

COMMISSION OF THE EUROPEAN COMMUNITIES

COM(78) 226 final.

Brussels, 30 May 1978

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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INTRODUCTION

The research proposals on iron and steel contained in this memorandum have been selected from a total of 119 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, 37 proposals have been selected as first priority and, along with 23 projects carried over for budgetary reasons from the programme approved in 1977, constitute the new research in the iron and steel sector for 1978.

In examining the aims of these proposals and assessing their relevance to the needs of the steel industry particular attention was given to projects that would improve productivity, reduce production costs and increase the quality of steel products as well as their performance under service conditions. Within these major lines of technical development, increasing emphasis has been devoted to short-to-medium term research objectives.

The technical content of the proposed programme covers various aspects of iron and steel research related to problems in both the producer and the user sectors of the industry with the level of funding distributed as follows : iron ores (3,7 %); ironmaking (10,2 %); steelmaking (5,8 %); rolling mills and mechanical working (14,7 %); measurements and analysis (20,5 %) and properties and service performance of steels (32,1 %).

In the production oriented research sector of the programme, improving the economics of processes and reducing energy consumption are reoccurring themes while enhanced operational safety is sought in work proposed on the blast furnace and on continuous casting.

The continuing importance being attached to steel quality is demonstrated by the large amount of effort proposed in the fields of rolling mills and measurements and analysis. A number of projects are concerned with improving the flatness of sheet and strip by modifying or improving the control of various elements of the rolling mill (inter-stand tension, differential rolling speed, roll bending). In addition, the surface quality of semi-finished products (blooms and slabs) is the subject of research directed at the detection and removal of surface imperfections.

Studies in the properties and service performance of steels include major effort on the weldability of high strength steels with particular attention being devoted to avoiding the danger of heat affected zone cracking under service conditions. The exploitation and utilisation of structural steels is also the aim of a Community programme on the development of more satisfactory assessment methods for elasto-plastic fracture toughness testing. After a lapse of several years, further ECSC aid is requested for research in the important area of the machinability of steels in connection with the role of non-metallic inclusions.

The budget allocation for steel research was fixed in 1978 at 16 million EUA by Decision No 2996/ECSC of the Commission (OJ No L 351/55 of 31.12.1977). Financial aid for the 37 research steel projects represents an amount of 9.368.880 EUA. In addition, 23 research projects on which favourable opinions were delivered by the ECSC Consultative Committee and by the Council in 1977 could not be financed from the 1977 budget owing to budget reductions introduced in that same year. Financial aid for these 23 projects amounts to 6.001.760 EUA. Thus the total financial aid to be charged to the budget of 16 million EUA provided for, in respect of 1978, amounts to 15.370.640 EUA. The difference between these two amounts, namely 629.360 EUA, will be used to cover ancillary expenditure and the costs of dissemination of information.

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THE RESEARCH PROGRAMME

I. "IRON ORE" Programme

The various experiments with mechanical cutting have shown that this is a feasible method for use in the Lorraine iron mines provided that the machines used are specially designed to cope with the hardness and abrasiveness of the ore and the thickness of the seams. The experiments have also shown that the powered support system developed was suitable for the roof and pressure conditions. An economic study has shown that the use of cutters and powered supports would be economically viable in 3.50 m seams if an output of 1.600 tonnes per shift could be obtained and in 2.50 m seams with a lower output.

The aim of the research project is to try out the equipment in various panels typical of the whole of the Lorraine ore field (calcareous and siliceous).

If the research is successful, the Longwall face method would have numerous advantages over the conventional methods : higher ore recovery, mining of thin seams currently considered unworkable, production of a cleaner and finer ore, improvement of safety, working conditions and productivity.

II. "DIRECT REDUCTION AND PIG IRON" Programme

a) Sinter

Project P 546 aims to produce a high-grade sinter without using the normal bedding methods. Bedding systems for the pre-mixing of the various ore fines or concentrates, together with basic addition agents and possibly recycled materials, take up a large amount of space and, especially if the plant is close to residential areas, cause environmental problems. In this project the raw mix will be blended in a mixing and rolling drum. The basicity of the sinter will be measured automatically and used as a controlled variable for the blending installation. The degree of basicity not only affects blast furnace operation but also determines the degree of separation of solid in the waste gas electric filters and the proportion of gaseous fluorine compounds released. This system is expected to have a lower capital cost than a bedding system for ore fines and also take up less space and cause less pollution.

b) Blast furnaces

Project P 500 concerns the operation of large blast furnaces. It is known that a smaller proportion of fines in the burden, an increase in the mechanical strength of the iron-bearing materials charged and of the coke and a larger average particle size in all burden materials have a favourable effect on blast furnace operation, in particular by reducing specific coke consumption. However, the costs of preparing the burden and the coke will clearly be higher. The purpose of this project is therefore to attain the economic optimum. The project will help to increase the competitiveness of our steel industry and hence to secure jobs.

Project P 519 relates to the operation of blast furnaces in general. Most blast furnaces have safety devices that control the blast flow per tuyere. If the flow falls below a minimum value, the oil feed is automatically switched off. These anomalies are foreshadowed by fluctuations in hot blast volume. The purpose of the project is therefore to analyse and interpret this phenomenon with electronic equipment so as to provide the operator at an early stage with a decision-making aid. There are two aims in view : conservation of energy and operating safety.

III. "STEELWORK" Programme

In the steelplant sector there is one application relating to casting and solidification and two relating to electric steelmaking.

a) Casting and solidification

In project P 520 an electromagnetic delivery system to meter the casting stream will be used for the first time in an industrial continuous casting machine. The stream can be regulated very precisely by electromagnetic means. A uniform stream gives a constant liquid steel level, which is one of the conditions for good product quality. The main aims of this research project are :

to increase plant safety, and

to prevent reoxidation of the stream between the vessel and the mould.

b) Electric steelmaking

Project P 549 is an extension of the current project on a mathematical model to optimize the electric steelmaking process (agreement 6210-CA/1/105). The application for an extension is being made in order to allow the most recent developments in electric steelmaking to be incorporated in the model.

