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**DG Research**

***European Coal and Steel Community***

**Synopsis of the ECSC Steel projects**

**1994-2001**

<http://www.cordis.lu/coal-steel-rtd/home.html>



## Table of content

<b>B</b>	<b>Reduction of iron ores</b>	<b>2</b>
<b>C</b>	<b>Steelmaking</b>	<b>28-89</b>
C1	Primary Steelmaking	28
C2	Secondary Steelmaking	49
C3	Casting and solidification	62
<b>D</b>	<b>Rolling mills and mechanical working</b>	<b>90-159</b>
D1	Rolling long products and reheating furnaces	90
D2	Rolling flat products	100
D3	Physical metallurgy of rolling and finishing	129
<b>E</b>	<b>Analytical techniques for processes, products and environment</b>	<b>160-177</b>
<b>F</b>	<b>Properties and service performance</b>	<b>178-289</b>
F3	Special and alloy steels	178
F4	Thin sheets	205
F5	Mechanical characteristics	220
F6	Steel structures	235
F7	Surface characteristics	259
<b>T</b>	<b>Pilot and demonstration projects</b>	<b>290-338</b>
T1	Iron and steelmaking	290
T2	Hot rolling continuous casting	303
T3	Cold rolling and product treatment	314
T4	On-line control	324
<b>TGS1</b>	<b>Ore agglomeration and iron making</b>	<b>339</b>
<b>TGS2</b>	<b>Steelmaking processes</b>	<b>350</b>
<b>TGS3</b>	<b>Casting, reheating and direct rolling</b>	<b>368</b>
<b>TGS4</b>	<b>Hot and cold rolling processes</b>	<b>382</b>
<b>TGS5</b>	<b>Finishing and coating</b>	<b>398</b>
<b>TGS6</b>	<b>Physical metallurgy and design of new generic steel grades</b>	<b>416</b>
<b>TGS7</b>	<b>Steel products and applications for automobiles, packaging and home appliances</b>	<b>436</b>
<b>TGS8</b>	<b>Steel products and applications for building, construction and industry</b>	<b>448</b>
<b>TGS9</b>	<b>Factory-wide control, social and environmental issues</b>	<b>471</b>

**Technical Group B : "Reduction of Iron Ores"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-AA/135	B.1/94	1.182.936	668.522	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Improved blast furnace control

**OBJECTIVES AND CONTENTS**

Changing technical and economic constraints on blast furnace operation require that flexible blast furnace control methods be adopted in order to ensure stability of the required iron quality and quantity under any conditions. The objectives of this research are to investigate different approaches which are claimed to surpass control methods currently in use: application of model-based control strategies for improved regulation of hot metal qualities, application of automatic knowledge acquisition methods for ensuring that supervising expert systems are kept up to date, and application of artificial neural networks for data compaction and process state classification and prediction.

**State of progress:** Research completed; publication EUR N° 19342

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7210-AA/419	B.2/94	1.679.735	991.160	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Development of a combined postcombustion model (CPM) for smelting reduction processes

**OBJECTIVES AND CONTENTS**

In smelting reduction processes, oxygen and coal consumption is strongly dependent on the gas chemical energy utilization, i.e. on the postcombustion ratio.

The objective of this project is to develop a combined postcombustion model for improving operation and engineering of smelting reduction processes.

Three existing mathematical models are to be improved. In two of these models, kinetic aspects of postcombustion are included; one model refers to the free space zone and the other one to the slag zone. In this latter model, foaming phenomena are also considered. The third model - dynamic slag-droplet model of converter - will first be modified to take into account postcombustion, and then to incorporate elements of the first two models.

Single improved models are validated at different scales from laboratory, to pilot plant and to industrial scale, and then the combined model is validated on pilot and industrial plant and finally, implemented for on-line validation on a pilot plant for process management.

**State of progress:** Research completed; publication EUR N° 19346

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7210-AA/320	B.1/95	1.957.500	1.174.500	48 (Mths)		1/07/1995	30/06/1999	30/06/1999

**Title:** Assessing the internal state of the raceway/dead man area of the blast furnace at low coke rate

**OBJECTIVES AND CONTENTS**

The use of high rates of coal injection in the blast furnace and the resulting reduction of coke charged in the furnace lead to important modifications of the internal state of the furnace, especially in the hearth and raceway areas. The objective of this multinational project is to obtain improved control of three important phenomena regarding high coal injection rates, i.e.: the consumption of coal in the furnace (combustion vs gasification), the permeability of the hearth and dead man, the behaviour of the raceway as gas distributor in the furnace. These phenomena will be assessed by direct investigations and measurements on operating furnaces, and data will be provided for further modelling of the processes.

**State of progress:** Research completed; publication EUR N° 20172

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7210-AA/219	B.2/95	1.974.500	1.184.700	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Modelling of gas and char flows at high PCI rates through experimental and theoretical studies of the raceway and the dead man

**OBJECTIVES AND CONTENTS**

There is a general consensus that gas flow monitoring is one of the keys to high PCI (Powdered Coal Injection) rates. Since gas distribution is the result of numerous phenomena with complex interactions, the best approach appears to be its simulation by mathematical modelling.

In order to attain even greater PCI rates, the project is aimed at developing a mathematical model of the gas flow in the blast furnace based on experimental and theoretical studies of the raceway and the dead man, taking into account the distribution and consumption of unburnt particles of coal.

**State of progress:** Research completed; publication EUR N° 20094

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7210-AA/421	B.3/95	761.500	456.900	30 (Mths)		1/12/1995	31/05/1998	31/05/1998

**Title:** Investigation of fuzzy logic and neural network based strategies for control optimisation of iron making processes

**OBJECTIVES AND CONTENTS**

The objective of the present proposal is to investigate the application of fuzzy logic and neural network-based systems to the control of ironmaking processes. In particular, the objectives relate to control of blast furnace parameters, as well as advisory systems intended to optimize use of fuel and coke. The third objective is to use such strategies to aid in desulphurization of hot metal in torpedo ladles. Various control strategies will also be compared, e.g. adaptive model algorithmic control (AMAC), internal model control (IMC), fuzzy control strategies.

**State of progress:** Research completed; publication EUR N° 19348

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7210-AA/901	B.4/95	500.000	300.000	36 (Mths)		1/12/1995	30/11/1998	30/11/1998

**Title:** Advanced control of operational sintering using on-strand-measurements and neural network

**OBJECTIVES AND CONTENTS**

The aim of the research project is to study advanced control of operational sintering using on-strand measurements of permeability, waste gas oxygen concentration and temperature; ultimately a study using neural networks will be used. The results will improve energy consumption and strand productivity.

**State of progress:** Research completed; publication EUR N° 19344

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7210-AA/142	B.1/96	996.500	597.900	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Optimization of tapping strategy by advanced assessment of the liquid level in the heart of the blast furnace

**OBJECTIVES AND CONTENTS**

This research project aims to investigate the electromotive force on the blast furnace shell as a means of determining the level of liquid metal in the hearth. EMF measurements are currently difficult to interpret and it is considered that this project will provide a comprehensive understanding of the mechanisms involved, leading to improved stability and control of furnace operation with higher productivity and reduced lining wear.

**State of progress:** Research completed; publication EUR N° 19482

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7210-AA/143	B.2/96	1.560.500	936.300	48 (Mths)		1/07/1996	30/06/2000	30/06/2000

**Title:** Coke quality requirements for blast furnace operation with high levels of coal/oil injection

**OBJECTIVES AND CONTENTS**

The aim of the proposed work is to develop a cost-effective coke quality specification which will provide stable, efficient and consistent blast furnace operation at high injection/low coke rates. Investigations of the relationships between feed coke quality, coke degradation in the blast furnace, bosh coke quality, raceway structure and furnace operation will be carried out on blast furnaces operating at low coke/high injection rates. Comparisons will be made with furnaces operating with low injection levels, or possibly with the coke-only situation.

**State of progress:** Research completed; publication EUR N° 20105

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7210-AA/144	B.3/96	1.613.000	967.800	48 (Mths)		1/07/1996	30/06/2000	30/06/2000

**Title:** Fe burden quality at high coal injection rates

**OBJECTIVES AND CONTENTS**

Blast furnace operations involving high productivity, high PCI rates and low coke rates depend upon good coke quality and excellent Fe burden materials. Sinter quality is influenced by the components, chemical composition and preparation techniques. This project aims to investigate the chemical and physical properties of sinter samples prepared both in sinter plants and in laboratory trials, and also to conduct blast furnace pilot and plant trials to determine the quality requirements of sinter for high coal injection rates.

**State of progress:** Research completed; publication EUR N° 20106

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7210-AA/425	B.4/96	1.049.000	629.400	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title: Development of technologies for treatment of dusts and sludges containing zinc and lead to improve their recycle reuse (TREATDUST)**

**OBJECTIVES AND CONTENTS**

This research project aims to improve pyrometallurgical processes for treating zinc- and lead-containing dusts and sludges, whether they are produced directly or result from recycling within the plant. Work will include the study of pre- and post-treatment of charges and intermediate products in order to obtain richer Zn and Pb fractions. Purification processes for Zn and Pb enriched materials, arising from pyrometallurgical processes, will be developed which are able to produce cleaner fractions of various metals, more suited to metallurgical industries.

**State of progress:** Research completed; publication EUR N° 19474

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7210-AA/824	B.5/96	761.000	456.600	54 (Mths)		1/10/1996	31/03/2000	31/03/2001

**Title:** Reductions in dust and gaseous emissions from sinter strands

**OBJECTIVES AND CONTENTS**

A high temperature metallic filter has recently been developed. A pilot unit using this new filter will be installed on a full-size sinter plant to evaluate the filter in an industrial application. Other partners in the project will evaluate various filter materials as well as the implications of the metallic filter on recycling dusts collected and on the possibility of improving sinter strand operations to minimise the generation of corrosive and polluting components in the gas stream.

**State of progress:** Research completed; publication EUR N° 21146 EN

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**Technical Group B : "Reduction of Iron Ores"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/001	B.1/97	661.000	396.600	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Industrial operation at low coke rate and coal injection in excess of 220kg/tHM

**OBJECTIVES AND CONTENTS**

High coal injection rates have been achieved on several blast furnaces, but only for limited periods. The aim of this project is to establish the required conditions for achieving very low coke rates (< 300 kg/tHM) and coal rate in excess of 220 kg/tHM, under long-term industrial conditions. Special emphasis will be placed on the characterisation of the process. This investigation will be carried out on blast furnaces where the injection facilities have been recently revamped and extended. Operating at high coal rates has a beneficial effect on the environment in so far as it reduces coke consumption and allows for the closure of older installations.

**State of progress:** Research completed; publication EUR N° 20107

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/002	B.2/97	1.446.500	867.900	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Intelligent monitoring systems for blast furnaces

**OBJECTIVES AND CONTENTS**

Keeping process disturbances to a minimum helps in prolonging blast furnace campaign life. These disturbances can be rapidly determined by analysing thermal distribution in the wall and other stability indices using statistical techniques and neural networks. This research project will employ wall thermal data and existing mathematical models to recognise disturbances in burden permeability and asymmetric three phase furnace behaviour. New measurement and monitoring techniques for water leakage, tuyere leakage, iron temperature and hearth thermocouples will be developed to provide rapid warning of poor operation. The monitoring of wall temperatures and internal water leaks (tuyeres, cooling plates) can greatly contribute to avoiding breakouts and other critical situations.

**State of progress:** Research completed; publication EUR N° 20110

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/003	B.3/97	1.593.500	956.100	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Improvement of the yield of sinter strand and the regularity of sinter by control of charging conditions and monitoring of the flame front propagation

**OBJECTIVES AND CONTENTS**

This research project will attempt to improve control accuracy of the sintering process to achieve high productivity, stable operation and high sinter quality. The project has the following objectives:

- monitoring of flame front propagation. Investigation of ways of improving the uniformity of propagation across the width of the cake;
- evaluation of charging conditions on permeability; validation on industrial sinter strand equipped with charging control device;
- development of a tool, involving advanced techniques, to control the operating conditions of sintering.

**State of progress:** Research completed; publication EUR N° 20171

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7210-PR/004	B.4/97	962.500	577.500	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Characterizing the blast furnace cohesive zone

**OBJECTIVES AND CONTENTS**

In the blast furnace the cohesive zone greatly influences the gas flow pattern which in turn determines overall performance. Effective gas monitoring required by high coal injection rates cannot be achieved without a good knowledge of the cohesive zone characteristics and in particular its gaseous permeability. "Under load reduction" tests developed around the world are more concerned with the softening, melting and dripping temperatures of the ore. The objectives of this research project consist of characterising the permeability of the burden during softening and melting based on laboratory measurements, and in developing an improved model of the cohesive zone.

**State of progress:** Research completed; publication EUR N° 20197

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7210-PR/005	B.5/97	1.261.500	756.900	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Briquetting of self-reducing blendings of waste iron oxide mixtures

**OBJECTIVES AND CONTENTS**

The objective of this research project is to develop a technically and economically acceptable recycling process for residues with a high iron content in order to avoid their being dumped. To be more precise, it is intended to develop a low temperature briquetting process of self-reducing blendings which could then be charged into an Electric Arc Furnace (EAF) or into a cupola.

This research will be mainly focused on the processing of two kinds of residues:

- oily mill scales and sludges;
- EAF dust.

**State of progress:** Research completed; publication EUR N° 20108

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7210-PR/006	B.6/97	1.430.500	858.300	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Wear of the blast furnace hearth

**OBJECTIVES AND CONTENTS**

Maintaining and extending the safe working life of blast furnace linings is a major factor in prolonging productive asset life and maximising the recovery of capital investment by operators of integrated works.

This project will attempt to develop a clearer understanding of conditions within the furnace hearth, focusing on this critical area of the BF lining.

Knowledge of liquid motion in the hearth and the position of the 'furnace' deadman are important factors in prolonging the life of hearth refractories and will be used to improve process control.

**State of progress:** Research completed; publication EUR N° 20109

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/068	B.1/98	2.347.500	1.408.500	42 (Mths)		1/07/1998	30/06/2001	31/12/2001

**Title:** Investigations of chlorine and alkali behaviour in the blast furnace and optimization of blast furnace slag with respect to alkali retention capacity

**OBJECTIVES AND CONTENTS**

The blast furnace operation is known, but behaviour of chlorine in interaction with alkali within the blast furnace is quite unclear. With increasing injection rate of coal and especially plastic, the chlorine input is increasing. The aims of the project are: to investigate influences of alkali and chlorine compounds on sinter and coke quality ; the study of the formation of primary slag; the investigation of the influence of softening and melting behaviour of burden in a pilot blast furnace; the experimental study, in laboratory, of the influence of slag conditions on the alkali and sulphur removal and the verification of experimental results of laboratory and their application to the operation of blast furnaces.

**State of progress:** Research completed; publication EUR N°

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7210-PR/069	B.2/98	1.476.000	885.600	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Control of pollutants during sintering operation

**OBJECTIVES AND CONTENTS**

Sinter plants produce waste gas containing pollutants like dust and PCDD/F which have to be reduced to comply with the more and more stringent environmental regulations. The existing end-of-pipe cleaning techniques are very expensive in the case of sintering because of the large amount of waste gas to be treated. The objective of this research is to determine the most effective actions and to minimise the pollutants emissions without expensive end-of-pipe cleaning of the waste gases and with acceptable sintering results in terms of productivity and quality. The results of the project will strongly reduce pollution in and around integrated steel plants.

**State of progress:** Research completed; publication EUR N° 20373

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7210-PR/070	B.3/98	1.358.500	815.100	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Injectant coal gasification, char formation and char utilisation at high injection rates

**OBJECTIVES AND CONTENTS**

The aim of this project is to carry out an integrated laboratory, pilot and plant scale investigation of injectant coal gasification, char formation and properties, the effects of char on melting zone behaviour and the utilisation of char in terms of top gas dust carryover at high levels of injection. This involves primarily the study of coal devolatilisation and gasification leading to char formation; the effect resultant chars have on melting zone rheological properties and the influence of coal and char properties, injection conditions and coke properties on the composition of dust in the top gas at the blast furnace stockline.

**State of progress:** Research completed; publication EUR N° 20940 EN

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7210-PR/071	B.4/98	1.216.500	729.900	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Injection of slag correction components into the blast furnace

**OBJECTIVES AND CONTENTS**

The injection of slag correction components into the blast furnace is expected to influence the metallurgical reactions in the lower part of the blast furnace positively due to an aimed change in the slag composition in the hearth and a better raw material utilisation. The different injection techniques (reductant mixed with flux, reductant and flux separate) shall be evaluated comparatively. The experimental investigations shall be carried out at two different blast furnace plants. The results shall be compared with thermodynamic calculations to obtain generally acceptable knowledge applicable for an optimised slag metallurgy in the blast furnace operation. Based on that the development of an operational concept for an optimum slag correction in the blast furnace by tuyere injection shall be worked out.

**State of progress:** Research completed; publication EUR N° 20472

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/072	B.5/98	1.094.500	656.700	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Improved process control of a sinter plant

**OBJECTIVES AND CONTENTS**

The work program will include applications of burn-through profile management across the strand by automatic control of the roll feeder gates, burn-through point management along the strand by automatic control of strand speed, improved coke utilisation and ignition control, development of an on-line parameters, advanced control strategies for control systems which have long time delays and optimisation of mix moisture and permeability. A much better understanding of the mechanisms relating control variables to their effect on sinter production / quality and energy costs needs to be established. The project concentrates on sinter quality and production and their relationships, both statically and dynamically. Use of disturbance testing will provide the relationships necessary to investigate the potential improvement to the control of permeability, coke rate, strand speed and bed height.

**State of progress:** Research completed; publication EUR N° 20585 EN

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7210-PR/073	B.6/98	1.433.333	860.000	42 (Mths)		1/07/1998	30/06/2001	31/12/2001

**Title:** Above burden & in burden probe data interpretation by neural network based model to improve blast furnace control

**OBJECTIVES AND CONTENTS**

The objective of the present proposal is to investigate the application of fuzzy logic and neural network-based systems for control of ironmaking processes. Such objective relates in particular to control blast furnace parameters, such as data supplied by the above burden probes as well as advisory systems that aid in recognition of the relationships between these sensing devices and cohesive zone shape, burden materials, top level temperature distribution and other factors with an aim to optimise their use for the process control.

**State of progress:** Research completed; publication EUR N° 20725

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7210-PR/074	B.7/98	1.183.500	710.100	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Optimized blast furnace slag water quenching with sulphur compounds control

**OBJECTIVES AND CONTENTS**

Currently blast furnace slag is quenched by water mainly in order to produce high quality slag sand for utilisation in cement industry or cast into pits for lumpy materials. The project aim is to develop an improved industrial quenching process with regard to process conditions which avoids formation of H2S. It is expected that the results will provide a firm basis for the design and operation of slag water quenching which will reduce the generation of sulphur compounds in the gas phase and in the water phase to acceptable levels. This achievement will strongly reduce costs of operating slag quenching and granulation plants in the European steel industry.

**State of progress:** Research completed; publication EUR N°

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/122	B.1/99	1.006.500	603.900	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** New approach for the determination of the blast furnace cohesive zone

**OBJECTIVES AND CONTENTS**

The cohesive zone of the blast furnace acts as a gas distributor that has a powerful influence on the performances of the blast furnace through the gas/solids heat exchange phenomena, ores reduction by gas and heat losses control. As a consequence, this zone has a remarkable impact on the regularity of blast furnace operation and operating performances such as productivity, hot metal quality and regularity or reducing agent consumption. Many techniques have already been tried in the past but either they cannot be used on a routine basis or they lack of accuracy, or, else, they are hardly verifiable. The objective of the project is to propose a reliable methodology for the determination of the cohesive zone shape on the basis of the real time process data of the furnace. This methodology will stem from the performance of different kind of trials using existing techniques for the practical characteristics of the cohesive zone and their analysis in relation with the on-line measurement of the installations.

**State of progress:** Research completed; publication EUR N° 20941 EN

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7210-PR/123	B.2/99	1.537.000	922.200	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title: Determination of the coke bed voidage in the blast furnace hearth**

**OBJECTIVES AND CONTENTS**

The hearth lining is the most critical region of the blast furnace in terms of campaign life. Its wear is greatly determined by the iron flow pattern in the hearth which is governed by the distribution of the coke bed permeability, the structure and position of the deadman and the casting management technique. The knowledge related to these factors is not sufficient to get the heat flux under control; moreover this lack of knowledge is worsened by a lack of instrumentation in the hearth. The research aims at the development and the application of techniques and model tools that will allow an on-line evaluation of the blast furnace hearth conditions and permeability in order to guarantee a stable furnace operation and to control the refractory wear through early corrective actions.

**State of progress:** Research completed; publication EUR N° 20942 EN

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7210-PR/124	B.3/99	1.221.500	732.900	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Study of the behaviour of cement and mass joints utilized in aggregates of the steel industry

**OBJECTIVES AND CONTENTS**

In order to obtain high production rates and low production costs, the steel industry uses large vessels lined with high quality refractory materials and expects long campaigns without stoppages or incidents. The stability and the performance of the refractory lining of blast furnace hearth and of various other metallurgical reactors not only depend on the quality of the basic lining but also on the behaviour of the joining materials. The research project will focus on the study of these joining materials. Its main tasks will be: to study the behaviour of various kinds of joints at laboratory scale; to devise models that will use experimental results and industrial experience as a base for evaluating the behaviour of the entire line; to apply these models to actual situations

**State of progress:** Research completed; publication EUR N° 21133 EN

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**Technical Group B : "Reduction of Iron Ores"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/125	B.4/99	920.500	552.300	36 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title: Critical review of existing procedures for the characterisation of the metallurgical properties of blast furnace burden material at conditions of high injection rates**

**OBJECTIVES AND CONTENTS**

The metallurgical properties of pellets, sinter and lump ore are predominantly described by their disintegration behaviour, their reducibility as well as by high temperature properties like melting and dripping. Under conditions of high injection rates and extended retention time of the burden in the blast furnace, the standardised test procedures, usually applied for the characterisation of burden materials, do not longer correspond to the actual conditions and do not sufficiently describe the quality parameters of the burden. Research work is necessary to define temperature and gas composition profile, at the blast furnace periphery, and at half radius over the furnace height. Research is also necessary to determine the effects on the metallurgical properties. New routine test procedures for the characterisation of the disintegration behaviour and the reducibility are also to be developed.

