).

Comparison of the results obtained by the following three methods :

- macrography;
- sulphur prints;
- ultrasonic macrography.

Applicant : Italsider - Taranto
Amount : 326.500 Ecu
Duration : 3 years

P 945 : Further developments in continuous on-line measurement of gauge profile of hot strip

Under ECSC Contract 7210-GA/806 the BSC laboratories carried out work aimed at the on-line measurement of profile of hot strip, with a view to developing a theoretical specification. The proposed objective of this research is to ensure the logical continuity of this work on an industrial site (Port Talbot Works), so as to demonstrate the potential of on-line measurement of profile of hot strip and to highlight the advantages and disadvantages of on-line measurement.

Applicant : BSC (Port Talbot) - London
Amount : 178.500 Ecu
Duration : 1 year

P 946 : The analysis of slurries and powders by inductively coupled plasma spectrometry

A coordinated project involving four beneficiaries was executed under the ECSC Contracts (7210-GA/114, GA/208; GA/313; GA/805) with a view to studying inductively coupled plasma spectrometry for the iron and steel industry. The aim of this project is to ensure the continuity, as it were, of this work with particular reference to research on specific applications. The object will be the development of techniques to inject powder directly or in the form of a slurry into an inductively coupled plasma and to develop calibration and analytical procedures to convert the optical spectra produced into analytical results.

Applicant : BSC (Teeside Laboratories) - London
Amount : 203.000 Ecu
Duration : 3 years

P 972 : Improvement of analytical methods using plasma torch spectrometry

An important research project has been financed by the ECSC with the aim of developing methods for the application of inductively coupled plasma spectrometry to the iron and steel industry. The additional coordinated work has been carried out by four beneficiaries (Hoesch, BSC, Irsid and CRM).

On the basis of the results obtained, it is planned under this project to study a single "synthetic" standard solution containing the maximum levels of all the elements, so as to ensure the rapid calibration of the ICP spectrometers and to secure all the potential advantages which this method offers.

The study will deal with the production and preparation of a "synthetic solution" for the quantitative analysis of certain elements and with the definition of the exact composition of the calibration solutions to be used in the analysis of steels, cast iron, ores, sinters, slag dusts and ferro-alloys.

On the basis of the results, a compensating mathematical model could be drawn up.

Applicant : CRM - Liège
Amount : 166.500 Ecu
Duration : 2 years.

P 973 : Development of a prototype gauge for hot detection of internal defects in concast steels

The continuous casting of steels requires frequent specific checks. The main concern of the steel producers is the state of the surface and the distribution of defects within the mass of the material. The obstacle to be overcome is the temperature slightly in excess of the Curie point. In the course of earlier research (ECSC Contract 7210-GA/2/207) the CRM studied and developed a principle of observation based on the so-called ENA (electromagnetic acoustic) technique, which is less sensitive to the effects of the temperature emitted. The aim of this proposed project is to apply previously acquired knowhow to the task of producing, designing and bringing into service a prototype industrial gauge for the contactless detection of defects in continuous castings. This covers both slabs and blooms of various steel grades when these products are still in the casting machine. The work will conclude with the setting-up of an industrial system which will be placed at the disposal of the plants.

Applicant : CRM - Liège
Amount : 337.500 Ecu
Duration : 3 years

P 988 : Ultrasonic defect differentiation using the PPE method

With current ultrasonic monitoring techniques, the extent of the defects is evaluated exclusively on the basis of the amplitude of the reflected echo. The aim of this project is to apply a new method developed by the BFI, Düsseldorf and commonly referred to as the PPE (Pulsart Phasenlage-Echodynamik) process.

The study will deal mainly with the ultrasonic examination of steels aimed at detecting all harmful defects such as cracks, blow-holes, inclusions and other discontinuities. Similarly - and this is the major objective - an attempt will be made to differentiate defects by assessing the phase relationship, and more particularly the polarity of the pulses received by the various reflectors. All of the work will be carried out on samples incorporating artificial and natural defects. The validity of the results will be compared by prior X-ray examinations and a metallographic destructive test will then be carried out.

Applicant : BFI - Düsseldorf
Amount : 479.500 Ecu
Duration : 3 years

P 1008 : Control of beam rolling tolerances

Appropriate techniques must be evolved for the control of rolled-beam tolerances, and in particular for the measurement of the web and flanges. Under the proposed research it is planned to study and develop a basic process for the application of a γ -ray source. A system of measurement and control will be set up which will be capable of indicating to within $\pm 0.5\%$ the thicknesses of the beams during rolling.

After finalization in the laboratory, series of tests will be carried out in situ on an ARBED beam mill. Irrespective of the validity of the method, these tests will also make it possible to test the reliability of the equipment, including the electronic components, under mechanical and thermal rolling stress conditions.

Applicant : Arbed - Luxembourg
Amount : 472.000 Ecu
Duration : 3 years

P 1009 Automatic control of steel level in the continuous casting mould

The automatic control of the steel level in the continuous casting mould is dictated both by the surface quality requirements of the semis and by the need to reduce casting incidents resulting from manual operation. Under the research project, Arbed is planning to carry out a comparative study on two types of sensor :

- sensor employing capacity-measurement techniques;
- sensor employing induction-measurement techniques.

Optimization will be carried out in the laboratory where the control system will be adapted for use in conjunction with microprocessors, in order to control the casting stream or the rate of withdrawal of the strand.