The purpose of project P 554 is to investigate the high-voltage system and have feedback effects of the arcs. These effects result mainly from the non-linear behaviour of the arcs. The practical difficulty in a precise investigation of these phenomena lies in the fact that the voltages and wattages of the three phases whose star point is the furnace cannot be measured directly but only via measuring loops in which error voltages are induced.

The aim of the project is to determine the precise causes of the line feedback effects and their relationship with the mode of operation of the arc furnace. In addition the superimposed effects of several furnaces will be investigated.

IV. "ROLLING MILLS AND PROCESSING" Programme

When the economic situation was at its best, the rolling mills were faced mainly with problems of production and productivity. The present crisis has caused the manufacturers of rolled products to turn their attention to improving the competitiveness of their products.

As a result, the main aims of the current research projects are economy (three projects) and improvement of quality (five projects).

One project (P 591) relates to energy conservation by improved operation of soaking pits.

Two projects aim to reduce maintenance and repair costs in the rolling mill, one of them (P 578) by diminishing wear on cold rolling rolls and the other (P 551) by studying rolling mill drives and their problems.

The surface finish of hot-rolled products largely depends on reheating conditions and consequently the better control of decarburization and scaling in reheating furnaces is the aim of project P 592. There are three projects designed to improve the flatness of rolled products (P 552, 553 and 579).

Finally, one project (P 507) is devoted to coiling temperature control in a wide strip mill as the metallurgical qualities of the product depend on this temperature.

V. "MEASUREMENT" Programme

Under the prevailing economic conditions it is constantly necessary to improve the quality of steel products.

This is particularly so in respect of the surface defects tolerated on long flat products and wire rod. Quality control for this purpose should be carried out at two different stages.

1) Semi-finished products

The economic advantages of the inspection of semi-finished products are obvious as it prevents the rolling of defective billets (see projects P 514 and 516 for example).

What is more, if surface defects are detected and marked on billets they can be repaired prior to rolling, giving a definite quality improvement.

2) Finished products

The inspection of flat products and in particular wire rod during rolling in the rod mill enables mill maladjustments causing defects to be detected so that rapid action can be taken to correct them, thus preventing defective rolling. In view of the high production rates on modern multi-strand wire mills and the normal practice of detecting defects on cold wire by random sampling, the advantages of early detection are obvious.

Of the existing techniques, the Eddy current methods (see project P 581) appear well suited for automation of inspection.

Subsurface defects in rolled products are of major concern to steel companies, as regards both the inspection of materials and the production and working of steel. Although the introduction of continuous casting has helped to bring

about a considerable reduction in the proportion of major defects such as blow holes in steel parts, it is nevertheless true that, as technological requirements are incessantly stepped up, the detection of ever smaller defects has become necessary. For the purpose, use is made chiefly of the ultrasonic inspection and detection method (see project P 555) which has the advantage of being suitable for contactless use, so that parts can be examined and/or inspected at high temperature and their surface state does not in any way affect good definition.

Although the problem of detecting and locating defects is on the way to being solved, there is another extremely important aspect : the removal of the defects by a suitable process. For example, the steel industry has to carry out the conditioning of slabs in order to meet the quantity and quality requirements for production. At the present time, this is done manually with the oxy-acetylene torch by workers who remove visually detected defects under extremely arduous working conditions characterized by heat, dazzle and dust caused by the lance. As this problem is growing worse, it is proposed to solve it (see project P 516) by investigating an Eddy-current method of detecting defects combined with an automatic on-line installation for locating the defects and storing their coordinates for automatic control of a multiple-head spot scarfing machine.

It is obvious that such a system could have an important socio-economic impact.

VI. "PROPERTIES AND SERVICE PERFORMANCE" Programme

The research proposals selected in this field reflect a desire to reach practical conclusions; their choice was based on the criteria of quality, productivity and development. This is in line with the current needs of our steel industry which must above all show its vitality and efficiency.

Much work is being devoted to the development of steel grades enabling better service properties to be obtained in welded structures or pressure vessels. The subjects proposed also show the need to support projects in very specific fields where special alloys should enable the Community to hold its own.

Better productivity and new uses can be envisaged for steel if the aims described in some of the proposals can be attained.

Annex 1 : Summary table

Annex 2 : The research projects

| Project n° | Title of the Research | Proposed Research | | Financial Aid | | |
|------------|--|-------------------|----------------|-----------------------|----|-----------------------|
| | | by | Duration years | Amount EJA (15.12.77) | % | Amount EJA (15.12.77) |
| 581 | Examination for surface defects on billets and wire by Eddy-currents | IRSID | 3 | 296.000 | 60 | 177.600 |
| 595 | Acoustic emission defects location and grading in welded structures | C.S.M. | 3 | 140.000 | 60 | 84.000 |
| | <u>PROPERTIES AND SERVICE PERFORMANCE</u> | | | | | |
| | a) <u>Weldability</u> | | | | | |
| 563 | Crack sensitivity, deformation and fracture behaviour of the heat affected zone of weldments in high-strength fine-grained construction steels | VDEh | 3 | 775.500 | 60 | 465.300 |
| | b) <u>Formability</u> | | | | | |
| 505 | Spot welding of high-strength deep-drawing steels and properties of weldments | C.R.M. | 2 | 158.000 | 60 | 94.800 |
| 508 | New continuous reheating cycle for tinplate | C.R.M. | 4 | 753.000 | 60 | 451.800 |
| 538/2 | Resistance spot weldability of steel sheet | Weld.Inst. | 3 | 216.000 | 60 | 129.600 |
| 583 | Suitability for cold forming | IRSID | 3 | 288.500 | 60 | 173.100 |
| | c) <u>Constructional steels</u> | | | | | |
| 586 | Plastic deformation in the $\gamma + \alpha$ range for various ordinary steels | IRSID | 3 | 296.000 | 60 | 177.600 |
| | d) <u>Fracture</u> | | | | | |
| 539 | Elasto-plastic fracture toughness testing and assessment methods | Weld.Inst. | 1 1/2 | 448.800 | 60 | 269.280 |