**State of progress:** Research completed; publication EUR N° 20943 EN

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**Technical Group B : "Reduction of Iron Ores"**

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7210-PR/128	B.7/99	1.406.000	843.600	42 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title:** Improved process control of hot metal production through a non-intrusive, on-line sensing system for metals in topgas of blast furnace (PROCSSYMO)

**OBJECTIVES AND CONTENTS**

The production of high quality hot metal (pig iron) at relatively low cost is the most important prerequisite for an economically competitive quality/price ratio of the steel products. The need for use of on-line measurement systems for process control purposes is creating an exploding field of research and development. The aim of the project is both to adapt an in situ, on-line, analytical tool of LIBS using laser modulation for continuous detection of K, Na, Zn and Pb and to install and operate it in order to assist the process control and optimisation of the blast furnace operation and to contribute to close the mass balances of K,Na, Zn and Pb.

**State of progress:** Research completed; publication EUR N° 21127 EN

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***Technical Group B : "Reduction of Iron Ores"***

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GR-71110 HERAKLION

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**Technical Group B has 29 Projects and 116 Partners**

**Total Projects: 29 - Total Partners: 116**

**Technical Group C1 : "Primary Steelmaking"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-CB/309	C1.1/94	1.236.353	588.000	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Melting of high carbon pre-reduced products by the JUPITER process

**OBJECTIVES AND CONTENTS**

The proposed research project concerns the second step of the JUPITER reduction melting process, the first step of which is the subject of a current pilot project.

The aim of the research is to determine the feasibility and the main features of this melting step, taking into account the very specific composition of the JUPITER pre-reduced ore (about 80% iron metallization, 5% to 10% C).

The features to be investigated concern mainly:

- the type of energy to be used: i.e. coal or electricity;
- the material feeding technique;
- the metallurgical process.

It is also intended to develop numerical simulation codes (heat transfer, melting kinetics, metallurgical route) which are very flexible concerning raw materials and energy types.

**State of progress:** Research completed; publication EUR N° 19469

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7210-CB/205	C1.2/94	5.555.810	3.000.765	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Recycling of scrap for high quality products

**OBJECTIVES AND CONTENTS**

In the future, an increased percentage of steel will originate from the Electric Arc Furnace and from the scrap route, for both long products as well as a proportion of flat products.

Since a deterioration in scrap quality is also predicted, the European steel industry could be faced with quality problems due to the higher content of tramp elements in steel, which may affect end user properties to a greater or lesser extent.

In order to analyze and overcome these problems, a major research project is proposed dealing with the control of residuals in scrap and liquid steel, and with the influence of tramp elements on steel product properties.

It is composed of four main sections:

1. Scrap preparation for reducing the tramp element content;
2. Purification of scrap melts for removing residuals at the liquid stage;
3. Influence of tramp elements on the properties of flat products;
4. Influence of tramp elements on the properties of long products.

**State of progress:** Research completed; publication EUR N° 19468

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7210-CB/312	C1.1/95	1.842.500	1.105.500	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Low nitrogen in EAF steelmaking

**OBJECTIVES AND CONTENTS**

The low nitrogen content required for highly ductile steel grades (strips, bars, wire) is not usually achieved in conventional, 100% scrap-based EAF steelmaking. The aim of the research is to establish the feasibility and the features of an industrial process for producing low nitrogen (50 ppm and less) steels in the EAF, using scrap as iron source, in adapting technologies which are already available (coal/oxygen injections, arc setting, bath stirring, etc.). This new ability of the EAF will enlarge the production range of the short, steel recycling route towards higher grade steels without the need to import special iron sources (pre-reduced ore) which are not yet produced economically in Europe.

**State of progress:** Research completed; publication EUR N° 19349

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7210-CB/206	C1.2/95	1.982.500	1.189.500	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Improvement of the EAF performances through optimization of foaming slag practice

**OBJECTIVES AND CONTENTS**

The advantages of producing steels in EAF with foaming slag is becoming increasingly clear. Decisive progress could be attained by developing, for both DC and AC furnaces, a more accurate slag height detection and control system based on complementing arc reactance measurements with other types of parameters such as noise level.

To achieve optimized and dynamic control of the foamy slag practice, several items will be investigated during this collaborative research:

- identification and selection of foam height monitoring systems using various sensors (sonicmeter, photometer, etc.);
- assessment of the optimum operating zones (slag formation, arc behaviour, etc.);
- modelling of slag detection and slag control.

The test programme will be carried out on several modern EAF furnaces (DC single vessel, double shaft AC furnace, AC single vessel).

**State of progress:** Research completed; publication EUR N° 19470

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7210-CB/124	C1.3/95	899.500	539.700	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Decreasing the scorification of chrome

**OBJECTIVES AND CONTENTS**

The aim of this project is to limit chrome scorification in the EAF as well as in AOD processes without increasing operation times or affecting productivity and production facilities:

- to decrease chrome scorification during smeltdown in EAF in order to reduce energy consumption and alloying additions. Finally, the chrome content of the slag should be minimized;
- to decrease chrome scorification during the blowing period in the AOD process to improve the efficiency of alloying addition;
- to reduce chromium content in slag to less than 1% and to stabilize it in phases which are not water-soluble;
- to improve the environmental impact of the process.

**State of progress:** Research completed; publication EUR N° 19382

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7210-CB/903	C1.4/95	471.000	282.600	36 (Mths)		1/11/1995	31/10/1998	31/10/1998

**Title:** Improvement of the EAF performances through an optimization of the foaming slag practice - slag level measurement using radio wave techniques

**OBJECTIVES AND CONTENTS**

Without proper control, the potential energy savings and increased productivity when producing steel in an EAF with foaming slag may not be achieved. The objective of this project is to develop a detection system based on radio wave technology to control the foam height in AC and DC furnaces. The aim is to integrate the foam height detection and measuring system with a dynamic control system for the furnace.

**State of progress:** Research completed; publication EUR N° 19470

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7210-CB/126	C1.1/96	984.500	590.700	36 (Mths)		1/09/1996	31/08/1999	31/08/1999

**Title:** Optimization of energy consumption of three-phase electric arc furnaces using plant signals and thermal modelling

**OBJECTIVES AND CONTENTS**

The major objective of this research project is to develop a control algorithm to optimise the input of electrical energy to the three-phase electric arc furnace (EAF). This algorithm will use plant data signals which will be collected and analyzed in real time. The control algorithm will be derived from a thermal model of the furnace, from analyzing extended data of the furnace and from process knowledge of EAF operators. Results are expected to be applicable to any three-phase electric arc furnace equipped with modern electrode regulators.

**State of progress:** Research completed; publication EUR N° 20174

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7210-CB/313	C1.2/96	620.000	372.000	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Quality of heavy market scrap: development of new and simple methods for quality assessment & quality improvement

**OBJECTIVES AND CONTENTS**

The increasing use of scrap can only be sustained if the quality of commercially-available scrap is improved. This research project intends to develop and refine simple and rapid methods for evaluating scrap quality in the steel shop, based on statistical analysis of production data and simple melting tests. It will focus on commercial heavy scrap and investigate the practical possibilities for eliminating foreign, non-ferrous elements by mechanical fragmentation and sorting. True value analysis of scrap will then help decide on how far these methods need to be implemented.

**State of progress:** Research completed; publication EUR N° 20175

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7210-CB/503	C1.3/96	1.265.000	759.000	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Modelling and optimization of oxygen lances, tuyeres and of the injection technique of various materials into electric arc furnaces

**OBJECTIVES AND CONTENTS**

The main objective of this research project is to define through mathematical and physical modelling, followed by large scale industrial trials, the optimal layout of injection lance equipment. Control systems will also be developed to optimize energy efficiency, the decarburization and dephosphorization behaviour of the oxygen, and to optimize lime powder and other material injection via lances, and finally to avoid splashing and iron losses.

**State of progress:** Research completed; publication EUR N° 19471

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7210-CB/817	C1.4/96	729.500	437.700	42 (Mths)		1/07/1996	31/12/1999	31/12/1999

**Title:** Radio wave interferometer technique for BOF slag control

**OBJECTIVES AND CONTENTS**

The aim of the project is to use radio-wave interferometry to determine the BOF slag and metal heights in both a quiescent and a blowing BOS convertor. The hydrodynamics of the slag/metal emulsion and 1, 2 and possibly 3D representations of slag and metal movements during the blowing phase will be made. Process factors such as vessel shape, lance movements, bath agitation, flux/ore additions and fume generation will be considered.

**State of progress:** Research completed; publication EUR N° 19473

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7210-CB/818	C1.5/96	888.500	533.100	42 (Mths)		1/07/1996	31/12/1999	31/12/1999

**Title:** Neural networks for process condition prediction in basic oxygen steelmaking

**OBJECTIVES AND CONTENTS**

The project objective is to improve end-point analysis and temperature control in the BOS process through the application of neural networks to current computer models for primary charge balancing, sub-lance end-blow control and end-point analysis prediction. Conventional statistical process models based on thermal or physical logic are limited in their ability to account for interrelated variables whose influence is not well understood. Neural networks with their self-learning capabilities are expected to be more accurate, faster and more precise.

**State of progress:** Research completed; publication EUR N° 19467

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7210-CB/819	C1.6/96	995.500	597.300	42 (Mths)		1/07/1996	31/12/1999	31/12/1999

**Title:** Improving the recyclability of organic coated/metallic coated steels

**OBJECTIVES AND CONTENTS**

The volumes of organic and metallic coated materials will increase rapidly over the next few years. This project proposes to develop countermeasures to reduce the impact of emission levels during BOS/EAF steelmaking by establishing a scrap treatment system to remove organic/metallic coatings from scrap strip and to provide cost effective methods to treat the resultant residues, including zinc recovery.

**State of progress:** Research completed; publication EUR N° 19847

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7210-CB/130	C1.7/96	948.500	569.100	24 (Mths)		1/07/1996	30/06/1998	30/06/1998

**Title:** Characteristics of hot-air/oxygen/fuel burner for increasing the input of fossil energy in the EAF and comparison with conventional burners

**OBJECTIVES AND CONTENTS**

The aim of the project is to determine methods of increasing fossil energy input during scrap melting in EAF operations. This could reduce energy costs while providing more even smelting of the charge, thus reducing tap-to-tap times. Fundamental flow and pyrometric characteristics and physico-chemical properties of burner operation will be investigated in a 10 tonne smelting plant in order to evaluate differing charge conditions, fuel/oxygen mixtures and tuyere and burner geometries.

**State of progress:** Research completed; publication EUR N° 19472

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/007	C1.1/97	962.500	577.500	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Reduction in BOS stack emissions by controlling the combustion of waste gas

**OBJECTIVES AND CONTENTS**

Many European steel plants are fitted with equipment for recovering "waste" gas from the BOS process for use as a fuel in the rest of the works. The objective of this research project is to refine operation of the gas recovery system so as to increase the calorific value of the recovered gas. This will be achieved by minimising ingress of air into the vessel hood, thereby suppressing combustion of the gas. This has the added benefit of reducing the volume of gas to be recovered, giving greater effective storage capacity.

**State of progress:** Research completed; publication EUR N° 20205

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7210-PR/008	C1.2/97	1.346.500	807.900	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Optimization of high voltage AC electric arc furnace control

**OBJECTIVES AND CONTENTS**

The objectives of this research project are to improve the performance of high voltage AC electric arc furnaces which have the advantage of high power input for high productivity with low electrode consumption. In order to utilise these advantages to the full, the stability of long arcs shall be improved by modifying the electrical parameters of the furnace and also by the controlled injection of material into the arcing zone. Improved arc stability reduces current fluctuations, and thus mechanical stresses on the electrodes, as well as flicker in the power supply system. Energy efficiency shall be improved through the use of advanced electrode controllers, by restricting thermal load on the water-cooled panels, and by adopting predictive melt-down control.

**State of progress:** Research completed; publication EUR N° 20176

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/040	C1/E.3/97	1.463.500	878.100	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title: Monitoring decarburisation in the EAF**

**OBJECTIVES AND CONTENTS**

The main goals of this research project are to define the operating conditions and methods required to control decarburization and stirring efficiency in the EAF. The goals for decarburization control are to produce carbon steels with C contents of 0.05 - 0.06% or less with high productivity of the shop when carbonaceous material (i.e. cold or pig iron) is used. Pilot and industrial testing will be carried out during this fundamental study, to assess liquid bath depth, to study decarburization phenomena even with high carbon removal rates, and to analyse fume formation rates.

**State of progress:** Research completed; publication EUR N° 20173

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/075	C1.1/98	1.317.000	790.200	54 (Mths)		1/07/1998	31/12/2001	31/12/2002

**Title:** Production of steels at lower operating costs in EAF

**OBJECTIVES AND CONTENTS**

The main goal of this project is to promote a working practice for EAF which minimises the intermediate stops and the power off time in order to favour an efficient use of the energy input and a direct tapping procedure. Application of the appropriate sensors and measurements techniques will allow a more accurate control of the melting and refining phases. For this purpose, it is mandatory to master the working periods of the furnace: the minimisation of the power-on time through an on-line detection of the scrap melting rate and of the end point of the refining phase; the minimisation of the power-off time through an optimum management of the repairing periods of the furnace.

**State of progress:** Research completed; publication EUR N° 20895 EN

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7210-PR/076	C1.2/98	1.414.000	848.400	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Artificial intelligence/expert systems for steelworks pollution controls

**OBJECTIVES AND CONTENTS**

The aim of this project is to reduce costs of pollution controls and instrumentation with improved environmental performance. The project will develop, apply and evaluate expert systems and artificial intelligence using neural networks and fuzzy logic controls across a range pollution control equipment. The project will develop systems project to operate throughout the life of a plant. The system will be designed to enable transfer of the new technology to other sites in a form to be used by plant operatives to maximum effect.

**State of progress:** Research completed; publication EUR N°

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/077	C1.3/98	933.333	560.000	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Improved utilisation of fossil fuel by injection through hollow electrodes in the EAF

**OBJECTIVES AND CONTENTS**

The overall objective of this project is to develop systems and find suitable conditions for injection of fossil fuels through hollow graphite electrodes in the EAF. The project shall also determine the expected improvements in performance for: arc-voltage to arc-length ratio, electrical consumption and productivity, arc stability, harmonics and flicker, graphite consumption, melt out analysis of N and O and energy yield from combustion of fossil fuel.

**State of progress:** Research completed; publication EUR N° 20730

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7210-PR/078	C1.4/98	689.000	413.400	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Reoxidation and ignition behaviour of DRI to improve safety

**OBJECTIVES AND CONTENTS**

This project undertakes to investigate the reoxidation and ignition behaviour for different parameters of sponge iron handling. Synthetic sponge iron will also be produced by laboratory trials to acquire knowledge about the influence of parameters not available by testing materials in operational plants. The research will contribute to the improvement of safety in transport and storing of sponge iron and will enable realistic estimate and control of hazards linked to the handling of these raw materials for steelmaking.

**State of progress:** Research completed; publication EUR N° 20632

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7210-PR/130	C1.2/99	992.000	595.200	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Mechanical & metallurgical study & modeling of the fragmentazing of end of life goods in a scrap shredder

**OBJECTIVES AND CONTENTS**

Scrap has become a major raw material of the steel industry. The results of the ECSC "scrap-project" have shown that the shredder is a critical tool for improving scrap quality. The influence of the outside parameters of this process is now better known, but the influence of the inside parameters is still unclear. The objective of this research is therefore to understand the fragmentising of goods that contain steel and to model the shredding of scrap. This investigation will also study how to improve the degree of liberation of metal-metal and non-metal-metal composites; how to increase the specific throughput of shredders; how to decrease specific power consumption equipment wear; how to minimise copper content in shredded scrap and it will propose solutions for the low-cost treatment of fluff. The results of this research would be beneficial both to the workers and the environment. The introduction of a shredding unit could mean the creation of new workplaces. The development of a separation process of non-ferrous materials from the scrap will reduce the emissions of volatile organic components to the benefit of the workers.

**State of progress:** Research completed; publication EUR N° 20894 EN

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7210-PR/131	C1.3/99	1.112.200	667.320	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Neuro-fuzzy systems to improve the control of electric arc furnace process

**OBJECTIVES AND CONTENTS**

Steelmaking with an electric arc furnace is a complex process with many variables. Generally, these variables are controlled by classical PID and set points elaborated with linearised models. Errors could occur. Also, conditions in the EAF can change and for this reasons PID adjustments and initial conditions in the model can cause further errors in the control. The project aims at the improvement of the control system in the EAF. The system will combine the physical model with the knowledge accumulated by the technicians as well as the information contained in the data mostly with the use of artificial neural networks and fuzzy logic methods.

**State of progress:** Research completed; publication EUR N° 20944 EN

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**Title:** Improving the productivity of electric arc furnaces

**OBJECTIVES AND CONTENTS**

In operating electric arc furnaces, high productivity generally has the highest priority besides low consumption of electric and fossil energy as well as electrode graphite. The fossil energy input has been considerably increased in recent years, in order to reduce the electric energy consumption and to raise the productivity by shortening the power-on, time. For AC furnaces it has been shown that the electric energy consumption is minimal at an operating point below the electric power maximum. Similar relation has been observed at a DC furnace. The aims of the project are to improve the knowledge about the influences of energy consumption and productivity of electric arc furnaces and to achieve the optimum between these key variables by an adequate control of electric power input. The investigations will be performed on single and double shell furnaces, single and double shaft furnaces and AC and DC furnaces.

**State of progress:** Research completed; publication EUR N° 20803 EN

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7210-PR/133	C1.5/99	855.200	513.120	42 (Mths)		1/07/1999	31/12/2002	31/12/2002

Title: Consistent BOS performance

**OBJECTIVES AND CONTENTS**

Slag splashing as a means of extending vessel-lining life was first implemented on BOS vessels. Since its introduction, lining performance has dramatically improved. At the same time, it has been proved impossible to maintain the bottom stirring systems in operation beyond about 2000 heats. The project aims to improve BOS steelmaking operations and achieve consistent performance, throughout a campaign, by extending the availability of bath stirring to match the vessel life. This will be extended by practices such as slag splashing and by linking blowing strategies and lance designs to vessel shape. This will be attained by: identifying the criteria that link vessel geometry to blowing practice to assist in achieving consistent end point and yield; by making recommendations on lance design and slag splashing procedures; by increasing life of tuyere blocks to ensure that bottom stirring is available throughout the vessel campaign life.

State of progress: Research completed; publication EUR N° 20881 EN

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7210-PR/134	C1.6/99	200.000	120.000	24 (Mths)		1/07/1999	30/06/2001	30/06/2001

**Title:** Inclusion floating process for super clean steels

**OBJECTIVES AND CONTENTS**

The inclusion floating process using specially developed porous plugs that enable the creation of very fine, non-coalescing, gas bubbles, as it resulted from a previous ECSC research project, is to be carried out as P/D project in two, specially equipped 56t pilot ladles. In order to reduce the industrial risk, it has been decided to first carry out only the preliminary trials of the P/D project (as research project) which examine both the conditions for producing very small gas bubbles, as required by the process and the capacity of the porous refractory plugs to resist to the high gas pressures required.

**State of progress:** Research completed; publication EUR N°

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/201	C1.2/00	1.118.231	670.939	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Advanced EAF modelling and control

**OBJECTIVES AND CONTENTS**

In modern arc furnaces, uniform distribution of energy, mass and off-gases is critical. The project aims at modelling the EAF in "geographical zones". Fundamental modelling and a holistic, semi-empirical approach will be developed in parallel and where appropriate, combined in a hybrid model. Thermal and other photographic analyses and the use of fast off-gas measurement systems, arc exposure and mast position measurement, will be developed further. Mass and CO/CO2 ration modelling in each zone, and integrated zonal and global control of electrical and chemical energy input, will be taken into account aiming to improve productivity, energy efficiency, and yield.

**State of progress:** Unknown type of status (NA)

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Technical Group C1 has 26 Projects and 97 Partners

Total Projects: 55 - Total Partners: 213

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-CC/405	C2.1/94	491.500	294.900	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Improvement in performance of the tuyere/refractory system in AOD converter for stainless steel production

**OBJECTIVES AND CONTENTS**

The tuyere system (shape, type, gas used) and refractory surrounding is critical to metallurgical performance, productivity and consumption of AOD. Improvements of such a system are very effective in increasing AOD performance. The present proposal is aimed at developing improved refractories for use in the tuyere area and at developing improved shapes and sizes of tuyeres, as well as investigating their position in the AOD convertor.

The study of improved tuyeres/refractory system(s) will concern stainless steel production in both routine production processes and with injection of oxidizing powders.

The results of the research work will provide reduced tuyere and refractory wear, will evaluate the capabilities of innovative types of tuyere, and define production processes with improved industrial results.

**State of progress:** Research completed; publication EUR N° 19361

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7210-CC/808	C2.1/95	1.143.500	686.100	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Improving deoxidation practices for ultra clean steel production

**OBJECTIVES AND CONTENTS**

The overall objective of the research project is to increase product quality through improvement of steel cleanness and control of inclusion compositions to minimise product defects. Novel methods of deoxidation will be assessed theoretically and practically on the basis of co-addition of nucleants and control of deoxidation adjacent to inclusion-absorbing slags. In parallel, optimisation of ladle slag compositions will be developed on a production plant using pre-prepared fused slags.