After a choice has been decided on, a prototype appliance will be produced of a more or less universal type suitable for fitting to any kind of continuous casting machine mould.

Applicant : Arbed - Luxembourg
Amount : 202.500 Ecu
Duration : 2 years

P 1033 : Surface defect detection on hot semis using Eddy currents

In the course of earlier projects Insid has developed a method for the hot and cold detection of surface defects in steels using the Eddy-current technique.

Under this project it is planned to transpose the two industrial techniques for the detection of surface defects.

- a) Transposition of the multifrequency surrounding-coil technique for the hot testing of wire rod to the hot testing of billets with lateral dimensions of between 80 and 120 mm.

- b) Transposition of the so-called "multiprobe" technique for the cold testing, by means of Eddy currents, of rails and billets to the hot testing of continuous castings.

Once the problems have been solved both in terms of physical principles and at the technological level, a prototype appliance will be developed. Tests will be carried out at an industrial site on :

- a billet mill;
- concast slabs;
- concast semis.

Applicant : Insid - St. Germain-en-Laye
Amount : 551.000 Ecu
Duration : 3 years

P 1035 : Automation of non-metallic specimen preparation for atomic absorption and plasma torch analysis

A previous research project carried out by Insid as part of an ECSC programme (Contract No 6210-GA/3/307) led to the development of a device marketed under the designation PERL'X.

The research with which we are concerned here is based on the results of that work and will be devoted to the design and construction of a device to dissolve non-metallic specimens. The method and the principles to be applied will be derived from PERL'X : high-frequency heating, stirring during the entire melting operation and casting. Subsequent automation of the system will facilitate rapid analysis and immediate production control feedback.

Applicant : Insid - St. Germain-en-Laye
Amount : 121.500 Ecu
Duration : 3 years

P 1058 : Identification of inclusions and surface states in cold rolled products by photo-acoustic spectrometry

Present real-time inspection of the surface quality of cold rolled products (thickness, composition, phases, inclusions, deposits and other defects) is inadequate. The aim of this study is to fill the gap by making use of the principles of photo-acoustic spectrometry (PAS). The task will be to define the scope and quality of information supplied by the PAS technique at the level of surface layers. The initial work will be done in the laboratory. The experimental results will be evaluated with a view to the possible development of devices and analytical methods for industrial inspection procedures. Industrial-scale tests will be carried at several Italian works with which the CSM in Rome has regular contacts.

Applicant : CSM - Roma
Amount : 208.000 Ecu
Duration : 2 1/2 years

II - 5. PROPERTIES AND SERVICE PERFORMANCE

In the climate of the present economic difficulties, research covering the field of "Properties and service behaviour of steels" as far as the products are concerned, is being directed, towards three main objectives :

- safety
- service life
- reduction of overall cost

both from the point of view of component fabrication and from that of component assembly and maintenance of structures during service.

These concerns are reflected in the various projects to be undertaken under this programme, details of which will be found under the appropriate headings. The programme covers research on :

- weld quality and reduction in the cost of weld production by the development of automation, with due regard to minimizing the cost of inspection and acceptance procedures;
- base metal quality. The main concern here is to optimize purity for special applications, but with attention devoted to economizing on strategic alloying elements;
- the surface condition of thin sheet, which has a strong influence on forming and coating operations; these are of concern to the users and their economic aspect is not to be overlooked;
- the development of new products to meet the requirements of special applications, such as pipelines, marine structures, technologies for new and replacement energies;
- the popularization of knowledge in the field of continuously cast plate and in that of structural steelwork, the latter involving the supply of straightforward mathematical models to small undertakings;
- the real needs of users; a step has been taken towards researching this field, for example in the automotive sector.

It is interesting to note that the work proposed will result in concrete developments which may find applications in the near future among constructors. This testifies to the dynamism of the research workers in contributing in an increasingly direct manner to the task of bringing about a recovery in the Community steel industry.

a) Weldability

P 991 : Influence of aluminium and nitrogen on relaxation brittleness of weld-simulated refractory fine-grained structural steels during stress relieving

The programme of tests envisaged is intended to further our knowledge of the

metallographic causes of cracking, taking account of the interaction of aluminium and nitrogen. These tests will serve as a basis for the development of selective measures designed to ensure the reliable and economic production and heat treatment of these steels which, given the present state of the art, are still regarded as susceptible to cracking. Furthermore, the safety of welded structures will be enhanced as a result. In this way it would be possible to reduce the cost of the acceptance tests and of repairs to the cracked zones of the heat affected zone of welds on these low-alloy structural steels.

Applicant : Technische Universität Braunschweig - Braunschweig
Amount : 179.000 Ecu
Duration : 3 years

P 995 : New techniques for joining steel

With a view to drawing up practical rules for the low-temperature diffusion bonding of ferritic steels (thereby avoiding the incidence of metallurgical defects during the joining process and the need for heat treatment after joining, it is planned to carry out the following tests on the basis of the results obtained during the first stage of the research:

- examination of the possibilities of carrying out friction joining at temperatures below 600°C;
- preparation of the interface;
- development of surface analytical techniques over a higher temperature range (600-700°C).