| Project n° | Title of the Research | Proposed Research | | Financial Aid | |
|------------|--|-------------------|------------------|-----------------------|-----------------------|
| | | by | Duration (years) | Amount EJA (15.12.77) | Amount EJA (15.12.77) |
| 525 | e) <u>High temperature steels</u> Cavitation and fracture in creep resisting steels | B.S.C. | 3 | 187.500 | 112.500 |
| 590 | f) <u>Marine technology</u> Offshore structures : tubular joint stress analysis (complement) | UKAEA | 1/2 | 34.000 | 34.000 |
| 490 | g) <u>Light structures</u> Investigation in the criteria of European domestic comfort and the technical obstacles to industrialized building systems (complement) | Forsch. Bausyst. | 1 | 143.000 | 100.100 |
| 515 | Possibilities for the production of steel windows using stamping processes | Italsider | 2 | 143.000 | 85.800 |
| 487 | h) <u>Alloy and special steels</u> Research programme on losses in electrical sheets | Ist. Gal. Ferr. | 3 | 171.500 | 102.900 |
| 536 | Effect of sulphur and sulphide shape on the mechanical properties of machinability of alloy steels | B.S.C. | 3 | 466.500 | 279.900 |
| 544 | Basic properties of grain oriented electrotechnical steels | B.S.C. | 3 | 385.500 | 231.300 |
| 565 | Influence of sulphide shape and its effect on the mechanical properties and machinability of special construction steels | VDEh | 3 | 498.500 | 299.100 |
| | TOTAL | | | 15.568.300 | 9.368.880 |

THE RESEARCH PROJECTS

I. "IRON ORE" PROJECTS

P 501 - Advancing - face mining in Lorraine

The winning method most extensively used in Community iron ore mines is the room and pillar system. The ore is stripped by explosives; strata control is by roof bolting. This technique has evolved over time, and its evolution has made it possible to achieve record productivity rates. But it is currently levelling out.

The aim of the research is to improve productivity. It will utilize results previously obtained which have shown that mechanical working can replace shot-firing and that self-advancing supports can replace rock bolting in iron ore mines, provided a system based on working the face is adopted.

This change requires the design and construction of equipment specially adapted to iron ore mines.

The objectives of the research are :

- (a) to develop a method of shortwall working with wide cuts, first for siliceous ores and then for calcareous ores.

The development work will involve :

- adaptation of the continuous miner for face working
- adaptation of chocks to shortwall conditions.

- (b) to estimate the economic viability of the method and to improve safety for face workers.

All the tests will, in principle, be carried out in seams of thickness varying between 3 and 3.50 metres. During the tests a number of inspections and scientific experiments will be carried out, particularly continuous recording of rock deformation.

The equipment will be designed and constructed only by European firms.

The work described above, covering a period of eighteen months, will be complementary to that already in progress under contract 7230 - 15/301 with SAMIFER in Paris (F).

II. "DIRECT REDUCTION AND PIG IRON" PROJECT

a) Sinter

P 546 - Production of high-quality sinter at a sinter plant without bedding

The research will be carried out on an industrial sinter plant operating with two sintering belts of 150 and 174 m² draught area and a sintering capacity

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of 11 000 tonnes per day. Each sinter belt is equipped with two coke bunkers and 14 ore and additive bunkers discharging into the mixing plant by way of weight trucks.

Sampling is fully automatic. Fully automatic analytical equipment operating on the X-ray fluorescence system is also to be tried out for the first time for process control. This equipment can determine the contents of Fe, Ca, Si, Mg and the concentrations of F_3O_4 , Fe_2O_3 , CaO, SiO_2 and MgO, from which the CaO/ SiO_2 ratio important for control purposes can also be obtained.

At a later stage in the research it is planned to install suitable computer units to take over control of the mix composition.

Variations in the technological and metallurgical properties of the sinter will then be determined in practical tests. These data will be compared with figures obtained from sinter plants with bedding systems.

The research has been proposed by Hoesch-Hüttenwerken AG, Dortmund (D). It will take two years.

b) Blast furnace

P 500 - Characteristics of the charge in large blast furnaces

The research will be carried out on a 14m furnace fitted with all the modern auxiliary equipment.

In the preparatory phase, the necessary sampling and measuring systems will be installed and tested.

In the first experimental phase ore and coke samples will be taken from the tuyeres over a two-month period. During this time the influence on furnace working of the natural scatter in the burden material will be determined.

In the second phase the degree of oxydation of the sinter will be deliberately varied (FeO contents 5-9 %).

In the third phase the influence of sinter particle size will be determined.

In addition to the metallurgical tests on sinter and coke, relevant blast furnace operating data such as gas flow, radial gas distribution, etc. will be determined in order to identify factors limiting productivity.

The research has been proposed by Italsider in Tarento (I), in conjunction with the Centro Sperimentale Metallurgico in Roma (I). It will take two years.

P 519 - Flow control in blast furnace tuyeres

The experiments will be carried out on an 8.5m and a 9m furnace.

In the first stage the necessary technical data for the two blast furnaces will be collected over a specific period and a data processing model prepared.

In the second phase an electronic control system will be developed to perform the following tasks :

1. Measurement of the precise blast flow per tuyere.
2. Monitoring and indication of pulsation processes; analysis as regards frequency and amplitude.
3. Processing of the signals; possibly triggering of an alarm.

Finally, the control system will be tried out in a long-time test.

The work has been proposed by Arbed in Esch-Belval (L) and is expected to take two-and-a-half years.

III. "STEEL WORKS" PROGRAMME

a) Casting and Solification

P 520 - Industrial operating tests on an electromagnetic launder in a continuous casting plant

The experiments will be carried out on a four-strand industrial continuous casting machine on which either round billets of 120 to 240 mm diameter or rectangular billets of 90 to 158 mm can be cast.

The research programme can be divided into an electrical and metallurgical part. The electrical part concerns automatic control of liquid steel level.

The metallurgical research will be concentrated on steels killed with aluminium. Particular attention will be paid to centre segregation, surface defects and inclusions.

The refractory wear in the launder will then be determined in a long-term test. In conclusion a cost comparison will be made with the conventional continuous casting method.