**State of progress:** Research completed; publication EUR N° 19352

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-CC/114	C2.3/95	878.000	526.800	48 (Mths)		1/07/1995	30/06/1999	30/06/1999

**Title:** Improvement of cleanness and fine-grain structure of Ca-treated and Al-deoxidised steels with a high S content made by continuous casting of billets and blooms

**OBJECTIVES AND CONTENTS**

The automotive industry has requirements for Al-deoxidized steel grades with S-contents between 0.02 and 0.1% to ensure good machinability and high cleanness requirements.

Castability and cleanness of these steels are critical because the higher S-contents and basic top slags limit the Ca-treatment.

In this research project the process routes:

- EAF-LFV;
- LD-RH-degassing,

are to be optimized. Ladle metallurgy and process engineering will be investigated for the production of these critical steels with high cleanness requirements, aiming at good castability and improved cleanness. Depending on the results achieved with bloom casting, it is planned to investigate the suitability of billet cast material as well.

In addition, a novel "Oxide Metallurgy" to substitute for Al will be investigated for improvements in castability, cleanness and toughness.

**State of progress:** Research completed; publication EUR N° 19486

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7210-CC/116	C2.4/95	1.398.000	838.800	48 (Mths)		1/07/1995	31/12/1998	30/06/1999

**Title:** Improvement of vacuum circulation plant operation on the basis of the BFI simulation model

**OBJECTIVES AND CONTENTS**

A simulation model of the vacuum circulation process (VCP) for decarburization of steel has been developed. This model covers the steel circulation, the decarburization reaction, vessel pressure with its effect on the equilibrium conditions, and oxygen pickup from the ladle slag. Comparisons of simulation results with measured values of a VCP plant demonstrate that the model describes the process with excellent accuracy. Within the new project the simulation model shall be extended to include further metallurgical operations (such as stirring, gas input, oxygen blowing, dehydrogenation and nitrogen control), and it shall be applied in order to improve design, operation, process observation and process control of VCP plants.

**State of progress:** Research completed; publication EUR N° 19488

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7210-CC/118	C2.5/95	1.206.500	723.900	36 (Mths)		1/11/1995	31/10/1998	31/10/1998

**Title:** Development and control of suitable slag systems for improving steel cleanliness in ladle treatment and tundish metallurgy

**OBJECTIVES AND CONTENTS**

This research project will use plant trials in combination with laboratory measurements of slag parameters to improve steel cleanliness through:

- an extension of knowledge of the thermodynamics of slags;
- optimization of production processes;
- extension of process control;
- extension and improvement of existing thermodynamic models for application in practical steelmaking.

**State of progress:** Research completed; publication EUR N° 19476

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7210-CC/121	C2.1/96	1.248.500	749.100	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Dynamic modelling and control of the vacuum degassing process

**OBJECTIVES AND CONTENTS**

During this project a process control system shall be developed for vacuum treatment in ladle degassing stations or similar facilities. By means of dynamic process models for decarburization, desulphurisation, denitrogenation and dehydrogenation, the vacuum treatment time shall be predicted. In addition, the effects of various vacuum process parameters on steel castability, cleanliness, gas and exhaust gas flow and composition need to be taken into account.

**State of progress:** Research completed; publication EUR N° 19484

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7210-CC/123	C2.2/96	1.074.500	644.700	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Control of ejections caused by bubble bursting in secondary steelmaking processes

**OBJECTIVES AND CONTENTS**

Work to be undertaken in this research project is to investigate the ejection of liquid droplets from gas-stirred melts as a function of metal and slag properties, of gas injection methods, gas flow rates and surface-active additives. The aim is to acquire sufficient knowledge to control the ejections caused by bubble bursting with respect to quantity and size range of droplets and then to find the optimum process parameters for high productivity, low accretion rate and low dust losses.

**State of progress:** Research completed; publication EUR N° 19487

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7210-CC/125	C2.3/96	486.500	291.900	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Prevention of recarburization of ULC steels during reheating

**OBJECTIVES AND CONTENTS**

The aim of this project is to minimize recarburization during ULC steel production in ladle, tundish and casting systems in order to obtain carbon contents below the 20 ppm so often required nowadays. Work will examine the kinetics of recarburization by refractory material and fluxes by means of practical experimentation in steelmaking plants and also in the laboratory. Materials to be examined in detail include carbon-bonded refractories based on magnesia, dolomite and alumina as well as fluxes.

**State of progress:** Research completed; publication EUR N° 19483

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7210-CC/302	C2.4/96	815.000	489.000	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Development of techniques to minimise ladle/slag interactions and prevent uncontrolled inclusion modification

**OBJECTIVES AND CONTENTS**

The main goals of this project are to identify detailed mechanisms of mass transfers from refractory lining of ladles towards steel where contamination of metal by glazed ladle lining from previous casts and carbon pick-up by ultra-low carbon steels from carbon-bearing refractories occurs. Efforts will be made to improve process practices in-ladle that minimize both of these aspects and thus contribute to casting higher quality steels by better control of steel inclusion populations (tyre cord and rail steels) and of steel composition (carbon in ultra-low carbon steels).

**State of progress:** Research completed; publication EUR N° 19485

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/009	C2.1/97	1.501.500	900.900	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Control of inclusions in RH degassing processes

**OBJECTIVES AND CONTENTS**

The main aim of this project is to develop, test and validate modelling techniques for the evaluation of RH vacuum degasser performance with respect to steel cleanliness. Principally, physical model and plant results on a wide variety of steel grade (ULC and high carbon steels) will be used to validate computational fluid dynamic models which will take into account coalescence of inclusions, thermal effects, thermodynamics of inclusions and dynamic interactions between melt/inclusions/gaseous phases. It will thus be possible to fully predict the range of inclusion composition and the level of cleanliness of the steel with respect to treatment conditions.

**State of progress:** Research completed; publication EUR N° 20179

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/010	C2.2/97	1.315.500	789.300	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** The use of artificial intelligence to control secondary steelmaking practices

**OBJECTIVES AND CONTENTS**

The objective of this project is to develop tools and techniques based on artificial intelligence to monitor the performance of casts through secondary steelmaking stations and to calculate alloying requirements and strategy through the secondary steelmaking process, using a combination of metallurgical calculations and expert experience, to achieve optimum metallurgical and cost performance. The project will investigate the potential for combining these aspects into an intelligent secondary steelmaking supervisory system.

**State of progress:** Research completed; publication EUR N° 20178

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7210-PR/011	C2.3/97	1.284.500	770.700	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Dynamic process control of AOD converter

**OBJECTIVES AND CONTENTS**

The objective of this research is to increase the AOD performance by improving control of the decarburization process. Activities to be carried out on 140 t. AOD and 75 t. KCB-S will include:

- development of a system for the continuous analysis of exhaust gases;
- development of a process observation model;
- development of a control system;
- in-plant trials.

Results from this research will provide several technical and economic benefits which could be transferred to other AOD converters which produce stainless steels in the ECSC.

**State of progress:** Research completed; publication EUR N° 20177

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/079	C2.1/98	1.132.200	679.320	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Control of inclusion, slag foaming and temperature in vacuum degassing

**OBJECTIVES AND CONTENTS**

The overall objective is to develop a new concept and a new operative model for on-line control and optimisation of the vacuum degassing process. The concepts are either based on a new and unique technique as the modified OES method or complete new applications on proven technology as for slag level measurements by radio-wave interferometry and vacuum temperature measurements by thermovision camera. The concepts will be adapted to refining models developed in a current ECSC research program. The result will be an overall model for dynamic process control of the vacuum degassing process.

**State of progress:** Research completed; publication EUR N°

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7210-PR/080	C2.2/98	1.182.000	709.200	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Desulphurisation of liquid steel with refining top slags

**OBJECTIVES AND CONTENTS**

Lime saturated top slags, intensive ladle stirring and low oxygen potentials are prerequisite to desulphurize liquid steel to low residual levels. Although practical information is quite comprehensive, no attempt has been made until now to optimise the process with respect to slag control and refining kinetics. It is the objective of this project to investigate the influencing parameters of the desulphurisation reaction in detail, to quantify the reaction kinetics and to develop new methods of desulphurisation treatment

**State of progress:** Research completed; publication EUR N° 20474

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7210-PR/135	C2.1/99	1.031.900	619.140	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Production of EAF steels with low contents in N2 and S through vacuum treatment

**OBJECTIVES AND CONTENTS**

The major aims of this project are to define the metallurgical and economical limits of a vacuum treatment applied to EAF steels in order to reduce the nitrogen content under 50 ?g/g and sulphur content under 20 ?g/g and to simulate this treatment by a dynamic modelling. Laboratory pilot and plant experiments will be carried out and will be used to validate the models developed to simulate the de-nitrogenisation and the de-sulphurisation reactions. The final aim is to predict and achieve the targeted content in nitrogen and sulphur of EAF steels, processed under a defined vacuum treatment.

**State of progress:** Research completed; publication EUR N° 20945 EN

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7210-PR/136	C2.2/99	1.199.300	719.580	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Characterisation and optimisation of ladle stirring systems for the steelmaking industry

**OBJECTIVES AND CONTENTS**

More than 90% of the yearly production of steel in Europe is cast in continuous and approximately 70% of it is subjected to secondary metallurgy where metallurgical gas is introduced into the heat via stirring elements. The heats are homogenised, the metallurgical reactions accelerated and the degree of cleanliness improved. The project's aim is to improve the reliability and efficiency of the stirring process. Different stirring systems will be investigated with regard to their reliability, efficiency and wear. Rules regarding maintenance, servicing and selection will be derived from such investigations and the change of the stirring element will be facilitated.

**State of progress:** Research completed; publication EUR N° 20946 EN

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7210-PR/138	C2.4/99	446.500	267.900	36 (Mths)		1/09/1999	31/08/2002	31/08/2002

**Title:** Chromium free alternative refractory for the lining of rh/dh vessels

**OBJECTIVES AND CONTENTS**

Vacuum ladle treatment is increasingly being used due to expansion of the demand for high performance steels. Availability and cycle time of the vacuum vessels have become of strategic importance for steel makers. Since the introduction of vacuum vessels, chromium-containing refractory materials have been used. Though these materials do not pose safety problems during use in the steel plant, their re-lining results in outbreak material that is hazardous to health and environment. The project intends both to investigate the (re)use of chromium spinel outbreak material and its substitution with a chromium-free alternative refractory material to be used as in-vacuum treatment vessels in the steel industry. In order to assure economical operating conditions and reduce or eliminate the use of chromium, alternative mining materials and recycling of the present materials will be also investigated. The results of this project are expected to reduce the costs of landfill and the environmental impact of the production cycle.

**State of progress:** Research completed; publication EUR N° 21335 EN

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**Total Projects: 72 - Total Partners: 273**

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7210-CA/171	C3.1/94	2.098.729	1.125.124	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Properties of strip cast steel products arising from integrated processing

**OBJECTIVES AND CONTENTS**

The near-net-shape casting of carbon steel strip by the twin-roll process with subsequent "in-line" processing opens up many possibilities for manufacturing excellent cold rollable products with commercial combinations of properties. In this multinational project, strip of different carbon steel grades will be produced and processed "in-line" and "off-line".

The different grades of strip will be characterized in the as-cast and in the coiled state, as well as in the processed state. The material properties, as well as the hot forming behaviour, and the transformations during cooling will be investigated. Results from this technical research work are expected to provide information on optimum processing and enduser properties for these directly manufactured strip grades, and to reduce processing costs.

**State of progress:** Research completed; publication EUR N° 19364

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-CA/428	C3.2/94	873.500	524.100	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Improvement of side containment system for the strip casting process

**OBJECTIVES AND CONTENTS**

Twin roll strip casting technology is of great interest to the world's major steel producers because of the possibility of reducing or even eliminating the hot rolling stage, the potential of flexible manufacturing systems to cast smaller quantities of special steels, as well as the lower capital investment necessary for the plant. One of the critical aspects of the strip casting process concerns the liquid steel lateral containment system. The general objective of this research programme is the design, construction and trial of an economic mechanical lateral sealing system which would permit casting of a reasonable duration without introducing significant defects into the steel strip due to the side plates.

**State of progress:** Research completed; publication EUR N° 19362

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-CA/835	C3.3/94	2.729.098	1.519.633	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Improvements of cast product quality by using results from mathematical and physical modelling of the continuous casting process

**OBJECTIVES AND CONTENTS**

The objective of this research is to improve continuously cast steel product quality by using the results of second generation numerical models and physical models which are designed to produce more accurate and relevant modelling of multiphase interactions in the mould. Detailed investigations will be undertaken to develop improved descriptions of boundary conditions, turbulence models, multiphase flow, inclusion capture, emulsifications of flux, etc., which can be used directly or indirectly in numerical simulations or in design calculations. Physical modelling incorporating laser Doppler velocimetry and other advanced techniques will be used to check the numerical simulation methods. Plant trials will be undertaken to test recommendations for optimized casting conditions.

**State of progress:** Research completed; publication EUR N° 19853

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7210-CA/503	C3.1/95	1.174.000	704.400	48 (Mths)		1/07/1995	31/12/1998	30/06/1999

**Title:** Study and optimisation of the secondary cooling technique for the continuous casting of beam blanks

**OBJECTIVES AND CONTENTS**

The aim of this research is to develop a new selective secondary cooling technique for beam blank casting. This technique will provide a more homogeneous temperature field in order to avoid inner and surface defects. The solidification and the cooling process will be investigated mainly by numerical simulation, taking into account the different casting parameters (steel grade, extraction rate, cooling conditions, etc.). Prototype equipment will be designed and built. Cold tests will first be performed in the laboratory in order to define the optimum geometry of the cooling boxes. Hot tests will be then performed on a beam blank continuous caster.

**State of progress:** Research completed; publication EUR N° 20183

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7210-CA/838	C3.2/95	1.136.000	681.600	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Influence of mould metallurgy on concast surface quality

**OBJECTIVES AND CONTENTS**

Longitudinal surface cracking and depressions in continuously cast, medium carbon and austenitic stainless steels remain a problem, particularly for small cracks located near the slab mid-faces or close to the edges. The aim of the study is to develop mould technologies which will reduce the initial formation of longitudinal defects in steady state casting conditions and also to assess the effects of transient conditions on crack formation using neural network technology. The conditions immediately below the mould and in the top zone which influence crack propagation will also be investigated. The study will add to the fundamental knowledge of longitudinal defect formation and enable the identification of high performance casting conditions; this will also assist development of near net shape casting.

**State of progress:** Research completed; publication EUR N° 19380

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7210-CA/182	C3.3/95	1.069.500	641.700	54 (Mths)		1/07/1995	31/12/1998	31/12/1999

**Title:** Improvement of internal quality by controlling the microstructure of microalloyed cast steel

**OBJECTIVES AND CONTENTS**

Since failures originating from insufficient internal quality are most often not detected before the final product stage, production costs can be reduced significantly by controlling macro- and microsegregation and internal porosity. These effects are related to the microstructure of the cast steel. Measures improving the segregation index, such as casting with low superheat, are often related to a deterioration in steel cleanliness. An objective of this project is to systematically investigate the origin of defects related to microstructure and to investigate those parameters which control the development of the solidification structure and the centre segregation with a high residual level of steel cleanliness under industrial conditions. Therefore, coordinated plant trials, numerical modelling and laboratory experiments will be performed.

**State of progress:** Research completed; publication EUR N° 19491

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7210-CA/184	C3.4/95	913.500	548.100	48 (Mths)		1/07/1995	30/06/1999	30/06/1999

**Title:** Optimization of the straightening process in continuous casting

**OBJECTIVES AND CONTENTS**

The objective of the project is to establish a theory of the unbending process, which is required for improvements of the basic design of straighteners for new or enhanced casters, both conventional and near-net-shape, and also to investigate improvements in the performance of existing bloom and slab casters. Numerical modelling will be developed and validated by extensive plant measurements on casters employing different straightening techniques.

**State of progress:** Research completed; publication EUR N° 19850

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7210-CA/603	C3.5/95	1.397.000	838.200	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Blowhole prevention by optimal feeding systems

**OBJECTIVES AND CONTENTS**

In continuous casting the formation of blowholes presents a serious problem. Blowholes find their origin in the supply system from tundish to mould where argon is injected for the purpose of shrouding and as a means to prevent clogging. It is proposed to overcome the problem of blowholes by reducing the amount of argon injected into the feeding system. This implies that a new supply system should be developed to overcome clogging problems by combining the following items:

- a new collector nozzle;
- a new type SEN (submerged entry nozzle);
- a new flow regulating system;
- a new gas injection system.

**State of progress:** Research completed; publication EUR N° 19373

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7210-CA/902	C3.6/95	804.500	482.700	36 (Mths)		1/11/1995	31/10/1998	31/10/1998

**Title:** Control of liquid slag carry-away and entrapment in the CC mold for a better surface and subsurface quality: numerical and experimental study

**OBJECTIVES AND CONTENTS**

The main aims of this project are to investigate:

- the process conditions that significantly improve surface quality as well as the subsurface cleanness;
- criteria to ensure that lubrication remains homogeneous and avoids surface cracks and, that liquid slag entrapment is prevented;
- liquid slag carry-away at meniscus and detrimental perturbations of the lubrication between shell and mold.

A new type of physical model will be developed and used to study the mechanisms for slag carry-away at the CC meniscus. Numerical simulations as well as industrial characterizations of the meniscus behaviour will be carried out.

**State of progress:** Research completed; publication EUR N° 19360

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7210-CA/903	C3.7/95	378.500	227.100	36 (Mths)		1/12/1995	30/11/1998	30/11/1998

**Title:** Blowhole prevention by optimal feeding systems

**OBJECTIVES AND CONTENTS**

This research project will attempt to overcome the problem of blowholes by reducing the amount of argon injected by developing new feeding systems for slab and thin slab casting. Additional objectives include the development of a gas-tight stopper rod and a flexible and accurate gas feeding system. Extensive plant measurements are planned at bloom, slab and thin slab casters.

**State of progress:** Research completed; publication EUR N° 19373

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7210-CA/904	C3.8/95	281.500	168.900	36 (Mths)		1/11/1995	31/10/1998	31/10/1998

**Title:** Improvement of internal quality by controlling the microstructure of microalloyed cast steel

**OBJECTIVES AND CONTENTS**

Internal cracking of rolled, medium carbon, low alloy bars is caused by the central- and V-segregation that is associated with the formation of martensitic regions in the blooms. It is necessary to know the individual effect of interdependent casting parameters on the solidification of the bloom using a numerical model. The objective of the project is to find a combination of casting parameters that minimizes the segregation and consequently increases the quality of the final product.

**State of progress:** Research completed; publication EUR N° 19491

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7210-CA/905	C3.9/95	333.333	200.000	36 (Mths)		1/12/1995	30/11/1998	30/11/1998

**Title:** Optimisation of mould powder performance in casting long products

**OBJECTIVES AND CONTENTS**

The main objectives of the project are to improve the quality of as-cast billets and blooms, adopting two differing approaches:

- improvement of casting and casting flux behaviour for long products;
- investigation of the potential to use pre-heated and pre-molten casting powder and to develop the technique to melt and distribute molten casting flux.

**State of progress:** Research completed; publication EUR N° 19363

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7210-CC/112	C3/C2.2/95	1.420.500	852.300	48 (Mths)		1/07/1995	30/06/1999	30/06/1999

**Title:** Improvement of macro-cleanness of continuous-cast slabs for high specification products

**OBJECTIVES AND CONTENTS**

The aim of this joint research project is to quantify and to optimize the influence of process technique and process metallurgy parameters in the continuous casting of slabs on the macro-cleanness of various steel grades with very high cleanliness requirements.

The proposed research work is based on the MIDAS-US detection technique and QTM methods for measuring the macro-cleanness of as-cast samples of slabs, further to the significant progress made in cleanliness assessment methods in several other ECSC projects.

Using these systems the influence of process technique and metallurgy as well as plant type in the ladle-tundish-mould system are to be correlated with macro-cleanness, with special emphasis on tundish metallurgy and submerged nozzle design.

Steel grades with elevated product specifications are deep drawing steels for DWI tin cans with very thin walls, unalloyed and micro-alloyed deep drawing steels for car bodies, steels for shadow masks for HDTV, as well as steel grades for HIC resistant tubes.

**State of progress:** Research completed; publication EUR N° 19848

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7210-GB/811	C3/E1.1/95	1.266.500	759.900	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Continuous assessment of steel quality during continuous casting

**OBJECTIVES AND CONTENTS**

The objectives of the research are the development and testing of ultrasonic methods to determine, continuously on-line, the general levels of cleanness of molten steel during continuous casting. Two types of inclusion detector are to be developed, one to be mounted above a sliding gate fitted to a tundish or ladle, and the other a dipping probe to monitor steel cleanness in various parts of the mould tundish and, possibly, ladles. Previous work has demonstrated the feasibility of the concept and work is now required to optimise the ceramics and other materials used in construction and to produce a signal processing package to simplify the interpretation of results in order to provide a rapid feedback on factors affecting steel quality. Once developed and proven in trials the ultrasonic probes will be tested against plant results so that reliable process information can be generated for diagnostic and control purposes.

**State of progress:** Research completed; publication EUR N° 19351

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-GB/901	C3/E1.2/95	153.000	91.800	36 (Mths)		1/11/1995	31/10/1998	31/10/1998

**Title:** Continuous assessment of steel quality during continuous casting

**OBJECTIVES AND CONTENTS**

The objectives of this research are the development and testing of ultrasonic methods and others to detect, continuously on-line, the general level of cleanness of molten steel during continuous casting. Two types of inclusion detector are to be developed, one fixed above a sliding gate fitted to a tundish or a ladle and the other a dipping probe to monitor steel cleanness in various parts of the mould, tundish and ladle.