Applicant : Welding Institute - Cambridge
Amount : 103.500 Ecu
Duration : 1 year

P 998 : Welds in high-strength structural steels of the type StE460

This research is divided into two main parts:

- comparative examinations on the influence of the welding configuration on the effects of heat retreatment as regards the multipass welding of steels containing the crystallization agents V, Ti or Al;
- comparative examinations on the choice of products for welding these steels;

A joint study of these two problems can provide a secure basis for a general assessment of the ductile properties of welds in StE460 steel and facilitate an appropriate choice of filler for each base metal and an appropriate choice of welding powders in the event of submerged arc welding. As a result, it will be possible to ensure greater safety in the use of this steel and hence promote the future applications thereof.

Applicant : Bundesanstalt für Materialprüfung - Berlin
Amount : 277.500 Ecu
Duration : 2 1/2 years

P 1038 : Metallurgical study of molten metal in automatic welding under solid flux

Earlier work has demonstrated the fundamental role of welding flux on the properties of molten metal in the two-pass welding of 20 mm-thick CMnNb steel plate. The aim now is to :

- interpret the effects of the oxygen, boron and titanium already observed;
- evaluate precisely the role of certain elements attributable to the plate and the wire, taking into account the basic effects of the flux;
- monitor the pattern of these results with regard to stress relief treatment;
- examine the role of the welding flux and wire with regard to the significantly different circumstances associated with multipass welding under solid flux.

Applicant : Insid - St. Germain-en-Laye
Amount : 368.500 Ecu
Duration : 3 years

b) Corrosion and surface protection

P 969 : Suitability for pickling of hot-rolled strip

It has already been shown in the course of earlier work that the surface of pickled strip does not consist exclusively of a simple layer of hydrated oxide of iron. Accordingly, the presence of significant enrichments involving residual elements such as copper, nickel, arsenic, antimony and tin have been detected on the surface of pickled strip. The aim of the present study is twofold :

- to carry out a quantitative examination of the formation of these residual element enrichments, while at the same time differentiating between hydrochloric and sulphuric pickling processes. In particular, the role of the inhibitors will be studied.
- to determine the importance of this phenomenon as regards subsequent stages in the transformation of the product.

Applicant : CRM - Liège
Amount : 366.500 Ecu
Duration : 3 years

P 996 : Influence of alloying and accompanying elements on steel corrosion and hydrogen absorption

The effects of various additions of alloying elements such as Cu, Ni, Cr, Si, Mn and Sn on hydrogen absorption by a non-alloy steel in the presence of acid electrolytes must be checked in relation to the pH and also in

relation to the H₂S content added to the electrolyte. Steps must be taken to determine what kinds of metallurgical, hot-rolling and chemical pickling operations and what kinds of heat treatment or attack by a corrosive agent cause or make possible on surfaces the enrichment of the alloying elements under investigation. Surface enrichments must be determined by Auger electron spectroscopy. For experimental purposes steel test-pieces will have to be surface-enriched with elements which may have a pronounced effect on the absorption of hydrogen by the steel. A study will be made of the mechanism whereby copper, among other things, affects the hydrogen absorption phenomena.

Applicant : MPI - Düsseldorf
Amount : 309.500 Ecu
Duration : 3 years

P 1070 : Corrosion testing of automotive steel products

The aim of this work is to develop new tests from actual measurements of the corrosive conditions in vehicles in operation. The study will taken in the following points :

- analysis of microclimates at different points on vehicles in operation;
- simulation tests in the laboratory involving the reproduction of these microclimates and study of their effects on products displaying various surface conditions;
- optimalization of the simulation tests to define new test methods and recommended codes of practices;
- more generally, research on the development of corrosion mechanisms in automotive vehicles.

Applicant : Estel-Hoogovens - IJmuiden
Amount : 447.500 Ecu
Duration : 3 years

c) Formable steels

P 1041 : Transfer of roughness during skin passing

The aim of this study is to define, both theoretically and empirically, the transfer of roughness from the roll to the sheet, taking account of the various rolling parameters, e.g., speed, thickness, reduction, radius and roughness of the rolls.

The surface microgeometry of the steel sheet is one of the main parameters governing its use. Its roughness, which should be in keeping with its subsequent use, is usually conferred on it during skin passing. The following aspects will be studied :

- roughness of the surface before and after skin passing;

- simulated rolling by means of the double-stamping test;
- effects of the parameters associated with the sheet, dies and rolling conditions;
- tests on pilot and industrial rolling mills.

Applicant : Irsid - St. Germain-en-Laye
Amount : 417.000 Ecu
Duration : 3 years

P 1049 : Tests on the formation and decomposition of iron carbides in the annealing of cold-rolled products

The theory that the formation of graphite deposits (preventing subsequent surface treatment) during the annealing of sheet is attributable to the formation and decomposition of iron carbides does not appear to be valid. Apparently, account must be taken not only of the cementite but also of the iron carbides which form and decompose between 200 and 500°C. The aim of this research is to examine the phenomena which may cause graphite deposition and to make a special study of the possible formation of metastable carbides during the rolling and annealing processes, with specific reference to the conditions conducive thereto.

Applicant : CSM - Roma
Amount : 196.500 Ecu
Duration : 2 years

d) Constructional steels

P 990 : Influence of segregations during continuous casting on material properties

For technological and economic reasons, the production of steel by the continuous-casting process is constantly on the increase. In order to widen our knowledge of the properties of this type of steel, to convince users of the advantages of the product thus obtained and hence extend its range of application, steps should be taken to remove certain reservations which still persist. It is essential that objective data be compiled, in order to demonstrate to the producers and users the limits of the influence of segregations. This is the aim of the research. The work envisaged should cover not only alloy and non-alloy steels already obtained by continuous casting but also stainless steels. Apart from analysing the current status of knowledge of the influence of segregations, this research will be seeking to examine the following aspects : chemical analysis, structure, hardenability, mechanical and technological performance, welding, formability, machinability and corrosion.