The project is proposed by ARBED in Luxembourg (L). It will take approximately two years.

b) Electric steelwork

P 549 - Mathematical model to optimize the electric steelmaking process

Research project 6201-Ca-1/105 on the same subject is almost completed.

In the course of the agreement the following developments have been made in electric steelmaking :

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1. Appreciable increase in specific melting capacity.
2. Use of oil-oxygen burners in the electric furnace to increase melting capacity.
3. Automatic monitoring of furnace wall temperature.
4. Use of water-cooled wall components.

In order to bring the research results up to date with the newest developments, the four above-mentioned points are to be incorporated in the electric steel-making model devised.

The research has been proposed by the Betriebsforschungsinstitut in Düsseldorf (D) and is expected to take nine months.

P 554 - Investigation of the high voltage system and line feedback effects of arc furnaces

Theoretical studies and practical tests on an arc furnace are necessary for this programme :

1. The effects of voltage and wattage measurement errors (caused by harmonics and induction) on impedance control are to be investigated.
2. Alternatives to impedance control are to be investigated. These alternative methods of controlling the arc size will possibly be superimposed on impedance control.
3. Ways of reducing low frequency variations in mains voltage by the mode of operation of the furnace are to be investigated.
4. The way in which the powersystem voltage harmonics caused by the arc are dependent on mode of operation - especially on the symmetrical or asymmetrical setting of arc sizes, are to be investigated.
5. The way in which the low frequency voltage fluctuations and harmonics of several arc furnaces are superimposed are to be investigated.

The project has been proposed by the Betriebsforschungsinstitut in Düsseldorf, (D). It will take three years.

IV. "ROLLING MILLS AND PROCESSING" Programme

P 507 - Coiling temperature control in wide strip mills

When flat products are hot rolled, the intrinsic quality of the steel depends chiefly on the finding and coiling temperatures. Automatic monitoring and regulating systems have been introduced so as to maintain these temperatures as close as possible to their optimum set value throughout the coil but they only partly achieve their purpose because of the lack of flexibility and efficiency in existing cooling systems.

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The aim of this project is to develop a highly efficient cooling system to follow the main cooling sprays.

This will enable faults owing to poor regulation of the main cooling ways to be corrected by incorporating a cooling control algorithm in the computer controlling the mill.

The project is proposed by the Centre de Recherches Métallurgiques in Liège, (B), and will take four years.

P 551 - Optimum design of rolling mill drives

Like any machine, rolling mills have moving parts which start to resonate at certain production speeds, causing vibration of a frequency and amplitude that often adversely affect the service life of the rolling stand components. Various methods of overcoming the harmful effects of this vibration have been studied, but no systematic study has been made of the primary causes of the vibration, i.e. the drives themselves.

The project aims to fill this gap by systematically investigating a large number of mass distribution configurations in rolling mill drives.

The expected results should enable new rolling mills to be designed or existing installations corrected so as to eliminate such vibration.

The project is proposed by the Betriebsforschungsinstitut in Düsseldorf, (D) and will take three years.

P 552 - Improvement of loop lifter control in hot strip mills

In modern wide strip mills, the strip generally moves at around 17-22 m/sec and the speed may be as high as 30 m/sec in the most recent installations. Under these conditions, to obtain reliable guiding and constant strip width the strip tension between stands must remain constant in order to offset the relative speed variations between the rolls of successive stands.

Existing loop lifters of the electromechanical, pneumatic or hydraulic type are not entirely efficient, mainly because the relations between the dynamic position of the loop lifter and its consequences on rolling are insufficiently known.

The purpose of the project is to make a systematic study of loop lifter operating parameters so as to allow the various systems in use to be compared, with their advantages and drawbacks. In addition, the criteria to be met by a wide strip mill in order to eliminate the need for loop lifters are to be defined.

The research is expected to produce better knowledge of the tension phenomenon between stands and consequently better criteria for the design of new installations and the modification of existing ones.

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The project is proposed by the Betriebsforschungsinstitut in Düsseldorf, (D) and will take three years.

P 553 - Further development and testing of strip flatness and strip tension control system in cold rolling

Flatness is one of the most important quality criteria for cold-rolled steel strip, especially thin strip, tinplate and stainless steel. In addition, the flatness of the strip, with a specified tension equally distributed over its full width, is a very important factor for correct cold rolling without problems. Much research has recently been done on the design of a flatness measuring device for use on the mill in service (ECSC research 6210-60/070) but the conditions for its use have not yet been satisfactorily studied and defined.

The project proposes a systematic study of flatness and tension control during cold rolling on cold tension mills, Senzimir stands, flattening and skin-pass stands for cold strip, tinplate and stainless steel.

The research will include industrial-scale tests carried out on industrial plant in service.

The project is proposed by the Verein Deutscher Eisenhüttenleute in Düsseldorf, (D), and will take four years.

P 578 - Improvement of the cold rolling of Al or Si killed steels

At the present time 20 % of the steel produced in Western Europe is continuously cast and about 85 % of that 20 % takes the form of slabs, a large proportion of which will be cold rolled. Continuously cast steels are at the moment all killed steels (aluminium, silicon, etc.) as rimming steels cause casting problems. This technique, which is being used for an ever-growing share of steel for rolling, and particularly cold rolling, has one extremely serious drawback.

Killed steels contain inclusions of alumina or silicon carbide, depending on the addition used. When these inclusions appear on the strip surface they have an abrasive effect on the work rolls and this "polishing" effect causes slip necessitating replacement of the rolls, sometimes after they have been used for only a few tonnes of steel.

The project aims to study the distribution of alumina or silicon carbide in slabs and strip, together with the phenomenon of roll abrasion, and to seek metallurgical and/or technological methods of mitigating or eliminating rolling problems.

The project is proposed by the Institut de Recherches de La Sidérurgie Française at St Germain-en-Laye, (F), and will take four years.

P 579 - Roll bending of heavy plate mills

Two ECSC research projects (6210-71/3/031 and 6210-71/3/032) have already been carried out on the counter-deflection of mill rolls in heavy plate

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mills; the first was devoted to the theoretical aspects and to experiments and the second, which is still in progress, concerns the industrial application of the method.