**State of progress:** Research completed; publication EUR N° 19351

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-CA/186	C3.1/96	1.369.000	821.400	48 (Mths)		1/07/1996	30/06/1999	30/06/2000

**Title:** Strand reduction in slab casting and its effect on quality

**OBJECTIVES AND CONTENTS**

Thickness reduction of strand with liquid core is a technology to control cast thickness and improve the internal quality of continuously cast slabs. The objective of this project is to investigate criteria for improved selection of soft reduction arrangements. The planned research includes the effects of machine parameters on strand quality, deformation mechanics during compression and the formation of centreline segregation. Both numerical modelling and measurements on casting machines will be performed.

**State of progress:** Research completed; publication EUR N° 20190

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-CA/841	C3.2/96	1.062.500	637.500	42 (Mths)		1/07/1996	31/12/1999	31/12/1999

**Title:** Enhanced steel product quality and yield by applying the results of improved modelling of transient conditions in the tundish

**OBJECTIVES AND CONTENTS**

This project aims to increase understanding of the temperature stratification in the ladle and tundish under non-steady operating conditions using both numerical predictions and measurements of the temperature distribution in the steel and in the refractory. Another aim is to measure the steel temperature in the shrouding nozzle between the ladle and the tundish during non-steady teeming operations. Results from this combined theoretical and experimental study will be used to develop simple analytical equations for predicting the temperature of steel leaving the tundish.

**State of progress:** Research completed; publication EUR N° 19851

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7210-CA/842	C3.3/96	1.370.000	822.000	42 (Mths)		1/07/1996	31/12/1999	31/12/1999

**Title:** Mould powder development for higher casting speeds and thin slab casting

**OBJECTIVES AND CONTENTS**

The aim of this proposal is to develop and improve mould powders for faster casting of various steel grades. Investigations will be carried out in both the laboratory and associated production units that will lead to the development of mould powders allowing faster casting rates and higher productivity without increasing the risks of sticker breakouts or poor surface quality.

**State of progress:** Research completed; publication EUR N° 19490

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7210-CA/843	C3.4/96	1.136.000	681.600	42 (Mths)		1/07/1996	31/12/1999	31/12/1999

**Title:** Control of thermal and mechanical forces in the mould and upper part of slab, bloom and billet casters

**OBJECTIVES AND CONTENTS**

Variability in continuous caster operating performance effectively limits productivity and flexibility for hot charging and direct rolling. Casting powders are only one element which contributes to the problems encountered. This project aims to determine and quantify the mechanisms which lead to problems, to develop monitoring techniques, and to investigate novel techniques for improving control operating conditions.

**State of progress:** Research completed; publication EUR N° 20180

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7210-CA/191	C3.5/96	1.373.000	823.800	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Development of high speed casting in conventional CC stainless steel slab production

**OBJECTIVES AND CONTENTS**

The objective of this project is to achieve higher casting rates (up to 1.5 m/min) in conventional stainless steel casters. Numerical and physical models for casting stainless steel at conventional speeds will be improved in order to assess fluid flow, SEN geometry and operations, and heat transfer conditions in the mould. Mould and secondary cooling will also be investigated as well as the rim.

**State of progress:** Research completed; publication EUR N° 19849

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7210-PR/012	C3.1/97	716.500	429.900	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Control of the dendritic structure of the initial frozen shell in continuous casting

**OBJECTIVES AND CONTENTS**

Despite considerable progress in the field of continuous casting, problems still arise concerning surface and sub-surface quality. This variability limits productivity and flexibility if a direct rolling process is to be used. Much work has been done and continues to be done to optimise casting processes but innovative techniques also play a role. This project aims to determine and quantify the effect of non-conventional mould geometry on first frozen shell dendrite formation as a means of reducing the incidence of sub-surface defects.

**State of progress:** Research completed; publication EUR N° 20185

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7210-PR/013	C3.2/97	903.500	542.100	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Behaviour of argon gas bubbles in casting machine

**OBJECTIVES AND CONTENTS**

The main goals of this research project are:

- to describe the behaviour of the argon gas bubbles coming from the submerged entry nozzle into the casting machine with different sealing techniques and the characteristics of the casting processes used;
- to define the optimum gas injection mode with respect to casting, macro-cleanness of slabs and, if possible, to index defects on sheets;
- to define indicators of critical periods of casting in terms of mould meniscus perturbations.

**State of progress:** Research completed; publication EUR N° 20193

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/014	C3.3/97	1.377.500	826.500	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** The formation and prevention of scale during twin roller strip casting

**OBJECTIVES AND CONTENTS**

Scale formed on the surface of steel cast in the twin roller direct casting process results in yield loss and product quality problems. This research project will examine the mechanisms of scale formation and methods for its reduction. Shrouding and cooling systems to minimise scale formation will be investigated. The properties of scale will be characterised. Pickling processes will be studied. Steel grades include silicon steels as well as low and medium carbon steels. Laboratory investigations and tests on pilot casters will be carried out.

**State of progress:** Research completed; publication EUR N° 20192

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7210-PR/015	C3.4/97	1.377.000	826.200	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Fine steel alloying during continuous casting

**OBJECTIVES AND CONTENTS**

Previous trials in alloying liquid steel during continuous casting have not led to industrial applications despite encouraging metallurgical results. This research project will completely reconsider this question from both theoretical and practical points of view. Three techniques will be studied in particular:

- the addition of reagents in the tundish;
- the injection in a new submerged entry nozzle;
- the injection in a hollow jet nozzle.

Each solution will be developed with the support of dedicated mathematical and physical modelling and laboratory, pilot and industrial trials.

**State of progress:** Research completed; publication EUR N° 20184

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7210-PR/016	C3.5/97	750.500	450.300	54 (Mths)		1/07/1997	31/12/2000	31/12/2001

**Title:** Measurement and modelling of crater end position and shape during transient casting conditions

**OBJECTIVES AND CONTENTS**

The main objective of this research project is to minimise centre segregation especially under transient casting conditions. The project will undertake measurement and modelling of crater end position and shape during transient casting conditions. An innovative soft reduction concept is proposed where the bloom is preformed in the mould with an ellipse-like shape in order to promote soft reduction.

**State of progress:** Research completed; publication EUR N°

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7210-PR/017	C3.6/97	1.495.000	897.000	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Application of surface and internal quality forecasting and casting engineering monitoring to the online quality prediction of continuously cast semis

**OBJECTIVES AND CONTENTS**

The aim of this project is to enable prediction of both surface and internal quality of as-cast semis, on-line, on a per metre basis. This will facilitate direct connection of the caster to downstream processing. Various approaches will be considered, including statistical methods and neural networks. On-line displays to assist operators will be developed, as will feedback from the predictions to allow changes to be made to the underlying caster control parameters.

**State of progress:** Research completed; publication EUR N° 20191

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7210-PR/018	C3.7/97	900.500	540.300	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Real-time control of ferrite distribution in the manufacture of stainless steel slabs free of surface defects

**OBJECTIVES AND CONTENTS**

The overall objective of this research project is to develop real-time prediction of delta-ferrite content in continuous casting in order to prevent surface and internal cracking of the stainless steel slab. The main approach is to compare different mathematical models with direct measurements of residual ferrite distribution in slab sampling and with laboratory quenching tests of the same material. The results will also be of use in preventing cracking during hot rolling.

**State of progress:** Research completed; publication EUR N° 20189

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7210-PR/081	C3.1/98	1.752.167	1.051.300	54 (Mths)		1/07/1998	31/12/2001	31/12/2002

**Title:** Improved control of segregation in continuous casting & hot rolling processes

**OBJECTIVES AND CONTENTS**

Due to ever more stringent product quality requirements, it is necessary to improve control of segregation in the casting and rolling processes. The aim of the proposal is to determine and quantify the factors affecting centreline segregation and distribution to ensure segregation is minimised and/or restricted to areas least likely to affect final product quality or downstream operations. This will be achieved by combining plant measurements, modelling and metallurgical assessment and taking an integrated view of the casting and subsequent rolling procedures via slab, bloom and billet routes for both long and flat products.

**State of progress:** Research completed; publication EUR N° 20886 EN

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7210-PR/082	C3.2/98	1.749.000	1.049.400	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Self condition monitoring of continuous casting machines

**OBJECTIVES AND CONTENTS**

In the continuous casting process the effectiveness of plant condition monitoring methods is restricted by the severe conditions which make most of the measuring methods unreliable or expensive to maintain. The aim of this project is to develop new techniques and to improve existing techniques of monitoring and to improve the condition of continuous casting machines on both an on-line and regular off-line basis. This will provide reliable cost-effective methods to ensure an improved maintenance program for billet, bloom and slab casters, which will also indicate when casting machine condition is starting to deteriorate to the point where cast product quality suffers. The information obtained will be processed by the development of rule-sets and modelling to enable the installation of reliable and accurate plant condition monitoring systems, to assist prediction of maintenance requirements and thereby improve semi-finished product quality.

**State of progress:** Research completed; publication EUR N°

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7210-PR/083	C3.3/98	1.012.500	607.500	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Improvement of casting fluxes & slags by minimization of environment-polluting & corrosive constituents (fluorine, alkali)

**OBJECTIVES AND CONTENTS**

Fluorides and alkali metal oxides are widely used as strong fluxing agents for casting fluxes and slags. These components do, however, originate volatile compounds harmful to the workers health. The proposed project will provide essential information necessary for the production of environment friendly mould powders and slags. This includes the study of the formation mechanism of the volatiles, the individuation of fluxes free from fluorine and less stable alkali metal oxides, the examination and modelling of their properties and the development and test of fluxes in industrial trials.

**State of progress:** Research completed; publication EUR N° 20645 EN

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7210-PR/084	C3.4/98	1.727.000	1.036.200	48 (Mths)		1/07/1998	31/12/2001	30/06/2002

**Title:** Determination of high temperature surface crack formation criteria in continuous casting and thin slab casting

**OBJECTIVES AND CONTENTS**

Surface cracking is a serious problem in continuous casting. Although several investigations have been carried out in the past and have lead to considerable improvement, there is still a strong need to further reduce surface cracking. This research aims at determining surface crack formation criteria in continuous casting and thin slab casting. This will enable to use rules for the choice of << process with reduced cracking risk >> for as-cast products. The work will combine laboratory studies, mathematical modelling and industrial trials. The work in this project is performed in conjunction with the start-up of three most advanced casting machines currently built in Europe. Cracking problems, which may occur in the initial phase of these casters, can be immediately analysed with the numerical and physical simulations developed in this research This could help optimise casting parameters and cooling strategies.

**State of progress:** Research completed; publication EUR N° 20897 EN

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7210-PR/085	C3.5/98	1.703.500	1.022.100	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Direct application of direct cast steel products

**OBJECTIVES AND CONTENTS**

In the proposed project a further cutting of the production route making wide steel strip is to be investigated. Using the double roller method as an example of near-net shape casting, different ways of in-line strip treatment shall be investigated to optimise the strip properties for subsequent applications. The behaviour of the near-net-shape cast steel in the manufacturing of products is unknown, particularly when the steel sheets shall be applied directly for products without any cold rolling. The aimed product groups are e.g. high strength parts for the automotive production, fixing parts for shelves, pipes with longitudinal welding or wear resisting plates.

**State of progress:** Research completed; publication EUR N°

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7210-PR/139	C3.1/99	1.368.625	821.175	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** New approaches of the initial solidified shell formation mechanisms in the continuous casting mold

**OBJECTIVES AND CONTENTS**

Increasing demands for product quality in continuous casting of billets, blooms and slabs asks for an improved knowledge of the phenomena that occur at the meniscus in the mold. The overall objective of this project is to develop new methods of investigation in order to have a better insight into the initial solidified shell formation and therefore to identify new casting conditions for the improvement of the products quality. This will be achieved by studying, on the one hand, the interaction between the lubricant (oil or powder) and the solidified shell and, on the other hand, by studying the associated mold process parameters. The main part of the work will consist in simulation test, industrial characterisations and numerical modelling.

**State of progress:** Research completed; publication EUR N° 20947 EN

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**Title:** Castability & surface quality of steels microalloyed with Ti or TiNb in continuous casting of slabs, thin slabs and beam blanks

**OBJECTIVES AND CONTENTS**

The project is aimed at improving the castability and surface quality of Ti and TiNb micro-alloyed steels of medium and high Ti content (Ti 0.06 to 0.25 %, Nb ? 0.06 %) in continuous casting of thin slabs and beam blanks. The investigations will be focused on EAF steel for long and flat products (N content 80-100 ppm) as well as on high strength structural steels to be produced from converter steel (N<80 ppm) via thin slab casting and direct rolling of hot strip. Through analysis of different industrial situations and laboratory simulations possible causes of increased proneness for breakouts and the information of transverse cracks and other surface defects will be studied. The precipitation of Ti-containing phases prior to hot rolling will be investigated. Appropriate modifications of the working practice will be developed and tested under industrial conditions.

**State of progress:** Research completed; publication EUR N° 20812 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/142	C3.4/99	1.218.600	731.160	42 (Mths)		1/07/1999	31/12/2002	31/12/2002

**Title:** Detection and measurement of asymmetric flow in the mould and assessment of its effect on product quality of continuously cast slabs

**OBJECTIVES AND CONTENTS**

The flow of steel in the mould of continuous slab casting machines, which can be extremely complex, has a large impact on final product quality leading to entrainment of argon bubbles, powder and mould slag in the solidifying strand and in the worst case breakouts. The aims of the project are: the development of advanced simulation methods in addition to instrumentation systems; the detection and measurement of the flow of steel in the mould of slab casters using thermocouples and electromagnetic measuring devices. The impact of flow conditions and asymmetric flow on product quality will be investigated over the range of casting speeds and strand dimensions available to the partners. The wished aim is to display dynamically to operators the flow of steel in the mould and to highlight conditions deleterious to as-cast semi-finished product quality.

**State of progress:** Research completed; publication EUR N° 20887 EN

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Technical Group C3 has 35 Projects and 135 Partners

Total Projects: 107 - Total Partners: 408

**Technical Group D1 : "Rolling - Long Products and Reheating Furnaces"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-EB/504	D1.1/94	740.304	435.900	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Development of the beam blank manufacturing route to achieve the production of high quality structural sections and to enable new product development

**OBJECTIVES AND CONTENTS**

The overall objective of the proposed research is the development of a high quality beam blank manufacturing route with the potential for new product development using advanced casting and rolling technologies. The industrial application of new routes based for a large part on the near net shape casting concept undoubtedly allows a drastic decrease in processing costs. However it also opens up the question of the possible effect of a smaller reduction rate during the rolling of semis on the final properties of the products. For sections, which under the conventional route are processed by appropriate thermomechanical treatments during rolling, this aspect is particularly important. On the other hand, the beam blank offers the possibility of enabling more difficult sections to be rolled, and this project will take a major step forward in seeking to develop a methodology for exploiting this. The project is intended to be a multipartner work programme with involvement of CRM in beam blank property enhancement through the application of powder injection in the mould and of original casting technologies, PROFILARBED examining the rolling of beam blanks in mill trials and British Steel developing beam blank technology as part of an integrated manufacturing route.

**State of progress:** Research completed; publication EUR N° 19868

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**Technical Group D1 : "Rolling - Long Products and Reheating Furnaces"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-EB/810	D1.1/95	768.000	460.800	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Assessment of long product defects

**OBJECTIVES AND CONTENTS**

The objectives of the proposed research can be summarised as follows:

- enhancement of the hot deformation behaviour of CC semis through a thermal treatment combining "on-line" cooling at the caster below the critical point and a subsequent self-reheating of the cast strand;
- improvements to the surface quality of rolled products through the use of billets with unusually large corner radii (up to 1/3rd of the cast size);
- provision of a computer-based system which will enable the rolling history of any defect found in a long product to be determined. The system will initially be developed with reference to billets, and possibly extended to other long products at a later stage. Consideration will be given initially to rolling operations but the intention is to extend the system upstream to cover reheating, and downstream to include finishing operations.

The ways and means of achieving the objectives involve model development, plant trials in the continuous casting and mill areas, and product investigation. The programme for model development includes the formulation of Finite Element Models and their validation against plant data. Information from the models will then be incorporated in a database. Plant trials are to include innovative casting and rolling of the resulting product.

**State of progress:** Research completed; publication EUR N° 19869

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7210-EB/108	D1.2/95	927.000	556.200	48 (Mths)		1/07/1995	30/06/1999	30/11/1999

**Title:** Improved atmosphere control for product quality and combustion efficiency in reheating furnaces

**OBJECTIVES AND CONTENTS**

In order to improve the surface quality of steel products and to achieve high energy savings in hot rolling plants, it is necessary to control the atmosphere in each zone inside the reheating furnaces reliably.

The aim of the planned research project is to develop an improved control system for the air-fuel ratio in each zone using combustion gas analysis and model-supported process control. Real-time determination of physical characteristics is also needed to adjust the global air-fuel-ratio of furnaces. A feed-forward strategy for improved control shall be developed. Quasi-simultaneous combustion gas analysis at multiple locations inside the furnace shall be installed. Combustion gas analysis shall be introduced step-by-step to improve control of the air-fuel ratio.

**State of progress:** Research completed; publication EUR N° 19855

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7210-EB/901	D1.3/95	589.500	353.700	47 (Mths)		1/11/1995	31/10/1998	30/11/1999

**Title:** Improved atmosphere control for product quality and combustion efficiency in reheating furnaces

**OBJECTIVES AND CONTENTS**

The aim of the project is to improve the quality of rolled products and increase the capacity of existing furnaces by combining electrical heating and combustion heating. The lower energy consumption and decreased oxidation of steel will be achieved through computer simulation of gas flow, temperature calculations of heated stock, studies and evaluation of scale formation and gas analysis in pilot and production furnaces.

**State of progress:** Research completed; publication EUR N° 19855

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7210-EB/309	D1.1/96	788.000	472.800	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Descaling adherent scales while reducing hot bar heat losses

**OBJECTIVES AND CONTENTS**

The main objective of this research project is to define operating recommendations in order to improve the surface quality of steel grades recognised as difficult, for primary and secondary descaling, while saving energy and reducing operating costs, and perhaps allowing new rolling practices. Particular attention will be paid to scale-steel interface morphology, temperature path, thermomechanical stresses at the scale-metal interface, and thermohydraulic phenomena.

**State of progress:** Research completed; publication EUR N° 19856

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7210-PR/019	D1.1/97	1.552.500	931.500	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Oxidation and decarburisation of high carbon, special and general steels

**OBJECTIVES AND CONTENTS**

The aim of this proposal is to improve understanding of the related effects of scale formation and surface decarburization that arise from oxidation during steel reheating in order to meet increasingly stringent surface quality requirements and decarburization specifications of general, special and high carbon steels.

Laboratory measurements will be used to derive fundamental data related to scale formation and decarburization under a range of conditions for incorporation into a predictive mathematical model. This model will be extended by pilot plant and works trials to accommodate changes in the oxidation kinetics arising from the effect of sample geometry on scale adhesion.

**State of progress:** Research completed; publication EUR N°

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7210-PR/020	D1.2/97	859.500	515.700	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Optimization of beam reheating conditions in the reheating furnace

**OBJECTIVES AND CONTENTS**

Near net shape casting is currently the most competitive technology for producing beams. Prior to rolling, large beam blanks from continuous casting machines are reheated in a walking beam furnace which reheats both hot and cold charges as well as different beam blank profiles. The object of this research project is to optimise operation of the furnace with particular emphasis on the following topics:

- temperature homogeneity improvements;
- improving descalability;
- minimising scale losses;
- increasing productivity;
- metallurgical aspects;
- reducing energy consumption;
- NOx reduction.

**State of progress:** Research completed; publication EUR N° 20194

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7210-PR/021	D1.3/97	1.398.500	839.100	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** New steel generation for high strength, large diameter wire-rods

**OBJECTIVES AND CONTENTS**

This project aims to develop a new generation of high carbon (0.8 - 0.85%) steels for high strength wire-rods of large diameter (13 mm) suitable for producing cold drawn wires of 4 - 11 mm diameter, tensile strength 1560 - 2100 MPa and good ductility. In close association with this objective, work will be carried out on adapting this range of products to mechanical descaling. This aim will be achieved by optimising the thermomechanical treatment parameters and the steel composition. Extensive industrial and laboratory trials will be carried out.

**State of progress:** Research completed; publication EUR N° 20195

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7210-PR/022	D1.4/97	1.220.500	732.300	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Integration of reheating furnaces with rolling conditions at the roughing mill

**OBJECTIVES AND CONTENTS**

This project is aimed at improving reheat furnace control using the feedback of process measurements available on a routine basis. The primary objective of the project is to develop and demonstrate the methodology required for an effective reheat furnace control system to improve the temperature consistency of hot rolling feedstock discharged from reheating furnaces. The work programme will address strip, plate and long product hot rolling practices to improve consistency of final product properties. Several feedback strategies and a range of products and furnace designs will be investigated.

**State of progress:** Research completed; publication EUR N° 20196

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**Technical Group D1 : "Rolling - Long Products and Reheating Furnaces"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/086	D1.1/98	905.000	543.000	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Development of systems to aid flexible rolling of long products to close tolerances by on-line calculation of loaded roll gap, control of stand speeds and reheat

**OBJECTIVES AND CONTENTS**

The objective of this project is to develop means of achieving improved tolerances for long products given the trend of more demanding rolling schedules with frequent changes. This will provide competitive advantage in the future where the ability to roll profitably small orders of highly specified material to close tolerances will be crucial. This will be achieved by a novel combination of mill sensors and process models to control key parameters: loaded roll gaps, inter-stand tensions and stock temperatures. Each partner will initially focus on one control parameter; the project will then draw these strands together by proposing on-line control schemes.