Applicant : VDEh - Düsseldorf
Amount : 1.270.000 Ecu
Duration : 3 years

P 1000 : Extending the use of high-grade steels for cyclically-stressed structural components by the provision of reliable data

Little is known of the cyclical-stress resistance of the high-grade steels

currently available which offer major economic advantages as far as the steel industry is concerned. These steels are being used on an increasing scale in the light construction sector for the production of cyclically-stressed components. Consequently, there is a need for reliable parameters which, in view of the immense number of sizes involved, cannot be assessed purely on the rough basis of theoretical equations. These parameters are to be determined for several high-grade steels selected from structural steels, fine-grained steels and heat-treatment steels. The following aspects will be examined : systematic processing of the tolerances indicated in the literature on the subject, Wöhler tests using a spring-loaded bearing, standardized dynamic-resistance tests, elastoplastic performance of the material and fracture mechanics.

Applicant : Fraunhofer-Institut für Betriebsfestigkeit - Darmstadt
Amount : 213.000 Ecu
Duration : 3 years

e) Fracture mechanisms

P 919 : Evaluation of crack propagation resistance in hardened and tempered steel tubes by full-scale and laboratory tests

For economic as well as technical reasons there is an ever increasing demand for wide-diameter tubes for the piping of natural gas. This calls for the marketing of high-quality steel tubes which will enable the gas to be piped at a higher pressure, which contributes to an overall reduction in costs. Crack propagation tests on actual-size tubes (48 and 56 inches) have revealed gaps in our knowledge of crack propagation resistance in hardened and tempered steels. Accordingly, the aim of this research programme is to develop full-scale tests and to select the most representative laboratory test suitable for evaluating crack propagation resistance.

Applicants : CSM - Roma
 Italsider - Genova
Amount : 1.667.000 Ecu
Duration : 2 1/2 years

NB : In view of the fact that the Perdasdefogu test centre has been placed at the disposal of the CSM, the latter requests that work commence on February 1st, 1981.

P 964 : Fracture performance of welded structures. Interpretation of permissible defects on the basis of wide plate and impact tests

The main aims of this research are twofold:

- to seek to establish a relationship between the overall performance of welded and unwelded steels and their level of impact strength, taking account of the thickness of the product, its grade and the permitted heat input. Accordingly, an attempt will be made to define new design curves based on the Charpy V impact strength and laid down for a given type of stress in accordance with the permissible-defect concept.

- to determine suitable conditions for alleviating or optimizing the welding of joints by guarding against any reduction in toughness or, rather, by attempting to achieve greater toughness.

The study will cover structural steels having a limit of elasticity of between 355 and 550 MPa. Thicknesses will be in the range 10-50 mm.

Applicant : CRM - Liège
Amount : 515.500 Ecu
Duration : 2 years

P 965 : Influence of metallurgical factors on the toughness of tube steels

Tube steel must be weldable and resistant to brittle and ductile fracture, must have advanced mechanical properties and must have good corrosion resistance.

However, metallurgical responses to these requirements are often mutually contradictory. The aim of the proposed research is to examine the influence of metallurgical factors on the results of the toughness tests which, more often than not, are the subject of requirements laid down in the specifications and to define how far the various requirements can be reconciled. One of the effects of this work will be to rationalize the task of the steel metallurgist by defining the optimum working conditions necessary to fulfill the requirements laid down.

Applicant : CRM - Liège
Amount : 286.500 Ecu
Duration : 2 years

P 967 : Alpha-phase segregation in carbon steels

In the course of high-temperature heat treatment certain elements such as phosphorus, manganese and molybdenum have a tendency to segregate at the interface of austenitic and ferritic grains. As a general rule, this segregation is of an embrittling nature, resulting in reduced material ductility. The aims of this research are twofold:

- to define the effects on the main mechanical properties (strength, ductility) of segregation at the interfaces of the grains;
- to examine, on the assumption that a predetermined segregating-element content is inevitable by virtue of the technical constraints, whether such segregation can be reduced as a result of modifications.

This study will confine itself to phosphorus. A mathematical model will have to be drawn up permitting the optimization of the chemical analysis of steel and the thermomechanical treatment to be applied to the steel, so as to arrive at a better strength ductility compromise in the case both of thin products (sheets) or of thicker products (12-30 mm medium plates).

Applicant : CRM - Liège
Amount : 277.000 Ecu
Duration : 2 years

P 1044 : Evaluation of the collapse risk of a welded assembly containing a defect

The main aim of this research is to compare the permitted dimensions calculated by various methods against the critical dimensions measured on a wide welded assembly (wide plate test), where the assembly contains a real or simulated defect and is subjected to a decreasing temperature under prescribed load conditions. In order to ensure that this objective comparison is really worthwhile, a study will be carried out on a structural steel welded by two industrial processes (automatic welding under flux, vertical single-pass welding under slag) both in the raw state and after stress relief heat treatment. In this way it should be possible to assess how far each method of analysis takes account of residual welding stresses.