The two principles used (Worb and Burb) are efficient enough for the present purpose, i.e. to improve the design and flatness of the plate, but are extremely costly to use and necessitate extensive modification to rolling stands. Tests have shown that a balancing device (similar to the Worb counterdeflection system) is efficient. This device could be adapted fairly simply to most existing plate mills.

The purpose of the project is to study, develop and test a work roll balancing system similar to a Worb type counterdeflection system and adjustable to meet varying requirements.

It is expected to produce an average gain of about 15 points in yield (3 to 28 depending on the plate dimensions).

The project is proposed by the Institut de Recherches de la Sidérurgie Française at St Germain-en-Laye, (F), and the Forges et Aciéries de Dilling, (D), and will take three years.

P 591 - Optimum management of soaking pit batteries

Up to now soaking pits have generally been managed manually with an enormous wastage of energy. Two projects are now in progress in an attempt to optimize the reheating process, but mainly from the angle of the suitability of the ingot for rolling (6210.79.F and B).

In Japan, more or less automatic systems have already stepped up the output of a soaking pit battery and produced energy savings; but at the cost of enormous investment. The aim here is to remedy this situation by designing and constructing an automatic management system for a few celled only. After the development stage, if favourable results have been obtained, the system will be enlarged and in a second stage designed to manage all the cells. This step-by-step approach should enable the difficulties to be solved more efficiently and at lower cost.

The research is expected to lead to a considerable reduction in energy consumption and a more homogeneous thermal state of the ingots.

The project is proposed by the Centro Sperimentale Metallurgico in Rome, (I), and Fiat Teksid in Torino, (I). It is expected to take two-and-a-half years.

P 592 - Control of decarburization and scaling in industrial reheating furnaces for hot rolling

At present decarburization and scaling during the reheating of steel products are only empirically tracked and controlled. There is as yet no model describing these phenomena that can be applied to computerized reheating control. As a result, products are of poorer quality and there is a relatively high loss of production referred to specific input. The aim of the proposal is to

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develop an automatic system to predict the extent of decarburization and scaling in a product as it is being reheated, as a function of all operating conditions and variables such as time, product temperature, furnace temperature, flame characteristics, furnace atmosphere, steel composition, etc.

Then an automatic control system will be developed so as to optimize the above factors in order to reduce decarburization and scaling to a minimum.

The project is proposed by the Centro Sperimentale Metallurgico in Roma, (I) and Guest, Keen and Nettlefolds in Cardiff, (GB). It will take two years.

V. "MEASUREMENTS" ProgrammeP 514 - Inspection and repair of surface defects on hot slabs

The well-known advantages of direct rolling between a slabbing mill and a hot strip mill become even more profitable as the cost of energy and labour increases.

The main obstacle to such a method at the present time is the need for continuous inspection to remedy surface defects.

It is therefore necessary to find a means of defining the coordinates of defects on the slab surface.

This is the purpose of the project, which will analyse a lighting system helping to improve the contrast of the defects. Later a scarfing plan for selective repair of cracks and other defects observed will be formulated.

This project is estimated to take four years and has been proposed by Hoogovens of IJmuiden, (NL).

P 516 - Automatic recording and memorising of surface defects in cold slabs for the development of data prior the ordening an automatic spot scarfing machine

The steel industry is faced with the problem of conditioning slabs in order to meet the quantity and quality requirements for production purposes.

In most cases this is done empirically by a manual method. The workers who repair the defects use an oxy-acetylene torch under very arduous working conditions characterized by heat, dazzle and the dust caused by the lance. The project aims to make this type of work more efficient and at the same time socially more acceptable. First of all a study will be carried out to observe these defects and then a method will be selected and the repair operation will be mechanized and automated.

Major defects will be stored for automatic control of a multiple-head spot scarfing machine. Quite apart from the social consequences, this rational development will undoubtedly be economically viable.

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The project is planned to take three years and has been proposed by Italsider of Tarento, (I) and the Centro Sperimentale Metallurgico of Roma, (I).

P 523 - Gauging product length in long product mills

Systems for cutting products to length comprising length measurement and positioning that are suitable for installation on existing mills have to meet the following requirements :

- wide range of lengths for the initial product
- system independent of product speed
- system independent of product position on the roller table
- possibility of measuring useful length after cropping
- gauging facility.

Preferably the system should be able rapidly to calculate optimum lengths from the length of the initial product.

The methods currently available such as dynamic infra-red sensors, assemblies of local sensors and laser-based sensors are often extremely expensive or do not meet all the requirements mentioned above.

The purpose of this project is to develop a measuring system based on television cameras.

The system uses a microcomputer for line-by-line analysis of the televised image.

The principle of image analysis by computer is known in many fields and previous work has been done on it. It appears feasible to apply it to length measurement.

Planned programme :

- 1) Development of programming and laboratory simulation;
- 2) Erection of a pilot installation consisting of two cameras with interface and microcomputer on a blooming mill;
- 3) Industrial tests.

This research, planned to last two years, has been proposed by ARBED of Esch-sur-Alzette, (L).

P 531 - Condition monitoring of production machinery in steelworks

This project is a logical follow-up to previous ECSC-funded work (agreement 6210.92/8/801). That work was concerned in particular with the detection of incipient failure of bearings, using vibration analysis and spectroscopic analysis of the oil. The objects of the new project are to develop and apply

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in the steelworks situation the techniques of vibration analysis of machinery, particulate analysis of fluids and oils and other condition monitoring techniques in order to detect incipient plant failure and so increase the availability of plant machinery.

The plan of work is as follows :

1. The extension of vibration analysis techniques to slow-rotating larger machinery,
2. The use of vibration analysis in detecting incipient failure in gear boxes,
3. Condition monitoring of machinery using fluid-based techniques,
4. Incidence of certain criteria in preventing failure of journal bearings :
 - a) shaft orbits
 - b) housing accelerations
 - c) pressure distributions inside the centre bearings
 - d) housing and oil temperatures
 - e) pressure fluctuations in oil lines
 - f) contamination of oil using spectrometric methods
 - g) filter and magnet plug deposits.