**State of progress:** Research completed; publication EUR N° 20473

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7210-PR/087	D1.2/98	1.060.500	636.300	48 (Mths)		1/07/1998	31/12/2001	30/06/2002

**Title:** Automatic control of roller and gag press straightening operations for sections

**OBJECTIVES AND CONTENTS**

In recent years, significant advances have been made in increasing the understanding of, and the ability to control, section straightening operations, mainly through the combination of advanced mathematical modelling and process instrumentation/monitoring improvements. The objectives of the project are to make full use of these advances to develop and implement process control systems for automatic set-up and on-line adjustment of machine operating conditions, on the basis of feedback of both process information and outgoing straightness measurements, in order to maintain consistency of outgoing product straightness and, at the same time, ensure that section residual stresses are minimised.

**State of progress:** Research completed; publication EUR N° 20892 EN

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7210-PR/143	D1.1/99	986.500	591.900	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** New methodological approach to selective oxidation

**OBJECTIVES AND CONTENTS**

This proposal aims to develop new and more sensitive techniques in order to understand and quantify the effect (i) of additional (or residual) elements in steels and (ii) additional reactive gases in the atmosphere during annealing. The project combines in-situ and ex-situ surface characterisations to determine the kinetics of oxygen adsorption, to define the nature and the in-depth distribution of oxide precipitate as well as the development of more realistic models taking into account oxygen adsorption at the surface and the possible formation of mixed oxides. The understanding of the mechanisms controlling selective oxidation and their quantification as a function of process parameters, as also the development of predictive models will be useful to operators to control surface quality by minimising surface defects. The processes particularly concerned by this project are hot dip galvanising, electrogalvanising and all the surface treatment occurring after batch or continuous annealing.

**State of progress:** Research completed; publication EUR N° 21144 EN

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7210-PR/144	D1.2/99	1.300.500	780.300	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** New ways to improve longitudinal temperature homogeneity of slabs in reheating furnaces

**OBJECTIVES AND CONTENTS**

The production of high quality steel strips requires efficient ways to control temperature uniformity along the slab length. Today, in modern re-heating furnaces the over-heating of the slab-end is typically around 50°C, while the dissymmetry of temperature profile as of about 20°C. These defects produce bad thickness for heads and tails, scale incrustation and difficulties to insert sheets into the rolling mill with high speed. The objective of this research is to develop new technical devices to improve the longitudinal temperature homogeneity of slabs in re-heating furnaces. Simulations, experimental tests and full-scale trials of cooling systems, shadow masks, geometrical transformations of walls and waste-gas exit will be performed in order to obtain an innovative design of a new re-heating furnace.

**State of progress:** Research completed; publication EUR N° 21334 EN

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Technical Group D1 has 13 Projects and 39 Partners

Total Projects: 120 - Total Partners: 447

**Technical Group D2 : "Rolling - Flat Products"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-EA/142	D2.1/94	1.636.073	944.662	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Improvement of control and process strategy for strip flatness

**OBJECTIVES AND CONTENTS**

The aim of this research project is to improve control and process strategies for hot strip flatness.

Objectives are:

- the improvement of flatness control strategy through improved measuring devices which introduce self-learning pattern recognition methods to rolling processes, and the integration of closed loop, on-line control in the set-up calculations for shape and profile;
- the evaluation of effects and their interactions on strip flatness after runout from the finishing mill up to entry into the subsequent processing units, by investigating input variables with the aid of artificial intelligence methods;
- the definition of improved setpoint selections and alternative process strategies able to minimize negative modifications to strip flatness.

**State of progress:** Research completed; publication EUR N° 19873

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7210-EA/143	D2.2/94	1.442.953	825.000	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Development and testing of procedures for optimizing the degree of strip reduction during skin pass rolling

**OBJECTIVES AND CONTENTS**

On the one hand, this research project will investigate the problem of skin pass rolling by examining the correlation between all the relevant parameters which influence strip geometry and mechanical characteristics. A special approach will be adopted to determine those relationships required to control rolling force through a neural network.

On the other hand, the minimum or optimum values of the yield point are to be determined for those steels with an upper and lower yield point, by measuring the rolling force changes while modifying the roll adjustment.

Moreover, the degree of skin pass rolling is to be determined by means of a magnetic measuring method providing greater accuracy than those methods currently in use.

**State of progress:** Research completed; publication EUR N° 18917

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7210-EA/145	D2.3/94	645.000	387.000	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Improved strip quality through process control and design-out of chatter

**OBJECTIVES AND CONTENTS**

The aim of this research project is to develop a new strategy for eliminating chatter which will concentrate on developing a better understanding of the dynamic behaviour of the mill under operating conditions in order to generate on-line models rather than static modal models as currently available. This will be achieved by developing realistic models for the operational dynamic behaviour of the mill structure based on live modelling, a control strategy that will provide better control of the chatter problems, and examination of reduced chatter designs for mills. The project results should enable confident operation despite proximity of chatter frequencies through control based on on-line models, combined with improved design giving lower likelihood of chatter.

**State of progress:** Research completed; publication EUR N° 19875

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7210-EA/328	D2.4/94	1.167.130	564.000	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Flatness and internal stress evolution after hot strip rolling

**OBJECTIVES AND CONTENTS**

At the present time, flatness control is achieved at the exit of the finishing mill on a hot strip mill. Nevertheless, internal stresses and flatness evolution may occur after rolling, during cooling on the runout table, coiling operations, cooling of the coil, etc.

The aim of this research project is to measure and modelize the evolution of internal stress and flatness during the different steps of the process line between hot rolling and uncoiling of the strip, and to optimize the process parameters in order to produce tension-free strip with excellent flatness.

**State of progress:** Research completed; publication EUR N° 19874

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7210-EA/329	D2.1/95	1.983.500	1.190.100	48 (Mths)		1/07/1995	30/06/1999	30/06/1999

**Title:** Lubrication during cold rolling: understanding and control of main rolling parameters and improved use of rolling oils

**OBJECTIVES AND CONTENTS**

Insufficient control of lubrication in cold rolling has many consequences in industrial production. An improved understanding of phenomena involved in tinplate rolling, associated with improved filtering to limit the effects of ageing or pollution, will provide improvements in thickness control, constancy of rolling conditions, decrease in the number of strip breakages and reduction in oil cost and treatment costs (waste fluids).

The projected work includes a synthesis based on industrial data, construction of experimental equipment (oil treatment, pilot mill lubrication circuit), finite element model investigations, industrial trials and testing.

**State of progress:** Research completed; publication EUR N° 20092

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7210-EA/827	D2.2/95	1.872.500	1.123.500	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Optimisation of the use of strip geometry control system

**OBJECTIVES AND CONTENTS**

This project is aimed at improvement in process control techniques affecting strip geometry (including gauge profile and shape) in hot rolling, and is particularly concerned with establishing the optimum mill operational performance, on the basis of:

- to establish a common monitor of operational performance against which each of the partners can assess progress in fulfilling objectives;
- to measure and evaluate the influence of roll axis position tolerances and roll shifting on operational performance and strip quality;
- to quantify and prioritise the factors causing operational instabilities and to establish the recommended operating practices and roll gap and roll stack tolerances to minimise operational problems and maximise strip tracking and to develop operational control parameters;
- to develop and calibrate a stack deflection off-line model which takes account of asymmetric aspects in particular and which includes a predictive capability for strip tracking;
- to carry out a comparison of the effect of alternative or additional methods of shape profile control on conventional roll bending and shifting; this will include self compensating back up rolls, CVC rolls and tapered work rolls.

The use of four different hot strip mills with differing strip geometry control systems will allow in-depth comparisons to be made.

**State of progress:** Research completed; publication EUR N° 20101

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7210-EA/901	D2.3/95	335.833	201.500	36 (Mths)		1/11/1995	31/10/1998	31/10/1998

**Title:** Optimisation of the use of strip geometry control system

**OBJECTIVES AND CONTENTS**

The project has the following main objectives concerning rolling of stainless steel in Steckel mills:

- to establish common criteria of operational performance;
- to investigate operational instabilities in Steckel rolling and recommend improved operating practices;
- to quantify factors which influence strip tracking in Steckel rolling;
- to compare plant trials of Steckel mill rolling of stainless steel with conventional mill rolling.

**State of progress:** Research completed; publication EUR N° 20101

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7210-EA/150	D2.1/96	1.060.500	636.300	54 (Mths)		1/07/1996	31/12/1999	31/12/2000

**Title:** Optimizing and monitoring the impact of friction, wear and lubrication in hot rolling

**OBJECTIVES AND CONTENTS**

The objectives of this research project are to obtain information on the influence of friction and lubrication, the wear behaviour and roughness of work rolls in hot-strip rolling operations. Alternative rolling strategies will also be developed to improve roll service life, pickling properties and to minimize vibrations and chatter. Monitoring systems will be devised and tested for roll wear and other relevant process parameters, especially dynamic plant behaviour.

**State of progress:** Research completed; publication EUR N° 20209

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7210-EA/152	D2.2/96	1.452.500	871.500	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Improved strip flatness control and presetting systems by analyzing the strip behaviour as well as by simulating and practical testing the efficiency of actuators in cold roll...

**OBJECTIVES AND CONTENTS**

It is often impossible during cold rolling operations to achieve the required stress distribution due to limitations in the operating range of the control actuators and in automatic presetting techniques. This project aims to reduce operating costs through theoretical mathematical analyses, computer simulation and practical testing on different cold rolling mills in order to determine ways of improving strip flatness control and productivity.

**State of progress:** Research completed; publication EUR N° 20102

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7210-EA/205	D2.3/96	1.477.500	886.500	42 (Mths)		1/07/1996	30/06/1999	31/12/1999

**Title:** Improved strip shape in high speed continuous annealing lines

**OBJECTIVES AND CONTENTS**

This research project is aimed at improving the flatness quality of strip during continuous annealing. This will be carried out through the measurement of the geometry of the rolls during service, and through the analysis of the conditions during which buckles could occur mainly due to misalignments and transient states. Electric grade steel will also be examined. Results will lead to a reduction in the risk of heat buckles and an increase in the useable width of the product.

**State of progress:** Research completed; publication EUR N° 20095

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7210-EA/206	D2.4/96	1.178.500	707.100	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Increased efficiency and functionality of pickling lines

**OBJECTIVES AND CONTENTS**

This project is aimed at improving the efficiency of pickling lines in terms of capacity and total quality while reducing environmental impact. This will be carried out by inductive heating of the strip in the pickling tanks in order to increase the pickling rate. The quality of the pickled and downstream surface will also be improved through the introduction of monitoring and other control actions in a coupled "pickling line + cold rolling mill", and also through the analysis and optimization of the major pickling and rinsing parameters.

**State of progress:** Research completed; publication EUR N° 19872

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7210-EA/427	D2.5/96	736.000	441.600	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Improvement of micro-structural homogeneity of hot rolled strips through transverse temperature control

**OBJECTIVES AND CONTENTS**

This project is aimed at the development and implementation of systems for on-line transverse temperature control for the microstructural homogeneity of hot strip. Sophisticated mathematical models will be developed, using artificial intelligence neural network methods, to establish the relationships between hot rolling parameters and the final properties of the material, especially silicon and high strength steels, and an on-line control system will be developed on the basis of this model. Efforts will also be made to obtain strip with controlled graded properties across its width.

**State of progress:** Research completed; publication EUR N° 19870

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7210-EA/830	D2.7/96	959.500	575.700	42 (Mths)		1/07/1996	31/12/1999	31/12/1999

**Title:** Improving the hot rolling process of surface critical steels by improved and prolonged working life of work rolls in the finishing section

**OBJECTIVES AND CONTENTS**

This project is aimed at improving the campaign life of work rolls in the first 4 stands of a hot mill finishing train, while improving the efficiency of the rolling process. The project combines in-line monitoring of the roll wear process, of different types of rolls, with variants in roll temperatures, cooling and lubrication, and monitoring of the strip surface quality. Additional off-line modelling and test programmes to enhance understanding of roll surface degradation will also be undertaken.

**State of progress:** Research completed; publication EUR N° 19871

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7210-PR/023	D2.1/97	1.322.000	793.200	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Mastering gas flow inside continuous annealing furnaces

**OBJECTIVES AND CONTENTS**

This research project is aimed at improving the process control of continuous annealing furnaces to ensure improved surface quality and decreased gas consumption. It will focus on the control of gas flow in the furnace both close to the steel strip, and in each section of the furnace (injection and purge points, design of gas locks between sections, etc.).

This project combines the different approaches of the partners:

- design of a novel sensor (for industrial measurements);
- improvements of air lock design and sensor validation through pilot tests;
- furnace modelling (fluid flow and heat transfer and dynamic transfer functions).

These improvements may allow specific local surface treatments to be carried out in some furnace sections.

**State of progress:** Research completed; publication EUR N° 20207

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7210-PR/024	D2.2/97	796.500	477.900	54 (Mths)		1/07/1997	31/12/2000	31/12/2001

**Title:** Automatic recognition and quantification of flatness defects of heavy plates after water cooling treatment for on-line optimization of the cooling process

**OBJECTIVES AND CONTENTS**

This research project aims to develop automatic recognition and quantification of flatness defects in water cooled heavy plate (ACC) on the basis of the plate topology as measured using a laser system after the cooling line. A model for the prediction of plate behaviour will be developed and verified which has been deduced from parameters involving the cooling line, measured plate topology and a physically based deformation model. On the basis of the prediction model, a process control loop for the cooling line will be designed and tested. The implementation of such systems would reduce worker intervention under difficult working conditions.

**State of progress:** Research completed; publication EUR N°

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7210-PR/025	D2.3/97	1.560.000	936.000	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Internal stress and flatness after tension levelling

**OBJECTIVES AND CONTENTS**

Flatness of cold rolled products is one of the major requirements of users, especially of thin gauges. Residual stress imbalances can induce shape change after cutting or slitting. The aim of this project is to improve the knowledge of tension levelling and multi-roller tension levelling and their effects on flatness, bow and residual stresses. It is intended to use mathematical models, a tension flex levelling pilot machine, practical tests and measurements on industrial levellers to investigate flatness evolution including stress distribution of cold rolled products, mild steel sheet, tin plate and stainless steel.

**State of progress:** Research completed; publication EUR N°

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/026	D2.4/97	1.059.000	635.400	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** New continuous annealing technology with high speed induction heating followed by ultra fast cooling

**OBJECTIVES AND CONTENTS**

The main objective of this project is to develop technologies for ultra-fast heating and cooling of strip applicable to the continuous annealing process. Available technologies need further development to achieve higher rates, improved thermal homogeneity and surface quality, and easier control. Transverse flux induction technology will be improved and a new cooling technology using a liquid as a cooling medium will be developed. This work will result in an increase in the capacity and flexibility of existing lines and possibly in the ability to build very compact lines.

**State of progress:** Research completed; publication EUR N° 20203

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7210-PR/027	D2.5/97	1.315.500	789.300	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Optimization of plate and strip processing to meet high customer demands

**OBJECTIVES AND CONTENTS**

This research project will investigate the development of shape and residual stress in flat products during cold levelling, and the mechanisms governing the distortion of such cold levelled products during subsequent cutting and slitting operations. The shape and residual stress after uncoiling of hot rolled strip for cold levelling and for further internal processing are also to be studied. Existing mathematical models will be used to define upstream process operating parameters that will produce material of optimal condition for entry to the levelling process, and levelling engineering condition and operational practice, for plate which stays flat after cutting and slitting.

**State of progress:** Research completed; publication EUR N° 20211

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7210-PR/028	D2.6/97	1.175.500	705.300	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Profile, flatness and ski-end control in plate rolling

**OBJECTIVES AND CONTENTS**

Advanced plate profile and flatness control systems are used nowadays in plate mills. They are based on physical models derived from plate temperature, rolling force, roll deflection, roll wear, roll thermal expansion, plate crown and flatness parameters. The goal of this research work is to improve and speed up models for plate pass scheduling, profile and flatness using a profile and shape vector method which takes account of the decreased period available between passes in the plate mill. The temperature model considers phase transformation, latent heating and recrystallization. Rolling forces are calculated using a friction-hill model coupled to neural networks and the shape model is an empirical physical model deduced from FEM calculations.

**State of progress:** Research completed; publication EUR N° 20210

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7210-PR/029	D2.7/97	1.448.000	868.800	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Enhanced coating thickness control in hot dip galvanizing

**OBJECTIVES AND CONTENTS**

This project aims to enhance the control of coating thickness in galvanising lines.

The research work will be directed in particular at:

- correcting the cross-bow defect of the strip passing in front of the nozzles of the wiping device by an on-line control system acting on the snap rolls position in the zinc pot;
- reducing dynamic effects by developing air floating technology and process procedures;
- optimising air knife geometry for 55% Al-Zn coatings.

**State of progress:** Research completed; publication EUR N° 20206

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7210-PR/030	D2.8/97	1.256.000	753.600	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Reduction of chatter during cold rolling

**OBJECTIVES AND CONTENTS**

The goal of this research project is to reduce chatter marks without adversely affecting production. The project will concentrate on the following main tasks:

- analysing roll gap excitation;
- developing a comprehensive chatter model;
- deducing rules for improved processing and design;
- on-line detection of chatter marks and developing advanced chatter monitoring/control concepts.

The results will contribute to improved strip quality, a reduction in production costs, as well as reducing noise in the workplace and decreasing the risk of strip breakage.

**State of progress:** Research completed; publication EUR N° 20204

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7210-PR/032	D2.10/97	1.428.500	857.100	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Improvement of hot strip coiling by optimization of coiler control

**OBJECTIVES AND CONTENTS**

Insufficient coiling quality remains a severe problem in strip production and is due mainly to the fact that control of the multivariable coiling process is still performed by conventional single input/single output control loops. The overall aim of this research project is to define advanced control strategies for coiler control, including controllers which can adopt multivariable models, the provision of more accurate data on the speed and location of the strip as it approaches the coiler, and feedback on the actual coil profile. Attempts will also be made to incorporate an expert system to associate coiling defects with their causes.

**State of progress:** Research completed; publication EUR N° 20212

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**Technical Group D2 : "Rolling - Flat Products"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/043	D2/E.6/97	1.316.500	789.900	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Lubrication in hot rolling: Effect of different utilisation strategies on strip quality and process conditions for various steel grades

**OBJECTIVES AND CONTENTS**

This research project is aimed at improving quality and process conditions of hot rolled strip through roll gap lubrication. The objectives are:

- to develop models able to determine the laws of deformation of iron oxide scales for different rolling conditions and to utilise these laws to improve the mill preset;
- to analyse strip surface properties and mechanical properties as a function of different lubricants;
- to study changes in lubricant properties during rolling and the consequent effects observed;
- to calculate friction coefficients for different lubricants and steel grades through pilot experiments;
- to study the effect of lubricants, in terms of strip surface quality and roll wear for various steel grades;
- to study the influence of lubrication on strip profile and flatness, and subsequently to establish different operating practices.

**State of progress:** Research completed; publication EUR N° 20208

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7210-PR/088	D2.1/98	1.264.200	758.520	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** The development of portable expert systems for fault finding & maintenance of rolling mills

**OBJECTIVES AND CONTENTS**

Increasing pressure to maximise production and reduce manning have led to rolling mill plant facilities becoming some of the most difficult to maintain to the exacting mechanical and electrical tolerance required. The aim of the project is to evaluate the novel use of portable expert systems for improving fault detection, fault diagnosis and maintenance standards in these areas. Through the development of a number of portable advisory and fault diagnosis systems this project will provide a comprehensive evaluation of such systems. Hydraulic systems and main drive motors will be studied for two of the rolling mill areas.

**State of progress:** Research completed; publication EUR N° 21217 EN

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7210-PR/089	D2.2/98	1.301.500	780.900	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Improved control in cold rolling by use of information about incoming hot rolled cross sectional profile & camber

**OBJECTIVES AND CONTENTS**

The purpose of the project is to establish a close link between the length dependent hot strip characteristics cross thickness profile and camber and set-up and control of cold rolling mill. To this an incoming strip oriented command system and an open-loop control system for the command variables will be developed using data based hybrid models and knowledge about the influencing strip and process parameters. The specific aims are to improve cold strip flatness, reduce residual stresses, improve the operating process and reduce the camber. This will increase both the production and the product quality. The findings of the developed methods will be directly transferable to all cold mills.

**State of progress:** Research completed; publication EUR N°

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7210-PR/090	D2.3/98	1.263.000	757.800	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Controlled and improved work roll cooling

**OBJECTIVES AND CONTENTS**

The goal of this project is to improve the performance of the cooling system of the rolls of hot strip mills using two new different cooling strategies. The implementation of the new cooling strategies will use a combination of observers and intelligent controllers. The observers are based on simplified mathematical models that running in real-time generate the thermal state in the inner of the rolls. In addition they calculate the thermal crown of the work rolls. In order to study the physical phenomenon an off-line mathematical model of the cooling process will be developed. New instrumentation based on optical pyrometers and CCD cameras will be used to adjust the models and verify the improvements reached in the cooling system with the two previous strategies. The intelligent controllers are based on neural networks and fuzzy-based systems. They integrate the information supplied by the observers with the operational variables of the mill in real-time and generate the set-point for the basic regulators that control the valves of the cooling water.

**State of progress:** Research completed; publication EUR N°

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7210-PR/091	D2.4/98	1.346.000	807.600	54 (Mths)		1/07/1998	31/12/2001	31/12/2002

**Title:** Improved quality of hot rolled coil by means of advanced control methods

**OBJECTIVES AND CONTENTS**

In order to satisfy downstream and customer requirements referring to strip quality features, all influences on strip quality have to be taken into consideration by a comprehensive control strategy valid for the threading phase as well as for the rolling phase. By means of a multivariable control concept it seems to be quite possible to control simultaneously the different processes and actuators which influence the strip quality to meet the increased requirements sufficiently. The aim of the project is, therefore, to improve the quality of hot strip by use of advanced control strategies for the coil to coil adaptation of the mill set-up as well as for the in-bar process control.