Applicant : Insid - St. Germain-en-Laye
Amount : 501.000 Ecu
Duration : 3 years

f) High-temperature steels

P 916 : Influence of silicon on the creep performance of turbine steels

On the basis of knowhow acquired during earlier projects on the mechanisms responsible for fatigue in nickel - chromium - molybdenum - vanadium steel grades for turbine and alternator rotors, it is now possible to define fairly accurately the degree of predictable dissipation of impact strength from parameters relating to chemical composition, micrographic structure, cleanness and residual-element content, operating temperatures and length of use. Significant variations in creep properties have been detected and correlated with the microstructural and chemical parameters relating to rotors. Accordingly, the object of this research is to carry out a detailed study of the effects of silicon on the creep properties of Cr-Mo-(Ni)-V steels, which have nominal operating temperatures more typical of the creep zone than the Ni-Cr-Mo-V grades.

Applicant : Creusot-Loire - Le Creusot
Amount : 158.500 Ecu
Duration : 3 years

P 951 : Steel and fabrication requirements in coal utilization technologies

The aim of this project is to carry out a detailed survey of the requirements for steels and metallic materials in current and immediately foreseeable process routes for the combustion conversion of coal products. The following main aspects will be considered :

- materials used in these plants or, if no material is identified, the materials' requirements for the applications;
- design codes or criteria used for the plants and steel components;
- extent to which existing material properties data are compatible with production criteria;

- survey among steelmakers and fabricators to determine operational and quality-control potentials.

Applicant : BSC (Sheffield Laboratories) - London
Amount : 90.500 Ecu
Duration : 1 year

g) Off-shore technology

Once the preceding phase in the work had been completed, a coordinated supplementary programme was worked out by the laboratories concerned. The intention was to improve the knowledge acquired and to enable the research teams already set up to continue their tests while the analysis of all the results was being completed in order that, if necessary, a second phase in the work could be got underway.

The work under this supplementary programme can be broken down as follows:

P 915 : Service strength of welded offshore structures in sea water with particular reference to crack propagation measurements and post-weld treatment to increase fatigue strength

It is intended on the basis of work of a more basic nature already carried out, to elucidate certain questions relating to the strength of high yield strength steels under corrosion conditions. Tests simulating stresses due to wave swell will be carried out following a random procedure. The following points will be dealt with:

- influence of the post-weld treatment (TIG dressing);
- tests on specimens welded by the submerged process;
- corrosion conditions using different cathodic protection potentials;
- influence of time of exposure to relatively low load levels;
- crack detection and measurement of crack propagation on welded specimens;
- influence of the protective coating on fatigue behaviour under corrosion conditions.

Applicants : Fraunhofer-Institut für Betriebsfestigkeit - Darmstadt
Industrieanlagen Betriebsgesellschaft - Ottobrunn
Amount : 271.000 Ecu
Duration : 2 years

P 954 : Fatigue, corrosion fatigue and stress corrosion of steels for offshore structures

The objectives of this research programme are :

- to study the effects of geometrical parameters on the fatigue behaviour of components made of forged and cast steels in comparison with welded joints;
- study of behaviour in sea water containing hydrogen sulphide;
- evaluation of the rate of propagation of cracks in the most unfavourable cases. The effects of painting and cathodic protection will be examined.

- behaviour and use of steels with or without nickel.

Applicant : BSC - London
Amount : 251.000 Ecu
Duration : 2 years

P 1045 : Fatigue of welded assemblies of high yield strength steel in offshore structures

The objective is to supplement the result obtained on a steel of type E 36-Z and to study the influence of the grade of steel on the fatigue behaviour of welded joints, since considerable savings may be expected if materials with enhanced properties are used. These savings would arise from reductions in the weight of structures, greater ease of fabrication and assembly (tube forming, welding) and reduced risk of failure (plate thickness, elimination of stress relief treatments).

Applicant : Insid - St. Germain-en-Laye
Amount : 334.000 Ecu
Duration : 2 years

P 1061 : Fatigue and corrosion fatigue behaviour of welded steel joints in offshore structures

The safety of marine structures relies above all on resistance to fatigue cracking of welded joints. Research needs to be devoted to optimizing the dimensions of these welded joints, i.e. to finding the best compromise between fundamental safety levels and the economic design of joints. For this reason, the work proposed related basically to the study of fatigue behaviour in a corrosive environment under the following conditions:

A. Plate

- influence of thickness
- influence of weld geometry and post-weld treatment technique
- influence of sea water temperature

B. Tubular joints

- influence of post-weld treatment techniques
- influence of sea water, with and without cathodic protection of the welded joint.

Applicant : Stichting Materiaalonderzoek in de Zee - Delft
Amount : 403.000 Ecu
Duration : 2 years

P 1076 : Effect of the marine environment on the fatigue corrosion behaviour of offshore steel structure

The aim of this research is to study the influence of the natural marine environment, particularly the biological environment on hydrogen absorption by the steels with and without cathodic protection. Research will also be devoted to the effect of the hydrogen produced in the presence of cathodic

protection on the propagation of fatigue corrosion cracks under a variable load. The acoustic emission technique will be used in this case.

Applicant : Korrosioncentralen ATV - Glostrup
Amount : 91.000 Ecu
Duration : 2 years

h) Light structures

P 921 : Structural system of rigid beam-column joints using bolted brackets.
Typological definition and experimental verification

This project involves the development of a system of rigid bolted joints avoiding the need for a large number of welds and facilitating assembly operations. The aim is to optimize assembly and workshop preparation conditions for the joining of different sections, for example IPE and HE beams and cold-rolled joints. The technical and economic aspects of this development will also be investigated.