All this work is proposed by the British Steel Corporation, Battersea Laboratory in London, (GB). The estimated duration is three years.

P 555 - Ultrasonic examination of rolled products, particularly heavy plate. Development of a prototype machine

Electrodynamic ultrasonic transducers have been developed in recent years. The principle involved, the conversion of electric pulses into acoustic pulses and vice versa, has one great advantage : there is no need for the film of liquid formerly required. These methods are therefore extremely useful for industrial applications as contactless ultrasonic scanning can be carried out on parts at elevated temperatures. What is more, the surface state no longer affects the quality of the readings.

This research project plans to make maximum use of these advantages for industrial applications by developing the technique for the inspection of sheet and strip, i.e.

Inspection by means of transverse waves with vertical incidence

Inspection by means of surface waves

and by optimizing the transducers used for this purpose.

The work will be shared on site by the departments of Hoesch Hüttenwerke AG and the Institut für Zerstörungsfreie Prüfverfahren (IZfP). The programme is as follows :

- Detection on heavy plate (3-80 mm thick) of defects at least 2 mm in diameter;
- Construction of a pilot plant for inspection of heavy plate under industrial conditions.

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The following work will also be carried out in parallel :

- Development of transducers suitable for use in the mills (plate up to 25 mm thick);
- Installation of programmable electronics operating at about 50 Hz for a strip width of 5 cm and speed of 2.5 m/s;
- Improvement in the interpretation of the signals obtained;
- Evaluation of defect length and width;
- Increase in the light intensity of zones close to the surface.

The project is proposed by the Verein Deutscher Eisenhüttenleute in Düsseldorf, (D), and is estimated to take three years.

P 581 - Examination of surface defects location on billets and wire by Eddy-currents

The economic advantage of inspecting semi-finished as well as finished products is obvious as it prevents the rolling of defective billets and allows inspection of wire rod during rolling on the rod mill so that mill maladjustments can be detected and rapidly corrected. Of existing techniques, the eddy current methods appear well suited for automation. The purpose of this research project is to continue the development of surface defect detection on wire rod and also to apply the new "multiprobe and multifrequency" techniques to the inspection and surface examination of billets.

The aim is to detect, on hot or cold as-rolled billets, any seams, scabs or cracks requiring repair or warranting rejection of the billet in order to prevent the rolling of defective products.

It should lead to rationalization with definite economic advantages.

The programme is proposed by the Institut de Recherches de la Sidérurgie Française at Saint Germain-en-Laye, (F), and is estimated to last three years.

P 595 - Acoustic emission defect location and grading in welded structures

Acoustic emission is becoming a valuable dynamic non-destructive technique for evaluating the structural integrity of various materials and pressure retaining components.

It appears technically certain that there is a very wide range of applications for this new method.

The research proposal is limited to thin-walled (not more than 30 mm thick) welded structures, mainly pipelines.

The programme aims are chiefly :

- To complete the hardware and software of the multi-channel system already available in the laboratory concerned;
- To design an industrial plant permitting satisfactory detection.

The preliminary experimental approach will comprise :

Evaluation of the amplitude and energy distributions of the signals performance in the laboratory of experimental tests on a new design of test pieces for destructive testing.

The project is proposed by the Centro Sperimentale Metallurgico in Roma, (I), and is estimated to take three years.

VI. "PROPERTIES AND SERVICE PERFORMANCE" Programme

a) Weldability

P 563 - Crack sensitivity, deformation and fracture behaviour of the heat-affected zone of weldments in high-strength fine-grained construction steels

The welding of very thick-walled pressure vessels, especially for reactor engineering, is frequently a source of difficulty because the heat-resistant fine-grained construction steels suitable for this application have a definite tendency to cracking in the heat-affected zone under the relevant conditions (high internal stresses with a degree of multi-axiality) caused by the large thicknesses). The severe testing called for by the increasingly stringent safety requirements has shown that these cracks can occur even if the steels concerned, e.g. steels 20 MnMoNi 5 5 and 22 NiMoCr 3 7, are perfectly welded with the greatest care.

The aim of the project is to elucidate the causes and mechanism of this cracking in thick-walled weldments (internal processes and/or grain boundary processes). The chemical composition of the steels concerned will then be optimized in respect of accompanying elements in such a way as to retain a maximum of toughness even in the heat-affected zone of the thick-walled weldments found in reactor pressure vessels and to an increasing extent in general purpose pressure vessels, even under economic welding conditions, and to avoid the risk, which increases with wall thickness, of cracking during welding and stress-free annealing and of the propagation of these cracks under service stresses.

The tests are to be carried out both on industrially produced cracked components and on actual welds with large wall thicknesses for which industrial melts of the steels concerned with varying contents of trace and accompanying elements will be worked to the state of semi-finished products with a minimum thickness of 100 mm. This will enable the conditions in thick-walled weldments to be investigated without need to rely on simulation. The cracked components and actual weldments will be used to obtain information on toughness and fracture behaviour and in particular cracking mechanisms by means of all the suitable destructive, non-destructive, physical and chemical methods.

b) Formability

P 505 - Spot welding of high-strength deep-drawing steels and properties of weldments

In this project, the aim is to define the best method of spot welding high-strength deep-drawing steels so as simultaneously to meet the requirements

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resulting from static stresses and to retain the best possible resistance to dynamic stresses.

The various parameters examined will be :

- the thickness of the sheet and the grade of high-strength steel (yield strength 280-400 N/mm²), mainly of the low-carbon and microalloy type;
- the optimum welding conditions;
- the performance of the spot welds;
- the influence of the geometrical layout of the spot welds.

The work will take two years and is proposed by the Centre de Recherches Métallurgiques, Liège, (B), it will be coordinated with the work on proposal P 538/2.

P 508 - New continuous reheating cycle for tin-plate

This project is designed to develop a new annealing cycle for tin-plate including quenching in boiling water; it will extend up and down the temper scale (ASTM hardness scale) the range of steels suitable for continuous annealing.