**State of progress:** Research completed; publication EUR N° 21132 EN

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7210-PR/146	D2.1/99	797.000	478.200	42 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title:** Influence of pickling parameters on zinc coating & cold rolling

**OBJECTIVES AND CONTENTS**

Pickling of hot rolled material is one of the important steps in steel sheet production. The sheets are often mechanically deformed before pickling so that the oxide-steel interface can be rapidly attacked. In this project the influence of pickled surface on cold rolling and on the cold rolled product as well as on zinc coating and on the zinc-coated product is investigated. For a few hot rolled steel qualities, the present situation is recorded by making use of pilot line experiments. At the same time, laboratory experiments will be performed in order to obtain a better knowledge of the parameters that play an important role on the characteristics of the pickled surface. These results are then incorporated in a new set of pilot line or plant experiments.

**State of progress:** Research completed; publication EUR N° 20893 EN

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7210-PR/147	D2.2/99	992.500	595.500	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Heavy reductions on first stands of a tandem cold mill

**OBJECTIVES AND CONTENTS**

As rolling process costs are a significant part of the price of mild and high-carbon steel strips, the increase of reduction on the first stands of a tandem mill is an interesting way to increase productivity. This can lead to an improved productivity of the hot strip mill by providing thicker strips at the entry, while keeping the same final gauge. Furthermore, keeping the same entry gauge can lead to thinner and harder products. However, reduction is, so far, limited by the onset of strip defects (heat streaks or shape problems) or by technological problems (stand power problems, guiding problems). The goals of the project are: to explore new ways of increasing reduction while keeping the quality of the strips; to develop understanding of the defects and the problems arising in order to push further the limits of high reduction safe rolling; to assess the best performance available without increase in investments; to reach on the first two stands a 5% extra-reduction compared to actual reductions.

**State of progress:** Research completed; publication EUR N° 20929 EN

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7210-PR/148	D2.3/99	1.078.750	647.250	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Application of information technologies in the optimisation of roll shop department programming

**OBJECTIVES AND CONTENTS**

This project aims to develop new tools for the optimisation of the roll shop department which will be used to evaluate work roll performance in hot and cold strip mills. This optimisation will reduce the costs by a more accurate programming of the roll shop department and by a better selection of the providers. The quality of the service should also be increased by studying the rolling conditions and by improving the treatments in the roll shop department.

**State of progress:** Research completed; publication EUR N° 20930 EN

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7210-PR/149	D2.4/99	680.800	408.480	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** New contactless system to detect surface shape defects in strip rolling facilities based on fast thermography and neural computing

**OBJECTIVES AND CONTENTS**

The objective of this project is the development of a system for real-time detection and correction of defects in strip rolling facilities. In particular, the system will be focused on defects due to refrigeration failures in the rolls and on failures due to the improper setting of set-point forces in the stands of the mill. A high-speed thermographic line-scan sensor will be installed and its linear-infrared images will be correlated with other signals of the mill. The images will then be analysed, applying pattern recognition techniques, to detect and isolate the failures and their causes generating the proper correction signals.

**State of progress:** Research completed; publication EUR N° 20878 EN

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7210-PR/150	D2.5/99	984.500	590.700	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Development of multiple applications based on new magnetic sensors in steel industries

**OBJECTIVES AND CONTENTS**

Accurate control of certain processing lines in the steel industry demands the use of sensors all along the line so that the control variables can be determined and corrected if necessary. This project aims to develop new magnetic sensors that allow determination of the a-fore mentioned parameters in order to improve the control and quality of annealing and tempering processes. The signals provided by the sensors will be analysed on-line to control the process. They will also allow obtaining information that will be stored and/or monitored by means of real-time micro-processor-based systems that will constitute an appendage to the installation of the sensors.

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7210-PR/151	D2.6/99	1.177.000	706.200	42 (Mths)		1/07/1999	31/12/2002	31/12/2002

**Title:** Multivariable command & control of thickness profile, camber & flatness by use of topometrical measurements & hybrid models for heavy plate mills

**OBJECTIVES AND CONTENTS**

More comprehensive and enhanced measurements, procedures and control of the production process can achieve increasing quality requirements for hot rolled plates with regard to shape and metallurgical properties. The aim of the project is to better meet plate quality demands by command and control of time and plate length. For this purpose, a projected fringe-based area measurement system, comprehensive mill models including mill plant components for steady state and dynamic views, time and length dependent command systems and a multivariable control system will be developed and tested. The use of the advanced modelling, of the command and control methods will represent a considerable progression in production yield and rolled plate quality.

**State of progress:** Research completed; publication EUR N° 20932 EN

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**Technical Group D2 : "Rolling - Flat Products"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/152	D2.7/99	742.000	445.200	42 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title:** Simulating the use of lubricants during cold rolling: modelling the interdependence between lubricant properties and rolling performance

**OBJECTIVES AND CONTENTS**

The project intends to develop new methods to simulate the inter-dependence between rolling lubricant composition and rolling performance in order to evaluate the properties of rolling oils by simulation experiments and to bring about a better understanding of the role of lubrication in cold rolling. Different approaches will be developed. They are: mathematical modelling of the linkage between input and output parameters of the rolling process, in order to identify crucial lubricant parameters; simulation of emulsion-ageing in pilot scale pump tests and test performance on pilot mills and the development of an easy system of laboratory simulation procedures to test technological properties of rolling oils.

**State of progress:** Research completed; publication EUR N° 20933 EN

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7210-PR/153	D2.8/99	1.507.000	904.200	42 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title:** Investigation of the formation, constitution & properties of scale formed during the finishing rolling, cooling & coiling of thin hot strips

**OBJECTIVES AND CONTENTS**

The objective of the research is to assess the relation between rolling, cooling and coiling conditions and scale properties and to establish the relationship between these scale properties and the processability of unpickled or unpickled and directly galvanised strip. The research activity will essentially be performed on material rolled on industrial hot strip mills partly from conventional partly from thin slabs. The applicability of the final products can also be tested on an industrial scale. Process conditions leading to thin and highly adherent scale should enable to avoid pickling, as a stage of the process, for a part of the hot strip intended for direct use.

**State of progress:** Research completed; publication EUR N° 21128 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/154	D2.9/99	1.101.500	660.900	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Stainless steel cold rolling with emulsion

**OBJECTIVES AND CONTENTS**

The lubricants for cold rolling of stainless steel have a major influence on the surface quality of the rolled products and on the productivity of the rolling mills. Up to now only oils but no emulsions are used in cold rolling of bright-annealed stainless steel in Sendzimir mills. The aim of the proposed research is to increase the productivity of stainless steel cold rolling mills by use of emulsion advantages regarding cooling and surface cleanness. Emulsion selection will be based on laboratory tests and, in particular, on trials on pilot rolling mills. Selected new lubricants will be tested on Sendzimir mills. Finally an operational concept with included closed loop plant technology will be developed for Sendzimir mills.

**State of progress:** Research completed; publication EUR N° 20934 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/157	D2.12/99	1.015.200	609.120	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Pre-setting improvement of skin passing concerning flatness and reduction combined with defined strip surface texture by hybrid modelling techniques

**OBJECTIVES AND CONTENTS**

The particular properties of temper rolling and the importance of the equilibrium between the surface roughness and the reduction has made the development of models of this kind of mill difficult, but a considerable experience has been acquired. Using that knowledge, the modelling of the temper rolling has made considerable progress during the last few years, but there is little experience of control systems using new models. The project aims at the development of set-up control strategies using the existing knowledge and a combination of different methods such as hybrid modelling techniques. These techniques are capable of combining data based and explicit information to model coil characteristics as the perfect transmission of roughness, flatness and mechanical properties.

**State of progress:** Research completed; publication EUR N° 20935 EN

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Technical Group D2 has 37 Projects and 123 Partners

Total Projects: 157 - Total Partners: 570

**Technical Group D3 : "Physical Metallurgy of Rolling and Finishing"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-EC/109	D3.1/94	956.727	547.500	48 (Mths)		1/07/1994	30/06/1998	30/06/1998

**Title:** Development of high strength hot- and cold-rolled steel strip with extended production applications

**OBJECTIVES AND CONTENTS**

The aim of this project is to develop concepts allowing the increased requirements for steel strip products to be achieved using the smallest possible number of steel grades. The problem could be solved through variations of the heat treatment and cooling parameters during hot rolling and annealing. Laboratory experiments in combination with modelling procedures hold out the promise of effectively meeting the aims of this project. Focusing on a reduced number of steel grades would provide effective logistic and economic advantages.

**State of progress:** Research completed; publication EUR N° 19385

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7210-EC/807	D3.2/94	2.410.185	1.353.927	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Improvement of hot rolled products by physical and mathematical modelling

**OBJECTIVES AND CONTENTS**

Hot rolling is a crucial step in steel production, and as a consequence is the subject of major efforts to model the process, thereby identifying and testing potential improvements to the processing with less recourse to expensive plant trials. The current project, involving twelve partners, comprises three linked parts:

- 1) Modelling phase transformation in wrought steels (C Mn, HSLA, acicular ferrite and IF steels);
- 2) Experimental investigation of friction at the roll-metal interface in hot rolling;
- 3) Extension and validation of finite elements models of multi-pass hot rolling (including modules/data from parts 1) and 2)).

**State of progress:** Research completed; publication EUR N° 19879

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**Technical Group D3 : "Physical Metallurgy of Rolling and Finishing"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-EC/306	D3.3/94	1.273.848	635.100	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Simulation of post rolling cooling and microstructure of steel wire-rod for optimization and control of the process

**OBJECTIVES AND CONTENTS**

This research project will investigate optimization of post-rolling cooling of steel wire/rods. The aim is to develop a tool for the optimization of the cooling process with respect to microstructures and properties of the products, and their homogeneity; the stability with composition or process parameters will also be addressed. This tool will use results of previous as well as current work on hot-rolling modelling, so that improved process control of post-rolling cooling of steel wire (and bars) will be achieved. Furthermore, the research is expected to contribute to improvements of the products' metallurgy and to prepare the basis for further technical evolution of mills.

**State of progress:** Research completed; publication EUR N° 19386

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7210-EC/808	D3.4/94	957.788	512.689	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Modelling of microstructural development during continuous annealing processes

**OBJECTIVES AND CONTENTS**

A wide range of steel types can be produced by continuous annealing. It would be very beneficial to be able to predict microstructure and mechanical properties from a knowledge of steel composition, hot and cold rolling conditions and continuous annealing parameters. Such a predictive model would help to identify optimum conditions for continuous annealing for improving the properties of existing steels and would aid the development of new steels. There is a need to gain a fuller understanding of annealing conditions on recrystallisation, grain growth, carbide dissolution and texture development in current aluminium-killed and interstitial-free steels. There is also a need to learn more about the relationship between processing conditions, microstructural development and properties in ferrite-bainite, ferrite-martensite and multi-phase steels produced by intercritical continuous annealing. The microstructures of a wide range of continuously annealed steels will be characterised and mechanical properties measured. The relationships between processing conditions, composition, microstructure and properties will be examined in detail. From this, a mathematical model would be developed to predict microstructures and properties from compositional and continuous annealing parameters.

**State of progress:** Research completed; publication EUR N° 19877

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7210-EC/209	D3.5/94	1.081.349	585.900	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Computer assisted modelling of metallurgical aspects of hot deformation and transformation of steels

**OBJECTIVES AND CONTENTS**

The aim of this co-operative research project is to develop a metallurgical model, running on a personal computer, to predict the microstructural evolution in steel during hot rolling, from reheating to the final cooling, including the prediction of the mechanical properties.

This project is based on results achieved through other successful research work focused on C-Mn steels which allowed a prototype "skeleton" model to be developed which does not consider the complications of precipitation processes. In this research the existing model will be enlarged to cover the more complicated situation pertaining to microalloyed grades (e.g. HSLA and IF steels), such as interactions between precipitates, grain growth, recrystallization and transformation, and strain-induced precipitation during rolling.

**State of progress:** Research completed; publication EUR N° 18790

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7210-CA/220	D3/C3.4/94	2.459.689	1.419.900	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Thin slab casting

**OBJECTIVES AND CONTENTS**

Thin slab casting with direct rolling offers the steel industry new possibilities of producing steel at lower cost. Up until now, activities in the field have been focused on process development.

This research programme is mainly concerned with the problems of steel properties relating to this new process which may be characterized by high cooling rates at solidification, different equalizing heat treatment and less total reduction at the rolling mill.

This research programme will investigate:

- the possibility of achieving a fine-grained final microstructure despite a limited total thickness reduction during hot rolling;
- the over-saturation of residuals and/or microalloying elements in austenite depending upon the cooling rate during solidification and subsequent precipitation;
- the problem of hot ductility resulting from new solidification and cooling cycles applied before rolling.

Steel grades concerned in the programme are C-Mn and HSLA steels, hot rolled to a final thickness ranging between 2 and 12 mm. The present integrated research programme will be performed by 11 different partners.

**State of progress:** Research completed; publication EUR N° 19409

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7210-EC/406	D3.1/95	577.000	346.200	36 (Mths)		1/07/1995	30/06/1998	30/06/1998

**Title:** Development of high strength-high quality hot strip for ERW pipes, produced by the thin-slab casting technology

**OBJECTIVES AND CONTENTS**

Research on an industrial scale is to be carried out with the aim of ascertaining the feasibility of manufacturing high strength, high quality hot rolled strip for structural applications through thin slab/direct rolling technology. The AST plant in Terni will be used for processing a high quality, high purity liquid steel produced from an electric furnace and ASEA ladle refining cycle.

The final aim is to produce and qualify high standard ERW pipes of X60 grade using the hot rolled strip obtained by this innovative route and the pipe making facilities of T.D.I. pipe mill in Taranto.

**State of progress:** Research completed; publication EUR N° 19383

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7210-EC/605	D3.2/95	1.951.000	1.170.600	48 (Mths)		1/07/1995	31/12/1998	30/06/1999

**Title:** New hot rolled, deep drawing steel qualities

**OBJECTIVES AND CONTENTS**

The objective of the project is to establish general procedures for the production of hot rolled steel strip of deep drawing quality with a thickness less than 1.5 mm and an r-value greater than 1. The hot rolled deep drawing quality could replace cold rolled material. This substitution would offer cost savings and reduce impact on the environment.

**State of progress:** Research completed; publication EUR N° 19889

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-EC/115	D3.3/95	1.647.500	988.500	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** New cold rolled, deep drawing steel qualities

**OBJECTIVES AND CONTENTS**

High strength cold rolled steels offer the possibility of considerable weight reduction in the automotive industry if formability can be improved compared to conventional grades. Four promising steel concepts will be developed in this project:

- in multi-phase (TRIP) steels Transformation Induced Plasticity will retard local necking and thus improve formability;
- SULC Steels with extreme low C and N levels are bake hardenable steels without the drawbacks of conventional IF (Ti, Nb) grades;
- high strength IF steels (IFHS) are potentially capable of developing optimum combinations of formability and strength by using solid solution and bake hardening;
- IF steels (IF-D) doped with surface active elements, will develop the most favourable deep drawing textures.

Generally it is intended to develop new cold rolled steels with strength levels between about 200 and 600 Mpa with improved formability compared to existing grades. This will improve the position of steel compared to alternative materials, and promote more efficient use of high strength steels.

**State of progress:** Research completed; publication EUR N° 20099

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-EC/118	D3.4/95	898.500	539.100	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Strip with gradient properties by annealing in reactive atmosphere

**OBJECTIVES AND CONTENTS**

Cold rolled steel strip is often subjected to continuous annealing in a reactive atmosphere to achieve the required properties, while also ensuring appropriate states of surface cleanliness for subsequent treatment (e.g., phosphating, hot-dip galvanizing, etc.). Because the heat treatment cycle is very brief and the associated gas-metal reactions hardly achieve equilibrium, chemistry and property gradients can develop at the surface which have up until now been considered an unavoidable drawback of the process.

It is the objective of this project to investigate the possibilities of deliberately creating surface chemistry and property gradients by annealing in reactive atmospheres, with the aim of combining normally exclusive properties. This research programme will be specifically aimed at accumulating the necessary fundamental know-how to help create a new range of steel products. One of its constraints will be to maintain treatment conditions within the capabilities of existing processing lines, although minor modifications will obviously be necessary.

**State of progress:** Research completed; publication EUR N° 19890

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7210-EC/901	D3.5/95	170.000	102.000	36 (Mths)		1/11/1995	31/10/1998	31/10/1998

**Title:** New cold-rolled deep drawing qualities

**OBJECTIVES AND CONTENTS**

This project will examine the potential for improving strength and bake hardenability of high-strength IF steels without sacrificing deep drawability by annealing within the austenite temperature range. The main aims will be:

- to determine optimum contents of solid solution hardening elements such as P, Mn, Cr, Si to provide combinations of strength, ductility and normal anisotropy;
- to utilize thermodynamic calculations to provide a basis for assessing the solubility of interstitial elements, principally C, under different conditions.

**State of progress:** Research completed; publication EUR N° 20099

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7210-EC/119	D3.1/96	1.352.500	811.500	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Effect of the high speed cooling rate on the microstructure and precipitation state in hot rolled IF steels

**OBJECTIVES AND CONTENTS**

This project will investigate the precipitation sequences in ferrite and other major parameters of hot rolled strip manufactured from soft and high-strength ULC steels with low microalloy contents (Ti-Nb-B) and excellent forming properties for use in the automotive and other industries. Hot rolling operations will be carried out on both laboratory and industrial scale.

**State of progress:** Research completed; publication EUR N° 19878 EN

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7210-EC/811	D3.2/96	1.328.000	796.800	42 (Mths)		1/07/1996	31/12/1999	31/12/1999

**Title:** The effect of strain reversal and strain-time path on constitutive relationship for metal rolling/forming process

**OBJECTIVES AND CONTENTS**

It is proposed to develop constitutive models for situations such as hot rolling where material is subjected to highly non-uniform temperatures and strain rates, including data based on strain reversals, for use in finite element codes which allow specification of the material constitutive properties at all points in the roll gap. The models will allow prediction of rolling load, microstructural evolution and defect formation during rolling mill trials.

**State of progress:** Research completed; publication EUR N° 19891

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7210-EC/214	D3.3/96	1.459.500	875.700	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Texture control in rolled steel sheets for an optimized anisotropy

**OBJECTIVES AND CONTENTS**

The objective of the project is to analyze the influence of processing parameters at hot and cold mills on the texture development during annealing (batch or continuous) in order to establish guidelines for the control of r and delta r values, thus ensuring minimal planar anisotropy in cold rolled and annealed steel sheets. Steel grades to be considered are drawing grades (ultra-low C, extra-low C and IF steels) and high strength steels. Steel drawability will be assessed as a function of the balance between r and delta r.

**State of progress:** Research completed; publication EUR N° 20100

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7210-EC/215	D3.4/96	1.023.000	613.800	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Development of Al-killed weldable steels by near-net-shape-casting microalloyed with Ti and N2

**OBJECTIVES AND CONTENTS**

This project will analyze titanium microalloying procedures in the electric arc furnace and near-net shape casting processing routes by means of a thorough documentation of the properties of steels characterized among others by their defined nitrogen and titanium contents (up to 0.0080% and 0.050% respectively). Base metal and welded specimens will be tested and their microstructure documented. Torsion, plane strain compression and laboratory rolling techniques will be applied to analyze recrystallization. Welding will be simulated by the Gleeble technique or implant method to produce synthetic or real heat affected microstructure.

**State of progress:** Research completed; publication EUR N° 20217

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-EC/308	D3.5/96	791.000	474.600	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title: Optimization of thermomechanical treatments to improve the geometry control and the mechanical properties of high strength steel heavy products**

**OBJECTIVES AND CONTENTS**

The main objective of this project is to reduce the costs and delays in rolling and heat treating carbon and low-alloyed steels through improved monitoring. Particular attention will be paid to the suppression of rejects due to defects, to increasing service properties of the final products, and to reducing the distortion of thick plates, providing savings in metal, energy, time and costs. Improved knowledge of steel behaviour will lead to the development of new steel grades and improved processing procedures.

**State of progress:** Research completed; publication EUR N° 20096

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7210-PR/033	D3.1/97	1.312.000	787.200	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title: High strength, formable hot rolled steels for lightweight wheel disc applications**

**OBJECTIVES AND CONTENTS**

The most important in-service criterion for automotive wheels is high fatigue endurance which determines the extent of downgauging and weight reduction that can be achieved. This project will involve a systematic study of the effects of composition and hot rolling conditions on the microstructures and properties of a wide range of steel types (microalloyed ferrite-bainite and ferrite-martensite steels, low carbon bainitic steels and high aluminium TRIP steels) to enable identification of materials possessing optimum formability and fatigue performance over the tensile strength range 600 to 800 MPa. Production trials will be conducted on a selection of the more promising steel types.

**State of progress:** Research completed; publication EUR N° 20213

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7210-PR/034	D3.2/97	1.186.500	711.900	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Improved microstructural modelling of phase transformations in medium and high carbon and low alloy steels

**OBJECTIVES AND CONTENTS**

The aim of this research work is to develop computer code based on extensive testing for predicting the progress of phase transformation for use within thermomechanical codes of hot rolling and heat treatment of flat or shaped (mainly round) products. Quantitative metallurgical modelling minimises the need for expensive plant trials to develop new products and modify compositions and rolling schedules. This project extends the phase transformation work in hot rolled steels carried out under previous research work to low alloy (<5% by wt. total) and higher carbon (0.2% - 1%) steels, including the influence of boron and vanadium associated with austenite decomposition, and issues of perlite morphology.