Applicant : Italsider - Genova
Amount : 326.500 Ecu
Duration : 2 years

P 923 : Buckling of thin-walled hollow sections. Case of eccentrically
loaded rectangular sections

It will only be possible to optimize the use of thin-walled hollow sections when the final solution has been found to the problem of calculating columns subjected simultaneously to compression and bending (beamcolumns). This is the aim of the research in question which should make it possible:

- to verify whether existing formulae and rules for thick-walled sections remain valid for the sections covered by the research;
- if necessary to devise a new method of calculating thin walled beamcolumns of rectangular cross-section;
- where possible, to bring about the incorporation of this calculation method into European regulations;
- to set up programmes tailored to office computers.
- to supply the required data to the ISO Standardization Committee.

Applicant : Cometube - Paris
Amount : 88.000 Ecu
Duration : 2 years

P 999 : Hollow sections for load-bearing members of steel (complement)

The technical and industrial requirements of materials and structural components have increased significantly in recent years. The use of hollow sections has grown considerably, and the manufacturers of these products have undertaken to prepare and publish a technical handbook dealing with

their calculation and with the joining assembly of these components to each other and to other sections. Problems of protection against corrosion and fire and sandwich construction are also dealt with. A first version of this handbook has been drafted, but the Committee of experts assessing the document found it necessary to revise its presentation and a considerable amount of its content. It is thus necessary to prepare a new version of the document. This will clearly involve fresh expenditure, and this is the reason for the present request for assistance. The new version will of course take into account the results of the most recent work in the field.

Applicant : VDEh - Düsseldorf
Amount : 77.750 Ecu
Duration : Extension of the project to end 1982

i) Alloy and special steels

P 908 : Development of optimised steels for gears

In order to meet competition from other materials (cast iron, sintered materials, plastics of various types), it is necessary to undertake technical and economic research on case hardening steels for gears. With this aim in view the following points will be covered :

- The steelmaking process.
Comparison between steels continuously cast and then rolled and analogous steels obtained by conventional ingot casting.
- Alloying elements.
Study of the influence of alloying elements such as, in particular, Ni and Mo, in order to establish to what extent it is possible to economize on the quantities of these elements used while conserving the service properties of the steels concerned.
- Gear manufacture.
Study of machinability and cold-forming.

Applicant : Teksid - Torino
Amount : 652.000 Ecu
Duration : 3 years

P 957 : Evaluation of clean steel practices and resultant property improvements in alloy engineering steels

For certain products, for example pipe for transmission lines and heavy plate for structural applications, there have been extensive studies aimed at improving the steelmaking, deoxidation and desulphurization processes and the properties of these steels. However for heat treated low alloy steels little has been done in these lines. The aim of this research is to determine the differences between conventional steels and those for which special measures have been taken in production to minimize inclusions. The work will cover three types of steel :

- medium carbon, nickel-chromium-molybdenum
- nickel-chromium-molybdenum case carburizing steels
- chromium spring steels

Applicant : BSC (Sheffield Laboratories) - London
Amount : 366.500 Ecu
Duration : 3 years

II - 6. PLANT AVAILABILITY

The three research projects submitted in this new sector of the programme have, as a common objective, the need to achieve cost-savings in steel manufacture through improved reliability and performance of plant and equipment. The work concerns investigations of the wear of rolls, the abrasion and erosion of steel components in plant and equipment and the improved maintenance of steel works cranes.

P 950 : Abrasion, erosion and wear resistant steels for improved reliability and performance of plant and equipment

The total efficiency of steelworks operations has never been more important than at the present time when operating costs must be kept to a minimum. A major factor influencing this efficiency is the problem of wear which is identified frequently as a cause of plant failure.

The objective of this research will be to undertake a series of laboratory based tests using existing techniques to determine the operating and metallurgical characteristics which control the development of wear in steels used in plant and equipment construction. Based upon this understanding, alternative or modified alloys will be developed that are likely to show a cost effective improvement in performance.

Applicant : BSC - London
Amount : 192.500 Ecu
Duration : 3 years

P 985 : Reduction of wear on rolls in strip treatment plant

The economics of producing cold rolled and galvanized sheet are markedly influenced by the maintenance costs arising from wear problems.

The aim of this research is to achieve an improvement in the performance of critical mill components in these production lines. The study will include wear problems related to such aspects as immersed and stabilising rolls in galvanizing lines, rolls in mill roller tables, work rolls in pickling lines and guide rolls in cold rolling.

Applicant : BFI - Düsseldorf
Amount : 496.000 Ecu
Duration : 3 years

P 1005 : Reduction of crane maintenance costs by designing to meet service requirements

In spite of the progress that has been made through systematic studies designed to improve the service performance of cranes in steel plants, there remains scope for improvement to be made in their reliability and maintenance. The aim of this investigation is therefore :

- (1) to reduce maintenance costs through the quantitative assessment of crane reliability under normal working conditions and,

- (2) the translation of reliability characteristics into a cost-based maintenance strategy.

Applicant : BFI- Düsseldorf
Amount : 464.500 Ecu
Duration : 3 years

II - 7. MISCELLANEOUS

P 1071 : Use of steel in the automobile industry

The aim of this study is to determine what research projects should be conducted in the near future by steelmakers in order to supply automobile manufacturers with the steel qualities they will be needing. Steel is now in competition with other materials in this field, and it is important to meet new market requirements, such as reduction in vehicle weight (energy saving), safety, service life, environment (noise reduction), reduction in production costs.