- Test to obtain tempers 2 (hardness 50 - 56) and 3 (hardness 54 - 60) by continuous annealing (killed temper 1, hardness 46 - 52, should preferably be bell annealed to remain non-aging).
- Test to obtain tempers 4 (hardness 58 - 64) to 6 (hardness 67 - 73) from steels less hard than is currently possible.
- Attempt to obtain new extra-hard products by heat treatment.

This work, which will take four years, is proposed by the Centre de Recherches Métallurgiques, Liège (B).

P 538 - Resistance spot weldability of steel sheet

The purpose of this proposal is to :

1. Establish rational static (tensile shear, cross tension) and dynamic (impact tensile shear, impact cross tension, fatigue tensile shear, fatigue cross tension) strength tests for resistance spot-welded low-carbon and HSLA steel sheets (1-5 mm thickness), and to develop realistic shop floor tests to allow proper control of the weld quality in production.
2. Evaluate the tests established in 1, when welding suitable grades of low-carbon and HSLA steel sheets with single spot welds and when using arrays of spot welds.

The above work, which can be completed over a period of three years, is proposed by the Welding Institute, Abington, Cambridge, (GB), and will be coordinated with the work described in proposal P 505.

P 583 - Suitability for cold forming

The aims of the proposed research are :

- to define or confirm the relations between the law of work-hardening of steels and direct or indirect extrusion stresses;
- to define the influence of geometrical parameters (die) and metallurgical parameters on the conditions for the occurrence of internal removal of work-hardening in direct extrusion;
- to define the influence of the same parameters on conditions for the occurrence of surface cracks in indirect extrusion;
- to study the behaviour of grades or structures regarded as less favourable for cold forming but having other advantageous properties (lamellar structures for machining. Pb or S steels for seven cutting, etc.);
- to study correlations between extrusion performance and the results of laboratory tests used to define suitability for cold forming;
- to study the influence of forming conditions on the intensity of residual stresses.

This work, which will take three years, is proposed by the Institut de Recherches de la Sidérurgie Française, St Germain-en-Laye, (F).

c) Constructional steels

P 586 - Plastic deformation in the $\delta + \alpha$ range for various ordinary steels

Rolling schedules having fairly low final temperatures developed in recent years can now be used for the production of 40 % of European heavy plate. This tendency appears to be gradually gaining ground in the production of sheet on continuous strip mills where an excellent compromise is obtained between the characteristics of strength and ductility that can still be increased.

This research project will enable the influence of plastic deformation in the $\delta + \alpha$ range to be studied from various aspects.

The research will concentrate on ordinary C-Mn grades, semi-killed or killed with the possible addition of dispersoids (or very low alloyed grades).

Several aspects will be taken into account by using carefully selected experimental conditions.

- (a) Evolution of flow stresses for two-phase structures.
- (b) Influence of work hardening either before or during $\delta + \alpha$ transformation on the progress of this transformation.
- (c) Incidence of the two-phase state on intrinsic forgeability at high deformation speed and measurement of the relative plasticity of two phases for an imposed total deformation.

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- (d) Influence of work-hardening on recrystallization in the ferritic or mixed phase and on precipitation (AlN, carbides or carbonitrides of dispersoids) in the ferritic or mixed phase.
- (e) Incidence of deformation in the mixed phase on the properties of the final product (mechanical properties, textures, laminations).

The research was proposed by the Institut de Recherches de la Sidérurgie Française at St Germain-en-Laye, (F), and will take three years.

d) Fracture

P 539 - Elasto-plastic fracture toughness testing and assessment methods

The method used for assessing the toughness of materials which fail under elastic conditions are now widely accepted and based on the critical stress intensity factor K_{IC} . However, in the field of elastic-plastic fracture, i.e., for materials which, in the thickness and at the temperatures of interest, display significant plasticity prior to failure, there is still no consensus of opinion about the most satisfactory approach.

It is proposed that a medium strength C-Mn steel (tensile strength = 500 N/mm²) and a higher strength low-alloy steel (tensile strength = 600 - 650 N/mm²) both 50 mm thick, should be used in the programme. Each laboratory will prepare a report describing its own studies carried out within the programme. An overall review of the programme results will be prepared by the Welding Institute in collaboration with the other participants.

The above mentioned work, which can be completed over a period of one year and a half, is proposed by the Welding Institute, Abington, Cambridge, (GB).

The Welding Institute will be the programme coordinator with the following collaborating laboratories :

- Centre de Recherches Métallurgiques, Liège, (B)
- Laboratorium voor Weerstand van Materialen, Ghent, (B)
- Institute for Industrial Research and Standards, Dublin, (Ir)
- Institut de Recherches de la Sidérurgie Française, St Germain-en-Laye, (F)
- Atomic Energy Commission, Risø, (DK)
- Institut de Soudure, Paris, (F)
- Institut für Eisenhüttenkunde, Technical University, Aachen, (D)
- Max Planck Institut für Eisenforschung, Düsseldorf, (D)
- Centro Sperimentale Metallurgico, Roma, (I)
- Metaal Instituut TNO, Apeldoorn, (NL)
- British Steel Corporation, Physical Metallurgy Centre, Rotherham, (GB).

e) High-temperature steelsP 525 - Cavitation and fracture in creep-resisting steels

In a recent ECSC-supported study, cavity nucleation and growth during uni-axial testing was investigated in some detail and the nucleation and growth were related to stress, strain, temperature and time. It was also shown that the same basic phenomena of cavity nucleation and growth were responsible for the propagation of pre-existing cracks in Commercial steels tested under creep conditions. It would appear, therefore, that a knowledge of the effects of grain size and stress state on cavitation would be of direct relevance to "in-service" cracking of weldments and this proposed research is aimed at providing basic information on these aspects of creep performance.

The study will be confined to two high-temperature ferritic steels : 1 % Cr - 1/2 % Mo and 2 1/4 % Cr - 1 % Mo, and the programme of high temperature testing and subsequent cavitation damage studies will be directed at providing information on :

- the stress state dependence of the nucleation and growth of cavities
- the grain size dependence of cavitation processes
- the criterion of failure.