**State of progress:** Research completed; publication EUR N° 20216

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7210-PR/035	D3.3/97	1.261.000	756.600	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Control of the yielding and aging behaviour in temper rolling

**OBJECTIVES AND CONTENTS**

The development of ULC and BH steel grades and the adoption of short annealing lines with high speed cooling and short overaging sections, produces sheet with higher levels of carbon in solid solution. Accurate setting of the temper rolling conditions is required to suppress the yield point elongation while keeping final yield stress as low as possible to increase the deep-drawing properties. The aim of this research project is to improve knowledge of the internal stresses along the strip prior to skin-pass rolling and to develop a model which allows the internal strain to be estimated from the sheet thickness after temper rolling. It will allow final yield stresses and optimal rolling conditions to be determined, as well as the effects of temper rolling on the subsequent ageing phenomena.

**State of progress:** Research completed; publication EUR N° 20214

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7210-PR/036	D3.4/97	1.489.000	893.400	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Development of optimal rolling schedules for ferritic rolling

**OBJECTIVES AND CONTENTS**

This project will investigate the production of DQ-DDQ steel grades taking advantage of the ferritic processing route, combined with vacuum degassed steels, and will aim to:

- develop new low temperature ferritic rolling schedules for the production of ULC, ULC-IF (Ti or Ti/Nb), IF-HR and vacuum degassed microalloyed bake-hardenable steel grades with high drawability in the cold rolled and annealed state;
- assess the possibility of increasing production line flexibility in order to reduce the final thickness, combining hot and cold reduction in the case of IF-HR steels;
- investigate the effect of hot and cold rolling reductions.

**State of progress:** Research completed; publication EUR N° 20218

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7210-PR/037	D3.5/97	1.265.500	759.300	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Heterogeneous nucleation of acicular ferrite for toughness improvement of HSLA steels

**OBJECTIVES AND CONTENTS**

This research project investigates alternative means of achieving fine ferrite grains, exploiting the heterogeneous nucleation of acicular ferrite, for improving the strength/toughness properties of HSLA steel parent plate and welded material. Steel composition and fine inclusions will be designed in order to improve the low-temperature toughness of the HAZ in submerged arc welds (SAW) characterised by high heat input (>3.5 kJ/mm), and of the weld metal (WM) of joints made by power beam welding without using filler material. The effects of deoxidisation practice, microalloy (Ti, V, B) and alloy (Mn) additions, sulphur and nitrogen content, austenite grain size and cooling conditions will be studied, leading to the production of new AF steels for 15-70 mm thick plates of S355M/ML - S460M/ML grades with superior HAZ and WM toughness.

**State of progress:** Research completed; publication EUR N° 20215

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7210-PR/092	D3.1/98	733.500	440.100	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Ferritic-bainitic and trip steels for improved combination of strength and ductility

**OBJECTIVES AND CONTENTS**

The research will improve the detailed understanding of the effects of compositional and processing variables on the production, in the hot rolled condition, of high strength ferrite-bainite and TRIP steels with attractive combinations of weldability and formability. It will quantify the level of compositional and process control required for successful commercial production. This will result in improved yields for the production of these steel types as well as defending steel's market share and its expansion into new products in areas such as transportation.

**State of progress:** Research completed; publication EUR N° 20567 EN

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7210-PR/093	D3.2/98	1.096.500	657.900	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Influence of tramp elements on the resistance to hotdeformation and on the properties of hot rolled products

**OBJECTIVES AND CONTENTS**

The recent evolution of the steel industry leads to better identify and quantify the effects of tramp elements. Studies have shown that problems due to tramp elements should be expected during processing, the amplitude of which remains to be analysed depending on the applications. The aims of the project are: to complete the existing knowledge and to fully assess the influence of residual elements on the processing conditions and on the final properties of hot rolled products; to integrate the derived metallurgical relationship in a model able to pre-set the rolling parameters and to predict the end products characteristics.

**State of progress:** Research completed; publication EUR N° 20464

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7210-PR/094	D3.3/98	1.282.500	769.500	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** High productivity low temperature rolling

**OBJECTIVES AND CONTENTS**

The project aims to provide increased understanding of the microstructural and engineering parameters which influence the loaded roll gap profile and the development of associated models. The acquired knowledge would be incorporated into microstructure evolution models and assist in the establishment of a ferric rolling strategy from reheating to finishing/cooling. Productivity aspects will be assessed and a more appropriate roughing strategy will be developed. Benefits will include improved set-up and stock geometrical tolerance leading to improved yield, flatness and property control, with reduced down stream processing.

**State of progress:** Research completed; publication EUR N° 20471

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7210-PR/095	D3.4/98	1.243.500	746.100	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Influence of strain rate on deformation behaviour, austenite structure & kinetik of Gamma/Alpha transformation

**OBJECTIVES AND CONTENTS**

This project aims to investigate the influence of the strain rate on the behaviour of steels in the course of hot rolling performed mainly in the lower austenite range for hot strip and wire rod mills. Flow curves will be recorded in single and multiple pass deformations. The changes in the flow stresses, the resulting changes in the grain structure, the strain hardening, the precipitation behaviour, softening during deformation and interpass times, the deformation heat and the kinetics of the transformation will be measured and analysed. On the basis of the collected experimental data, the influence of the strain rate on the characteristic material processes which are relevant to the simulation of hot rolling will be described by mathematical equations. For this purpose existing models will be utilised and, if necessary, new models created.

**State of progress:** Research completed; publication EUR N° 20581 EN

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7210-PR/096	D3.5/98	1.236.167	741.700	42 (Mths)		1/07/1998	30/06/2001	31/12/2001

**Title:** Control of phase transformation during processing of partially bainitic multi-component strip steels for controlling the work hardening characteristics

**OBJECTIVES AND CONTENTS**

For partially bainitic hot- and cold rolled steels with retained austenite a model aiming at the prediction of the multi-component microstructure and the prediction of the resulting work hardening behaviour shall be developed. The project is expected to minimise experimental laboratory and industrial tests to define high strength steels with work hardening characteristics that are ideally suited to specific customers demands. The new steels are expected to play an important role in future light weight auto-body construction.

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7210-PR/158	D3.1/99	770.000	462.000	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Aspects on recrystallization-precipitation interaction in microalloyed steels

**OBJECTIVES AND CONTENTS**

The main aim of the project is to study the interaction between precipitation and recrystallization on all types of micro-alloyed steels. Special attention will be given to low carbon HSLA steels slab cast for strip rolling. The knowledge acquired will be extended to medium carbon micro-alloyed grades bloom or billet cast to be rolled into long products and used for drop forging of automotive components. Special care will be given to the determination of the not yet well known re-crystallisation-precipitation-time-temperature (RPTT) diagrams by different research techniques as hot torsion, hot tension, hot compression and deformation dilatometry.

**State of progress:** Research completed; publication EUR N° 20936 EN

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7210-PR/159	D3.2/99	998.800	599.280	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Influence of the heterogeneity in solidification microstructure on the hot rolling behaviour of stainless steels

**OBJECTIVES AND CONTENTS**

The production of high alloyed steel plates and sheets bears several problems of shape control during and after hot rolling. Many shape defects result from the behaviour of the solidification microstructure during hot rolling. This microstructure and the chemical segregation depend strongly on the solidification conditions. This leads to an anisotropy of the material at least during the first rolling passes, before re-crystallisation. The project aims at the control of the dimensions of flat products, the generation of savings in metal, energy and processing costs and the increase of the homogeneity of the delivered products. The research will look for an accurate understanding of the relationship between the chemical composition of the material and its initial microstructure in the as-solidified state as well as the microstructure and the shape after hot rolling.

**State of progress:** Research completed; publication EUR N° 20937 EN

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7210-PR/160	D3.3/99	1.033.500	620.100	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Development of methods for the characterisation & modelling of precipitation in steels

**OBJECTIVES AND CONTENTS**

The precipitation of elements from solid solution is an important factor in determining the microstructure and hence the mechanical properties of modern steels. Precipitation plays a crucial role in HSLA steels, strip steels and heat-treatable steels. In all of these steels, optimisation of both the final mechanical properties and the fabrication path requires a detailed knowledge of the mechanisms and kinetics of precipitation. This project aims to address the understanding of the mechanism of precipitation in two ways: by the development of new and improved methods of precipitation characterisation and by the construction of thermodynamic and kinetic precipitation growth/dissolution models using data obtained from the characterisation of selected micro-alloyed steels.

**State of progress:** Research completed; publication EUR N° 20938 EN

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7210-PR/161	D3.4/99	1.175.120	705.072	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Optimization of microstructure in multiphase steels containing retained austenite

**OBJECTIVES AND CONTENTS**

Recently, various kinds of high-strength steels have been developed to satisfy the requirements of the automobile industry. In this research project, multiphase steels containing a metastable austenitic phase such as TRIP-steels which represent a new generation of multiphase steels, will be examined in order to describe, evaluate and optimise the relationship between microstructure, mechanical properties and formability behaviour. The results obtained should lead to the expansion of the field of application of TRIP steels.

**State of progress:** Research completed; publication EUR N° 21131 EN

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7210-PR/162	D3.5/99	1.265.000	759.000	36 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title:** Control of the precipitation behaviour during integrated casting & rolling processes

**OBJECTIVES AND CONTENTS**

The focus of the project is the experimental and mathematical investigation and modelling of precipitation in integrated near net shape casting and rolling processes. The effect of combined micro-alloying with Ti, Nb and V on the precipitation behaviour both in soft deep-drawing steels and in HSLA grades is to be described taking into account realistic time and temperature courses of the industrial processes. The database for simulation calculations will be extended to Ti, V and Nb multi-precipitations in the short production routes of modern flat steel making.

**State of progress:** Research completed; publication EUR N° 20813 EN

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7210-PR/163	D3.6/99	1.564.000	938.400	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Improvement of cold rolled products by computer assisted metallurgical modelling

**OBJECTIVES AND CONTENTS**

For cold rolled steel grades (uncoated, electrolytically coated or hot dip galvanised) an increasing demand exists, concerning the mechanical properties, the uniformity along the strip length, the reduction of variation from coil to coil as well as the improvement of the yield rate. A very promising approach to reach these additional improvements is a metallurgical-based modelling using, simultaneously, experimental simulation trials and plant results. The aim of the project is therefore a metallurgical-based approach to follow a prediction of the microstructure and mechanical properties as a function of the chemical composition and processing parameters for Aluminium killed LC or ELC and IF based thin sheet grades. Concerning the annealing treatment the modelling will be carried out for batch annealing, continuous annealing and hot dip galvanising.

**State of progress:** Research completed; publication EUR N° 21136 EN

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7210-PR/164	D3.7/99	1.087.000	652.200	42 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title:** The prediction of the mechanical properties of hot rolled strip products by the means of hybrid methods

**OBJECTIVES AND CONTENTS**

Steel manufacturers are under a growing pressure to improve the yield and the quality of their products. To meet these challenges, highly advanced rolling systems are being applied to new and updated mills. Accurate material models are very important when simulating hot rolling and other forming processes. Though significant improvements have been made in mathematical modelling of rolling processes, the problem is how to control the rolling process optimally in such a way the finished product has the desired microstructure. The aim of the project is to acquire essential metallurgical know-how and to develop hybrid, physical-neural models that predict the variation of mechanical properties across the length and width of the product, in view of obtaining increased homogeneity of hot rolled material, higher mill productivity, lower costs and greater capabilities in meeting market demands.

**State of progress:** Research completed; publication EUR N° 20939 EN

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7210-PR/165	D3.8/99	987.500	592.500	42 (Mths)		1/07/1999	31/12/2002	31/12/2002

**Title:** Strain/transformation interaction & mechanical behaviour during intercritical rolling

**OBJECTIVES AND CONTENTS**

The aim of the project is to acquire information on the response of the two-phase structure to deformation in the inter-critical temperature range, and, likewise, on the corresponding flow stress behaviour on first reaching Ar3 and during continued rolling. CMn and CMnNb strip and plate grades, an Interstitial Free and Low Carbon strip and Dual Phase steel grades will be examined for better, quantitative knowledge of the metallurgical and mechanical behaviour at temperature with deformation and phase/texture analysis. The study will assist process design and control, ensuring that the optimum microstructure, texture, finished properties and product dimensions are obtained.

**State of progress:** Research completed; publication EUR N° 20879 EN

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7210-PR/166	D3.9/99	1.184.000	710.400	42 (Mths)		1/07/1999	31/12/2002	31/12/2002

**Title:** Property models for mixed microstructures

**OBJECTIVES AND CONTENTS**

A quantitative metallurgical understanding of the relationship between steel microstructure and properties is essential for optimising both product and upstream and downstream steel manufacturing processes. In this research, improved structure relationships will be derived for multiphase and mixed property grain size microstructures, including bainite and martensite. Laboratory hot rolling, heat treatment and controlled cooling will be performed to generate specific microstructures for mechanical testing and detailed metallographic analysis of the key parameters contributing to the properties, such as grain and lath size. Approaches for modelling multiphase structures other than a simple law of mixtures will be considered. A computer module will be developed for calculating the properties suitable for standalone use of linking with hot-rolling phase transformation models. The steels considered will mainly be low carbon, low alloy grades but the metallurgical principles of the model will be applicable to a wide range of products.

**State of progress:** Research completed; publication EUR N° 20880 EN

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7210-PR/167	D3.10/99	456.500	273.900	12 (Mths)		1/07/1999	30/06/2000	30/06/2000

**Title:** Ultra-fine steel flat products

**OBJECTIVES AND CONTENTS**

Refinement of grain size is the standard way to improve both strength and ductility. Recent work has indicated that ultra-fine grain structures of around 1µm could be achievable in commercial production with appropriate development of the production route. The project will assess what benefits are likely to be achievable in low microalloyed carbon and stainless steel flat products from ultra-fine polygonal grain sizes, and how these might be produced for bulk manufacture. The project comprises a literature review and experimental work following up on current leads, with recommendations made regarding the perceived potential of the different approaches.

**State of progress:** Research completed; publication EUR N° 20225

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Technical Group D3 has 36 Projects and 146 Partners

Total Projects: 193 - Total Partners: 716

**Technical Group E : "Analytical Techniques for Processes, Products & Environment"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-GD/210	E2.1/94	488.000	292.800	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Determination of low concentrations of inorganic and organometallic compounds present in steel products

**OBJECTIVES AND CONTENTS**

Ecolabels and environmental problems confront laboratories with the determination of elements such as Sn, Cd, Hg, Zn, Pb, Ni, Cr, As, present in low concentrations.

In addition to the analysis of the total concentration of such elements, laboratories are frequently requested to specify the fraction of these elements present as organometallic compounds.

The study of tribological processes (formation, etc.) also requires more and more speciation of the inorganic and organometallic compounds of certain elements.

This research aims at defining a "global index for the organometallic composition". Using HR-ICPMS equipped specifically for elemental analysis of organic solvents, and gas chromatography coupled with Mass Spectrometry, OCAS and CRM will study extraction and separation methods which allow, in solutions with different polarity, the speciation of the "inorganic and organometallic" fraction of the element in question.

The method will be applied to and the analytical performance defined for:

- 1) The characterisation of organometallic residues present on steel after friction tests and laboratory scale deep drawing operations (the reactivity of several additives based on zinc, phosphate, etc., added in particular to protective oils, will be examined;
- 2) The analysis of inorganic and organometallic residues of heavy metals on non-oiled steel sheet for the packaging industry.

One of the objectives of this research is to assess the potentialities of analytical tools such as LR-ICPMS, ETAA and ICPOES to determine such an index.

**State of progress:** Research completed; publication EUR N° 19415

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7210-GD/412	E2.1/95	446.000	267.600	36 (Mths)		1/07/1995	30/06/1998	30/06/1998

**Title:** Composition related properties of very thin films on steel products: rapid quantitative analysis by DC GD-OES

**OBJECTIVES AND CONTENTS**

This proposal is aimed at developing a new method based on quantitative depth profile analysis by DC GD-OES, which permits rapid multi-element analysis of very thin films (passive films on stainless steels, conversion layers on plane and coated steel sheets.), with the following technical specifications: minimum information depth about 5nm; multi-element capability of 20 elements in one measurement; quantification of major and minor elements with an accuracy better than 10%; analysis time (measurement + quantification) of a few minutes for very thin layers.

**State of progress:** Research completed; publication EUR N° 19413

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7210-GD/903	E2.2/95	832.000	499.200	24 (Mths)		1/11/1995	31/10/1997	31/10/1997

**Title:** Rapid quantitative analysis of non conductive surface layers of steels by RF glow discharge optical emission spectrometry

**OBJECTIVES AND CONTENTS**

The aim of this project is to develop a new, quantitative depth profiling method, that permits a rapid multi-element analysis of non conductive surface layers on steels (paints, polymers, enamels, etc.). The proposed method is based on quantitative depth profile analysis by radio frequency glow discharge optical emission spectrometry (FR GD-OES). The method is estimated to fulfil the following technical specifications:

- erosion rate 0.1-1 µm/s in the non-conducting layers;
- minimum information depth (<5 nm);
- multi-element capability of > 20 elements in a single measurement;
- quantification of major and minor elements (> 1 %) with an accuracy better than 10 %.

**State of progress:** Research completed; publication EUR N° 18919

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**Technical Group E : "Analytical Techniques for Processes, Products & Environment"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-GD/905	E2.3/95	950.500	570.300	42 (Mths)		1/12/1995	30/11/1998	31/05/1999

**Title:** The development of rapid assessment methods for inclusions in clean steel

**OBJECTIVES AND CONTENTS**

The overall objective of this project is to develop reliable and efficient methods for characterising the inclusion content in clean steel during different stages in the process. The methods will be rated on their ability to produce rapid feedback and their applicability for bulk material.

**State of progress:** Research completed; publication EUR N° 19892

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-GD/906	E2.4/95	1.019.500	611.700	36 (Mths)		1/12/1995	30/11/1998	30/11/1998

**Title:** Evaluation of the contents of trace elements in complex steel matrices from scrap to final component

**OBJECTIVES AND CONTENTS**

The determination of trace and ultratrace element concentration in steels is required for two main reasons:

- the drastic influence of some trace and ultratrace elements on their properties;
- the increasing need to put on the market only materials free of elements that are harmful for the environment or for health. The objective of this project is to produce operational protocols for evaluating the trace element contents in steels from scrap through to final products by Inductively Coupled Plasma Mass Spectrometry, (ICP-MS) and a guideline for correct use of ICP-MS.

**State of progress:** Research completed; publication EUR N° 19412

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-EA/428	E/D2.6/96	1.644.500	986.700	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Development of a knowledge-based system for improved operations of waste-water treatment plants in a cold rolling area (KNOWATER)

**OBJECTIVES AND CONTENTS**

Legislative and economic stimuli are increasing the pressure for effluent to be treated to a higher quality, with quality levels achieved more consistently. Many older treatment plants may be treating effluent with characteristics that were not considered during the initial design stage. This research project will investigate the feasibility of applying a knowledge-based system to monitoring and controlling an existing system in order to achieve improved quality of treated effluent, quality of product, reduction of pollution and to avoid the risk of incidents to personnel and the environment.

**State of progress:** Research completed; publication EUR N° 19414

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-GB/317	E/E1.3/96	1.366.000	819.600	42 (Mths)		1/07/1996	30/06/1999	31/12/1999

**Title:** On-line measurement of the surface cleanliness of steel strip

**OBJECTIVES AND CONTENTS**

After rolling, surface cleanliness is a key parameter for steel strip subjected to continuous annealing or metallic and/or organic coating operations. The aim of this research project is to investigate the possibilities of continuous on-line monitoring of surface pollution based on Optically Stimulated Electron Emission (OSEE) for light pollution levels after degreasing lines, and on infrared emission characteristics of semi-transparent thin layer for surface pollution monitoring at the input of continuous annealing and galvanising lines.

**State of progress:** Research completed; publication EUR N° 19893

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-GD/120	E2.1/96	1.113.000	667.800	36 (Mths)		1/07/1996	30/06/1998	30/06/1999

**Title:** Sensivity enhanced laser analysis (SELA) of steel melts for fast multi-element on-line analysis during ladle processing in secondary metallurgy

**OBJECTIVES AND CONTENTS**

The goal of this research project is the performance evaluation of fast multi-element, on-line laser analysis during ladle processing in steel metallurgy with determination limits of less than 10 ppm, especially for carbon, phosphorus, sulphur and nitrogen, and also for other elements such as titanium, vanadium, niobium, and molybdenum. The novel research approach is sensitivity-enhanced laser analysis (SELA) by combination of increased steel ablation and optimised plasma excitation for higher spectrometric signals.

**State of progress:** Research completed; publication EUR N° 19411

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**Technical Group E : "Analytical Techniques for Processes, Products & Environment"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/038	E.1/97	1.229.500	737.700	28 (Mths)		1/07/1997	30/06/1999	31/10/1999

**Title: Evaluation and improvement of the rapid multi-element determination of residual elements in steels for targeted production of steel quality by ICP-MS spectrometry (Phase 2)**

**OBJECTIVES AND CONTENTS**

Fast and reliable methods are required to determine elements at very low or ultra-trace levels which are harmful to steel quality or toxic to the environment. Inductively-coupled plasma mass spectrometry (ICP-MS) was identified as applicable. An initial collaborative investigation (Phase I) was set up to establish the performance of ICP-MS. The aims of the current research project (Phase II) are the evaluation and improvement of the methodologies already developed. Quality assurance and low cost requirements will be defined and introduced.

**State of progress:** Research completed; publication EUR N° 20222

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**Technical Group E : "Analytical Techniques for Processes, Products & Environment"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/039	E.2/97	1.419.000	851.400	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Improvement of sampling and analytical procedures for clean and high purity steels

**OBJECTIVES AND CONTENTS**

The main objective of this project is to provide metallurgists with rapid techniques for process evaluation. The first step is to reduce the relative importance of chemical analysis in overall steelmaking precision. This will be achieved through improved liquid steel sampling and the use of new analytical developments. In a second step the same analytical techniques will be used to characterise steel cleanliness and metal homogeneity to predict the quality of the final products as soon as possible. The most important techniques are Pulse Discrimination Analysis (PDA-OES) with and without a scanning system, and to a lesser extent Fractional Gas Analysis (FGA).