Applicant : Estel Hoogovens - Ijmuiden
Amount : 32.000 Ecu
Duration : 1 year

P 1072 : Technical steel literature

This project is a continuation of previous contracts giving ASELT financial assistance for the translation into the European Community languages of tests on iron and steel subjects published in the "difficult" languages (notably Japanese and Russian).

Applicant : Aselt - Luxembourg
Amount : 124.000 Ecu
Duration : 1 year

S U M M A R Y T A B L E

Annex

Project No.	TITLE OF THE RESEARCH	Proposed research			Financial aid	
		by	duration (years)	Amount ECU (4.12.80)	%	Amount ECU (4.12.80)
	<u>ORE REDUCTION</u>					
	<u>Blast furnace</u>					
1023	Investigations in the dead man and hearth of the blast furnace	IRSID	4	969.500	60	581.700
1047	Effects of blast furnace burden distribution on radial reduction behaviour of iron-forming elements	CSM	2	390.000	60	234.000
1069	Coal injection into the blast furnace	Hoogovens	1	200.000	60	120.000
	<u>STEELMAKING</u>					
	a) <u>Casting and solidification</u>					
928	Pilot plant process development for horizontal continuous casting of thin slabs	BSC	3	723.500	60	434.100
929	Establishment of design parameters for large slab-type ingot moulds	BSC	2	229.000	60	137.400
982	Influence of metallurgical and process engineering measures on solidification on the continuous casting of steel	VDEh	3	2.706.500	60	1.623.900
1054	New methods of alloying steel in continuous casting	CSM	2	367.000	60	220.200
1055	Corrugated-wall mould for the continuous casting of slabs	CSM	3	652.000	60	391.200
	b) <u>Steelworks metallurgy</u>					
975	Physical properties of slag used in basic oxygen steelmaking	N.P.L.	2	103.500	60	62.100
978	Development of the Klöckner steelmaking process. Construction and operation of a prototype	Klöckner	2	2.467.500	60	1.480.500
1021	Low-slag refining in the LD converter	Krupp	3	966.500	60	579.900

Project No.	TITLE OF THE RESEARCH	Proposed research			Financial aid	
		by	duration (years)	Amount ECU (4.12.80)	%	Amount ECU (4.12.80)
1025	Prerrefining of hematite pig iron	IRSID	3	741.000	60	444.600
933	c) <u>Steel works-technology</u> The use of plasmaguns for auxiliary heating in an electric arc furnace	BSC	2	274.500	60	164.700
1053	d) <u>Refractories</u> Use of calcium oxyde as a refractory material for the lining of ladles for refining outside the steel furnace	CSM	2	473.000	60	283.800
981	e) <u>Theoretical steelmaking</u> Optimization of desulphurization and inclusion formation in the calcium treatment of steel melts	VDEh	3	237.500	60	142.500
925	<u>MECHANICAL WORKING</u> The influence of manufacturing variables on the wear characteristics of hardened steel rolls	Brown Firth	3	356.000	60	213.600
936	The cause of end splitting during the rolling of free cutting steels	BSC	2	267.500	60	160.500
938	Metallurgical study of in-line hot scarfing	BSC	3	302.500	60	181.500
940	The use of hi-chrome rolls in cold tandem and temper mills	BSC	2	202.000	60	121.200
963	Crisis-pacing method for a wide strip mill	CRM	4	922.000	60	553.200
984	Rolling of high-alloy steels on wire mills at higher rolling speeds	BFI	3 1/2	549.000	60	329.400
1007	Cladding of rolling mill rolls by plasma arc welding	Arbed	3	435.000	60	261.000

Project No.	TITLE OF THE RESEARCH	Proposed research		Financial aid		
		by	duration (years)	Amount ECU (4.12.80)	%	Amount ECU (4.12.80)
1030	Flatness control on the hot strip mill	IRSID	3	498.500	60	299.100
1032	Width control in the roughing stand of the strip mill	IRSID	4	690.500	60	414.300
1056	Sheet mill micro-structural phenomena control system	CSM	3	517.500	60	310.500
906	<u>MEASUREMENTS AND ANALYSES</u> Analysis of trace elements in iron and steel materials by direct flameless atomic absorption on solid samples	Creusot-L CSM Arbed	2	99.000 99.000 99.000	60 60 60	59.400 59.400 59.400
907	Digital processing of radiographs.	INSA IRSID Creusot-L Framatome	3	261.500 70.500 124.500 109.000	60 60 60 60	156.900 42.300 74.700 65.400
920	Study of the solidification structure of slabs using ultrasonic methods	Italsider	3	326.500	60	195.900
945	Further developments in continuous on-line measurement of gauge profile of hot strip	BSC	1	178.500	60	107.100
946	The analysis of slurries and powders by inductively coupled plasma spectrometry	BSC	3	203.000	60	121.800
972	Improvement of analytical methods using plasma torch spectrometry	CRM	2	166.500	60	99.900
973	Development of a prototype gauge for hot detection of internal defects in concast steels	CRM	3	337.500	60	202.500
988	Ultrasonic defect differentiation using the PPE method	BFI	3	479.500	60	287.700
1008	Control of beam rolling tolerances	Arbed	3	472.000	60	283.200
1009	Automatic control of steel level in the continuous casting mould	Arbed	2	202.500	60	121.500
1033	Surface defect detection on hot semis using Eddy currents	IRSID	3	551.000	60	330.600