The project has been proposed by the British Steel Corporation, London, (GB) over a period of three years.

f) Marine technologyP 590 - Offshore structures : tubular joint stress analysis

The work proposed consists in a finite element elastic stress analysis of six tubular connections. The tubular joints studied consist of an unperforated principal tube or chord. One or two smaller tubes or braces have suitably profiled end faces and are attached to the chord so that the centre lines of the brace and chord are at 90°. Where a single brace is attached, this is referred to as T-joint; where two braces are attached, they are placed on opposite sides of a diameter of the chord and form a cross-joint or X-joint.

This work would be carried out as part of the current offshore research programme in order to calculate and provide the results necessary to continue the IRSID programme.

This work, which will take six months, will be managed by the UK Offshore Steels Research Project Management, and the calculations will be carried out by Atkins Research and Development using the finite element programme ASAS and the post- and pre-processor programmes developed for UKOSRP.

The work described above, covering a period of 6 months, will be complementary, to that already in progress under contract 7210-8/801 with the Department of Energy in London, (GB).

Annex 2g) Light structuresP 490 - Investigation in the criteria of European domestic comfort and the technical obstacles to industrialized building systems

The period of two years allowed for research project P 370 was too short to enable soundly-based criteria to be established. Several of the research topics included in the project require a longer period of research than the two years that have already elapsed :

- deflection of the steel structure and its effects on construction and engineering;
- mechanical testing of the slabing components with adjoining structures;
- measurement of the heat requirement at the "internal" heating plant through the constant conductor of the district heating system;
- cooperation with the test residents as regards the psychological and physiological aspects of living in the ECSC experimental station and the physical aspects of the buildings;
- a report on the experience gained will be prepared in cooperation with the residents of the experimental station.

The following research topics will be covered in detail :

- evaluation of living comfort and convenience with the existing building materials and layout by the tenants taking part in the research;
- analysis of the use of the free space in the dwellings such as terraces, central courtyards, balconies, porches, etc., with particular reference to the steel components used in them;
- other additional investigations that prove necessary during the research and are agreed with the Commission.

This work, lasting one year, to be executed by the Forschungsgesellschaft für Industrielle Bausysteme mbH, Berlin, (D), will be complementary to that already in progress at the Berlin station under contract 7210-SA/104.

P 515 - Possibilities for the production of steel windows using stamping

Under this research project, it is planned to study a new type of window which, designed to be both functional and aesthetic, can exhibit, can exhibit both more useful service properties than the windows available today and better corrosion resistance, giving it a longer life.

Stamping can give the rolled product the desired shapes and dimensions by exploiting the plastic properties of stamping steel which, when subjected to specific working, loses its original configuration and takes on a new permanent shape.

This research is proposed by Italsider, Genova, (I), and will take two years.

Annex 2h) Alloy and special steelsP 487 - Research programme on losses in electrical sheets

The theoretical results obtained under the previous ECSC contract require further investigation and verification on various materials. Consequently it is proposed to carry out a theoretical and experimental investigation to clarify the mechanisms and the actual extent of the contributions to losses made by the processes of correlation between Barkhausen effects, and consequently between irreversible motions of Bloch walls, according to the following general scheme :

1. Theory of losses

- effect of correlations on losses
- effect of nucleation on losses

2. Measurements on large electrical sheets

3. Contribution to the development of electrical sheets for use in electrical engineering.

P 536 - Effects of sulphur and sulphide shape on the mechanical properties and machinability of alloy steels

The aim of this research is to explore further the possibility of minimizing the adverse effects of sulphides on mechanical properties while enhancing the machinability of medium-carbon steels, through the addition of calcium by injection techniques. It is well established that sulphur additions can markedly improve the machinability of steels but, if not properly controlled, can produce adverse changes in the toughness or fatigue properties of the finished component.

The research will concentrate on the two steels - Cr - Mo (708 M 40) and Cr - Ni - Mo (AISI 8620) - which will be produced with two levels of sulphur content within the range 0.05 to 0.3 % as well as three levels and two rates of calcium addition.

The evaluation of the steels will cover machinability testing, the assessment of mechanical properties and metallographic examination.

The project will take three years and it has been proposed by the British Steel Corporation, London, (GB); the research will be co-ordinated with that to be undertaken in proposal P 565.

P 544 - Basic properties of grain-oriented electrotechnical steels

This proposal represents an extension of the more promising lines of investigation that have emerged from a current ECSC supported research project on the properties of grain-oriented electrotechnical steels; the main aspects to be studied in the next phase cover :

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1. Loss and domains - to include the examination of the factors that control domain wall spacing and motion as well as power loss in multi-grain domain systems.
2. Transformer wave forms and related topics - this will cover waveforms in single strips and Epstein Squares, waveforms in transformer cores and theoretical studies aimed at predicting flux distributions in different types or core configuration and to comparing the magnitude of calculated and experimental harmonic levels.

This project has been proposed by the British Steel Corporation, London, (GB) over a period of three years and will be coordinated with the research proposed in P 487.

P 565 - Influence of sulphide shape and its effects on the mechanical properties and machinability of special construction steels

The aim of the project is to investigate the influence of the elements zircon and calcium as special sulphide-forming agents on the mechanical properties and machinability of aluminium-killed special construction steels with a high sulphur content. Special construction steels with a ferritic-pearlitic structure (Ck 45 and 49 MnVS 3) and with a quenched and tempered structure (42 CrMo 4) are selected as materials for components to be subjected to intensive machining.

The research will be divided into three phases :

1. Optimization of the addition of zircon or calcium with sulphur contents varying from 0.03 to 0.1 % from the viewpoint of composition, quantity, size and hot formability of the inclusions and the mechanical properties and machinability of the materials. This work will be carried out on melts produced on a semi-industrial scale.
2. Using industrial melts, determination of the influence on mechanical properties and machinability of the zircon and sulphur contents determined selected on the basis of the semi-industrial scale tests.
3. Determination of the optimum conditions for the addition of calcium on an industrial scale to steels with a high sulphur content and testing of the mechanical properties and machinability of steels made in this way.

This work, which will take three years, has been proposed by the Verein Deutscher Eisenhüttenleute, Düsseldorf, (D); it will be coordinated with the work on proposal P 536.