Project No.	TITLE OF THE RESEARCH	Proposed research		Financial aid		
		by	duration (years)	Amount ECU (4.12.80)	%	Amount ECU (4.12.80)
1035	Automation of non-metallic specimen preparation for atomic absorption and plasma torch analysis	IRSID	3	121.500	60	72.900
1058	Identification of inclusions and surface states in cold-rolled products by photo-acoustic spectrometry	CSM	2 1/2	208.000	60	124.800
	<u>PROPERTIES AND SERVICE PERFORMANCE</u>					
	a) <u>weldability</u>					
991	Influence of aluminium and nitrogen on relaxation brittleness of weld-simulated refractory fine-grained structural steels during stress relieving	T.U.Brauns	3	179.000	60	107.400
995	New techniques for joining steel	W.Inst.	1	103.500	60	62.100
998	Welds in high-strength structural steels of the type St E 460	B.A.f.M	2 1/2	277.500	60	166.500
1038	Metallurgical study of molten metal in automatic welding under solid flux.	IRSID	3	368.500	60	221.100
	b) <u>Corrosion and surface protection</u>					
969	Suitability for pickling of hot-rolled strip	CRM	3	366.500	60	219.900
996	Influence of alloying and accompanying elements on steel corrosion and hydrogen absorption	MPI	3	309.500	60	185.700
1070	Corrosion testing of automotive steel products	Hoogovens	3	447.500	60	268.500
	c) <u>formable steels</u>					
1041	Transfer of roughness during skin passing	IRSID	3	417.000	60	250.200

Project No.	TITLE OF THE RESEARCH	Proposed research		financial aid		
		by	duration (years)	Amount ECU (4.12.80)	%	Amount ECU (4.12.80)
1049	Tests on the formation and decomposition of iron carbides in the annealing of cold-rolled products	CSM	2	196.500	60	117.900
990	d) <u>Constructional steels</u> Influence of segregations during continuous casting on material properties	VDEh	3	1.270.000	60	762.000
1000	Extending the use of high-grade steels for cyclically-stressed structural components by the provision of reliable data	LBF	3	213.000	60	127.800
919	e) <u>Fracture mechanisms</u> Evaluation of crack-propagation resistance in hardened and tempered steel tubes by fully-scale and laboratory tests	CSM Italsider	2 1/2	1.422.500 244.500	60 60	853.500 146.700
964	Fracture performance of welded structures. Interpretation of permissible defects on the basis of wide plate and impact tests	CRM	2	515.500	60	309.300
965	Influence of metallurgical factors on the toughness of tube steels	CRM	2	286.500	60	171.900
967	Alpha-phase segregation in carbon steels	CRM	2	277.000	60	166.200
1044	Evaluation of the collapse risk of a welded assembly containing a defect	IRSID	3	501.000	60	300.600
916	f) <u>High-temperature steels</u> Influence of silicon on the creep performance of turbine steels	Creusot-L.	3	158.500	60	95.100
951	Steel and fabrication requirements in coal utilisation technologies	BSC	1	90.500	60	54.300
915	g) <u>Off-shore technology</u> Service strength of welded off-shore structures in sea water with particular reference to crack propagation measurements and post-welded treatment to increase fatigue strength.	LBF IABG	2	271.000	60	162.600

Project No.	TITLE OF THE RESEARCH	Proposed research		Financial aid		
		by	duration (years)	Amount ECU (4.12.80)	%	Amount ECU (4.12.80)
954	Fatigue, corrosion fatigue and stress corrosion of steels for off-shore structures	BSC	2	251.000	60	150.600
1045	Fatigue of welded assemblies of high yield strength steel in off-shore structures	IRSID	2	334.000	60	200.400
1061	Fatigue and corrosion-fatigue behaviour of welded steel joints in off-shore structures	SMOZ	2	403.000	60	241.800
1076	Effect of the marine environment on the fatigue corrosion behaviour of off-shore steel structures	Korr. Cent.	2	91.000	60	54.600
921	h) <u>Light structures</u> Structural system of rigid beam-column joints using bolted brackets. Typological definition and experimental verification	Italsider	2	326.500	60	195.900
923	Buckling of thin-walled hollow sections. Case of excentrically loaded rectangular sections	Cometube	2	88.000	60	52.800
999	Hollow sections for load-bearing members of steel (complement)	VDEh		77.750	80	62.200
908	i) <u>Alloy and special steels</u> Development of optimized steels for gears	Teksid	3	652.000	60	391.200
957	Evaluation of clean steel practices and resultant property improvements in alloy engineering steels	BSC	3	366.500	60	219.900
950	<u>PLANT AVAILABILITY</u> Abrasion, erosion and wear resistant steels for improved reliability and performance of plant and equipment	BSC	3	192.500	60	115.500
985	Reduction of wear on rollers in strip treatment plant	BFI	3	496.000	60	297.600

Project No.	TITLE OF THE RESEARCH	Proposed research			Financial aid	
		by	duration (years)	Amount ECU (4.12.80)	%	Amount ECU (4.12.80)
1005	Reduction of crane maintenance costs by designing to meet service requirements	BFI	3	464.500	60	278.700
	<u>MISCELLANEOUS</u>					
1071	Utilisation of steel in the automobile industry	Hoogovens	1	32.000	60	19.200
1072	Technical steel literature	Aselt	1	124.000	100	124.000
	TOTAL			32.164.750		19.364.000