**State of progress:** Research completed; publication EUR N° 20219

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**Technical Group E : "Analytical Techniques for Processes, Products & Environment"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/041	E.4/97	1.481.000	888.600	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** On-line inspection of coated strip by laser based chemical analysis procedures

**OBJECTIVES AND CONTENTS**

Analysis procedures will be developed under this research project which are capable of providing compositional details of in-process materials and products in real time. Focused laser beams will be used to sample materials in-situ, the resultant aerosol being transferred to a remote excitation source for spectrometric analysis. The interaction of lasers of different wavelengths with a range of steelworks materials will need to be studied in order to optimise the ablation process. The effects of specimen temperature, homogeneity and the ability to penetrate scale to reach representative material will be investigated. It is intended that the work will establish design criteria for analysers suitable for a range of applications.

**State of progress:** Research completed; publication EUR N° 20221

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/042	E.5/97	1.102.000	661.200	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Biological degradation of organic pollutants in water circuits of degreasing systems

**OBJECTIVES AND CONTENTS**

Many processes in the steel industry give rise to waste water contaminated by fat and oil. The economic and ecological technique of using micro-organisms for cleansing has not yet been widely established. This research project is intended to develop a special high performance biological treatment system for removing organic contaminants from steel surfaces and water circuits.

**State of progress:** Research completed; publication EUR N° 20223

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7210-PR/031	E/D2.9/97	1.105.500	663.300	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Process water treatment using excess heat

**OBJECTIVES AND CONTENTS**

Polluted process water from galvanising processes can be cleaned by thermal treatment processes. Excess heat of galvanising plants is currently unused and removed by cooling towers. This research project will determine recoverable excess heat, whereby its use for economical recovery of high quality process water and valuable substances will increase productivity. Consumption of fresh water and process chemicals will be reduced. Valuable substances will be recovered, and the load on the environment will be significantly reduced.

**State of progress:** Research completed; publication EUR N° 20224

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/097	E.1/98	668.600	401.160	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** New method for contactless measurement of true temperature of hot steel strips and control of the total thermal process by in situ spectroscopy

**OBJECTIVES AND CONTENTS**

The target of the project is to work out a fully new way of measurement of the true radiation temperature of technical hot surfaces for example steel strips in a continuous furnace by using a Fourier-spectrometer where the strips work as infrared source for the device. The method will be used for the measurement of the temperature of hot steel strips in a continuous furnace and for the control of the thermal processes. The commonly unknown emissivity coefficient is separated by mathematical algorithms. Chemical agents generate narrow absorption lines from which the components can be identified by in situ spectroscopy that can be used for control of stability and quality of the processes. The experiments will be theoretically analysed and simulated by advanced numeric work.

**State of progress:** Research completed; publication EUR N° 20463

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/098	E.2/98	1.700.000	1.020.000	42 (Mths)		1/07/1998	30/06/2001	31/12/2001

**Title:** Recycling of rolling oil emulsions: towards an economic and environmentally sustainable process

**OBJECTIVES AND CONTENTS**

The main goal is to achieve a closed cold rolling process by introduction of separation techniques. This results in recovery of oil and water phases, which will reduce both the environmental load and the treatment costs of wastes. In order to judge the quality of the necessary ingredients, methods for chemical analysis (off- and on-line) and function tests will be evaluated and adapted. To secure the quality of the work environment, the atmospheres surrounding the rolling and annealing operations will be carefully studied.

**State of progress:** Research completed; publication EUR N°

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7210-PR/099	E.3/98	795.750	477.450	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Investigation of vacuum ultra violet optical emission spectrometry for the determination of low levels of C, N, O and H

**OBJECTIVES AND CONTENTS**

The main objective of the project is to extend the use of Optical Emission Spectrometry to include all routine determinations of C, N, O and H so that only a single method will be required in production-control analysis of steels. For this purpose the performance of the most modern commercially available spark and GDL spectrometers will be optimised and evaluated. The investigations will also include the use of improved experimental techniques like a high vacuum standard GDL, pulse discrimination methods for the spark and Laser Ablation High Temperature Plasma for the determination of extra low levels.

**State of progress:** Research completed; publication EUR N°

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7210-PR/100	E.4/98	823.500	494.100	24 (Mths)		1/07/1998	30/06/2000	30/06/2000

**Title:** Rapid quantitative depth profile analysis of non-conductive surface layers on steels by radio frequency glow discharge optical emission spectrometry - phase II

**OBJECTIVES AND CONTENTS**

The aim of this project is to develop practical, quantitative analytical methods for specific applications involving non-conductive surface layers on steel, using radio frequency glow discharge optical emission spectrometry. The applications aimed for are different types of paint and polymer coatings, non-conductive oxides and enamel. The work will be realised by making practical use of state-of-the-art quantification techniques recently developed by the team behind this proposal. The results of the project are expected to become valuable tools for surface composition control of a wide range of non-conductive coatings in different stages of product manufacturing.

**State of progress:** Research completed; publication EUR N° 20220

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7210-PR/168	E.1/99	1.270.200	762.120	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Improved production control through rapid characterization of non-metallic inclusions in steel

**OBJECTIVES AND CONTENTS**

Steel manufacturers have made great efforts to produce as clean as possible steel. However, classic methods for the characterisation of steel cleanliness are time consuming and can not be adapted to fast process control. Moreover, while sufficient results can be obtained for macro-cleanness, their spatial resolution is poor and does not fit for size determination, chemical composition and non-metallic inclusion frequency. First attempts with a commercial laser spark showed encouraging results and, on laboratory scales, laser sources have demonstrated that the composition of inclusions can be very well characterised. Aim of the project is to develop a fast and robust laser-method characterising inclusions over a large area or volume that can be integrated into the process control.

**State of progress:** Research completed; publication EUR N° 21627 EN

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7210-PR/170	E.3/99	788.600	473.160	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Control of CO-postcombustion inside EAF with FTIR (fourier transformed infrared) - spectroscopy system

**OBJECTIVES AND CONTENTS**

The share of the electric arc furnace in the production of crude steel increases steadily and it is expected to exceed 50% by the year 2010. The exhaust gas of an electric arc furnace contains a considerable amount of energy as heat and chemical energy from incompletely burned components CO and H<sub>2</sub>. Up to 30% of the total energy input to an EAF can be lost in the off-gas handling system. Therefore, post-combustion of CO and the effective recovery of heat generated during the flat bath period will be an integral part of the operating practice. The final aim of this research is to develop a concept of controlled post-combustion of CO inside the furnace. For this purpose, an integrated measurement system for the temperature and the gas components CO, CO<sub>2</sub> and O<sub>2</sub> for on-line monitoring the post-combustion process inside EAF will be developed based on the FTIR spectrometry.

**State of progress:** Research completed; publication EUR N° 21138 EN

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***Technical Group E : "Analytical Techniques for Processes, Products & Environment"***

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Technical Group E has 19 Projects and 86 Partners

Total Projects: 212 - Total Partners: 802

**Technical Group F3 : "Special and Alloy Steels"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-MA/948	F3.1/94	1.031.074	593.018	48 (Mths)		1/07/1994	30/06/1998	30/06/1998

**Title:** Optimization of the high temperature oxidation behaviour of conventional stainless steels by surface-applied rare earth elements

**OBJECTIVES AND CONTENTS**

Slab soaking, hot rolling and annealing after cold rolling are some of the processes that result in the formation of heavy oxide scales on stainless steels. The removal of these oxide masses has a tremendous incidence on final product cost due to the loss of scarce materials, nickel and chromium, and the use of chemicals required for pickling such oxides, and also on the environment through the production of polluting wastes.

Stainless steels are used for components which are required to withstand high temperature oxidation, according to temperature, gas phase composition and heating/cooling cycles.

The aim of this research project is to design low cost procedures for improving the high temperature behaviour of conventional stainless steels by means of surface modifications using rare earth elements.

**State of progress:** Research completed; publication EUR N° 19394

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-KB/338	F3/F2.2/94	1.093.091	549.900	42 (Mths)		1/12/1994	30/05/1998	31/05/1998

**Title:** Effects of residual stresses on the localized corrosion resistance of stainless steels

**OBJECTIVES AND CONTENTS**

Industrial experience frequently demonstrates that Stress Corrosion Cracking (SCC) affects vessels whose nominal service stress is lower than the stress threshold with respect to corrosion. This phenomenon is generally due to manufacturing processes which induce residual stresses.

The main objective of this research will be to ascertain whether the residual stresses of stainless steel products overload the intrinsic threshold stress of the candidate grades. In consequence, this will enable improvements in manufacturing process steps to be made in order to extend the service life of industrial structures.

The second objective will deal with the effect of stresses on pit initiation and the mechanisms which could eventually link crack initiation to existing pits. A better understanding of these processes would permit an improvement in the SCC resistance of industrial stainless steel products and vessels.

**State of progress:** Research completed; publication EUR N° 19377

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-MA/432	F3.1/95	532.000	319.200	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** New cold rolled stainless steels with deep drawing qualities obtained by ultra rapid heat treatment

**OBJECTIVES AND CONTENTS**

Transverse flux induction heating is a very efficient electrical technique able to anneal thin metal strips within a few seconds, thus opening new perspectives for more compact and flexible continuous coil treatment lines. However, the relevant properties, such as ductility and deep drawability, are expected to be strongly modified when ultra rapid heat treatment is applied to standard stainless steel grades.

The aim of this research work is to obtain new and improved deep drawing properties of the most widely used stainless steel grades processed by ultra rapid heating treatment, so as to verify and assess the high potential and limits of application of this innovative process.

**State of progress:** Research completed; publication EUR N° 19388

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7210-MA/433	F3.2/95	748.500	449.100	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Stainless and electrical steel strip properties as affected by high solidification rate of strip casting process

**OBJECTIVES AND CONTENTS**

The aim of the research is to study methods of producing various stainless and electrical steels by processing thin strips (2-3 mm) obtained through the rapid solidification of molten alloys on an industrial scale strip casting (SC) plant. The project target is to reproduce steels at least equivalent to various commercial products currently available. Microstructure, as well as internal and surface characteristics of the SC as-cast strips will be considered in detail, in order to determine the physical-metallurgical limits and possibilities for each product, and to define the required alloy composition, casting conditions and transformation cycles.

**State of progress:** Research completed; publication EUR N° 19981

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7210-MA/319	F3.3/95	577.500	346.500	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Elaboration of high-nitrogen stainless steels (>0.4% N) by AOD/VOD. Improvement of melting practices by thermodynamic and kinetic studies

**OBJECTIVES AND CONTENTS**

New high nitrogen (0,3 to 0,8%) stainless steels have recently been developed. The aim of this project is to compare the thermodynamic data with experimental results in order to define the thermodynamic and kinetic aspects of nitrogen in solid and liquid phases. These results would allow the production of high nitrogen composition by AOD/VOD methods.

**State of progress:** Research completed; publication EUR N° 19417

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7210-MA/321	F3.4/95	717.000	430.200	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Duplex stainless steels for structural applications: offshore, civil engineering, transport

**OBJECTIVES AND CONTENTS**

Their high strength and toughness levels make duplex stainless steels suitable for structural applications in the fields of civil engineering (buildings, bridges), offshore and transport. However, their mechanical behaviour is not entirely defined for structural applications. The aim of this project is to investigate the behaviour of duplex stainless steels in terms of mechanical properties (fracture mechanics, fatigue, corrosion fatigue, energy absorption properties) in unwelded and welded conditions. The results will be compared to those of the classical solutions and design rules used today for each field of application.

**State of progress:** Research completed; publication EUR N° 19974

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7210-MA/951	F3.5/95	823.500	494.100	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Fatigue design of welded stainless steels

**OBJECTIVES AND CONTENTS**

Although there is a wealth of information on the fatigue performance of welded carbon-manganese structural steels, welded stainless steels have been neglected. Consequently, there is little data available upon which to provide design guidance, particularly in the case of duplex steels. Therefore, it is proposed to carry out a thorough study of the fatigue behaviour of welded austenitic and duplex steels, to investigate any differences between them and structural steels and to provide design guidance. The research project includes the following:

- fatigue endurance tests of typical welded joints in plates and tubes;
- fatigue crack growth and threshold tests;
- metallurgical and fractographic examinations to establish the influence of microstructure;
- residual stress measurements;
- fatigue life modelling using local strain and fracture mechanics concepts.

**State of progress:** Research completed; publication EUR N° 19972

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7210-MA/901	F3.6/95	363.500	218.100	42 (Mths)		1/11/1995	30/04/1999	30/04/1999

**Title:** Duplex stainless steels for structural applications : Offshore, civil engineering, transport

**OBJECTIVES AND CONTENTS**

High strength and toughness levels make duplex stainless steel suitable for structural applications in the fields of civil engineering (buildings, bridges), offshore and transport. However, their mechanical behaviour has not been entirely assessed for structural applications and the aim of this project is to investigate their behaviour in unwelded and welded conditions through mechanical testing. Full scale testing will be performed on selected structures and components.

**State of progress:** Research completed; publication EUR N° 19974

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7210-MA/952	F3.7/95	698.333	419.000	36 (Mths)		1/12/1995	30/11/1998	30/11/1998

**Title:** Low nickel austenitic stainless steel with elevated resistance to pitting corrosion

**OBJECTIVES AND CONTENTS**

The project will develop new types of austenites, with nickel content reduced by 50%, while maintaining the molybdenum contents of standard 316 grades, which are structurally stable with high resistance to pitting corrosion. For this purpose, the fundamental part played by nitrogen (up to 0.5%) and the synergistic effects of manganese, copper and chromium will be analyzed.

**State of progress:** Research completed; publication EUR N° 19379

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-MA/903	F3.8/95	335.500	201.300	24 (Mths)		1/10/1995	30/09/1997	30/09/1997

**Title:** Fracture behaviour of welded duplex stainless steels for low temperature applications

**OBJECTIVES AND CONTENTS**

Duplex stainless steels provide unique advantages in demanding applications because of their high strength combined with corrosion resistance compared to conventional stainless steels. The main objectives for this project are:

- to study the low temperature fracture behaviour of SMAW and TIG welded duplex stainless steels;
- to correlate small scale (KCV) and large scale results in order to be able to generate realistic toughness requirements for weldments in duplex stainless steel for low temperature applications.

**State of progress:** Research completed; publication EUR N° 19973

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7210-MA/132	F3.1/96	857.500	514.500	42 (Mths)		1/07/1996	30/06/1999	31/12/1999

**Title:** Improvement of stainless steels for use at elevated temperatures in aggressive environments

**OBJECTIVES AND CONTENTS**

This project aims to improve the corrosion resistance of stainless steels at elevated temperatures, so that they can be employed in aggressive environments, e.g. in heat exchangers for coal gasification, for waste incineration and for reformer plants. For these purposes, the steels must be able to form protective oxide layers rapidly and at relatively low temperatures, this will be achieved a) by fine grain microstructure and near-surface deformation, b) by the addition of alloying elements which favour the nucleation and stability of the oxide layer. The proposed improvement will allow the stainless steels to be used at temperatures of 400 to 800°C: temperatures not yet accessible with these materials, thus increasing the efficiency of energy recovery in many processes.

**State of progress:** Research completed; publication EUR N° 20103

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7210-MA/133	F3.2/96	852.500	511.500	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Development of nitrogen-alloyed duplex stainless steel with optimized microstructure and texture by improvement of forming

**OBJECTIVES AND CONTENTS**

The aim of this research project is to optimise the microstructure of nitrogen alloyed duplex stainless steel (DSS) in order to improve their formability and as a consequence extend their market applications. Increased nitrogen content improves the corrosion resistance of DSS as well as the yield stress, and their mechanical properties increase with decreasing grain size or "phase" size, however, it also leads to brittleness which reduces formability. The partners in this project will attempt to improve the microstructure and the mechanical properties of DSS.

**State of progress:** Research completed; publication EUR N° 20326

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-MA/325	F3.3/96	985.000	591.000	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Influence of steelmaking processes on welding (cladding, repairing) and high speed machining of mould dies: Consequences of these parameters on chemical etching

**OBJECTIVES AND CONTENTS**

Faced with the economical development of moulds and tool steels, and the challenge from aluminium industry, steelmakers must understand the metallurgical parameters controlling the shaping of these materials. This research project will attempt to quantify the effects of chemical composition, specific additions, mechanical and physical characteristics on high speed machining and welding. It will also examine the effects of these metallurgical and technological parameters on chemical etching of moulds and tool steels. In particular, the problems of chemical etching on high speed machined and welded surfaces will be studied by a metallurgical investigation.

**State of progress:** Research completed; publication EUR N° 20587 EN

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7210-MA/437	F3.4/96	528.000	316.800	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Establishment of anti-crash/anti-intrusion solutions based on high-strength stainless steels to increase the passive safety of vehicles (INOXSAFE)

**OBJECTIVES AND CONTENTS**

The excellent mechanical properties and energy absorption shown by stainless steels make them very suitable for use in modern car manufacturing. The objectives of this research project are to supply the designer with technical data on stainless steels which are already available for other competing materials, in particular specific energy absorption and resistance to deformation, weight reduction and high reliability. Work will include studying and setting up, by means of mathematical models and CAD techniques, several component prototypes in different materials to allow comparative checks of technical and economic feasibility.

**State of progress:** Research completed; publication EUR N° 19982

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-MA/438	F3.5/96	594.000	356.400	3 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** In-service qualification of adhesive bonded stainless steel components (BONDINOX)

**OBJECTIVES AND CONTENTS**

This research project will attempt to solve the problems associated with adhesive bonding of stainless steel to stainless steel and SS to carbon steels with the aim of extending their range of practical applications. The project will investigate the problems involved with the particular surface properties and different classes of adhesive, design and realise examples of adhesive bonded components with the help of mathematical modelling, and then simulate in-service conditions including ageing effects and corrosion problems to verify reliability.

**State of progress:** Research completed; publication EUR N° 19979

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7210-MA/439	F3.6/96	909.000	545.400	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Development of a new electrolytic/potentiostatic pickling process for stainless and high alloyed steels (PICKINOX)

**OBJECTIVES AND CONTENTS**

This project aims to set up a continuous electrolytic pickling line for various steels including ferritic, austenitic and possibly duplex. This line will be ecologically acceptable based on an alternative system based on the dissolution rate of Cr-depleted alloy using the potentiostatic electrochemical control of steel dissolution. This process will be set up using simpler pickling solutions than in conventional HNO3/HF baths. This will lower costs, reduce environmental impact by reducing toxic NOX emissions, and improve efficiency.

**State of progress:** Research completed; publication EUR N° 20090

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7210-MA/440	F3.7/96	675.000	405.000	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Fatigue behaviour of stainless steels for railway carriages in corrosive environments (TRAINOX)

**OBJECTIVES AND CONTENTS**

The main objective of this project is to determine the fatigue behaviour of several stainless steels that are subjected to corrosive attack. The steels will be investigated in the unwelded, in the notched and in the welded state under constant as well as variable amplitude loading. Application of this newly derived fatigue data will help in the construction of stainless steel components, railway carriages, chemical plants, or components for the food industry. The data will enable optimised lightweight construction.

**State of progress:** Research completed; publication EUR N° 20327

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-TS/104	F3.8/96	1.289.500	773.700	36 (Mths)		1/07/1996	30/06/1999	31/12/1999

**Title:** Development of a new pickling technique for improved properties of high-grade steel surfaces

**OBJECTIVES AND CONTENTS**

The objective of the research project is to develop a new pickling technique based on continuous pickling bath regeneration using new processes for mixed acid pickling of high-grade steel surfaces. Different regeneration processes in combination with new mixed acids, oxidizing agents and stabilizers will be investigated and evaluated in comparative studies. The result will be an optimized pickling process with constant pickling bath composition for improved steel surface properties and reduced environmental impact.

**State of progress:** Research completed; publication EUR N° 19980

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7210-KB/441	F3/F2.1/96	885.000	531.000	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Environmentally assisted cracking and localised corrosion of some corrosion resistant alloys in brine and H2S containing environments (CORALLOY)

**OBJECTIVES AND CONTENTS**

This project is aimed at improving the knowledge of corrosion behaviour of duplex stainless steels and other corrosion resistant alloys (CRAs) in brine and H2S-containing environments, and to define the ranges of application of the different materials. The work is divided into three main activities: data acquisition in reference and in field-simulating conditions, the study of corrosion mechanisms on stainless steels, and the study of welded assemblies. Advantages of the application of CRAs in offshore situations include increased safety for personnel exposed to risk of component failure in the presence of poisonous or explosive gases.

**State of progress:** Research completed; publication EUR N° 20091

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7210-KB/340	F3/F2.2/96	520.500	312.300	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Assessment of stainless steels compatibility in food and health applications regarding their passivation ability

**OBJECTIVES AND CONTENTS**

The aim of this study is to assess the safety and compatibility of stainless steels in applications related to human health for everyday use or in biological applications. Stainless steels and alloys applied in the food industry and medical applications will be tested, both in laboratory and real conditions. The results will be related to the metallurgical and surface properties of the tested materials. Data will be used as the base for future campaigns of the stainless steels producers.

**State of progress:** Research completed; publication EUR N° 19986

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7210-PR/046	F3.1/97	1.225.000	735.000	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Stress corrosion cracking in newer stainless steel grades (NEWSCC)

**OBJECTIVES AND CONTENTS**

Chlorides are one of the primary causes of stress corrosion cracking in stainless steels and are also contributory in the majority of failures in process environments. However, there is a lack of adequate testing methods for evaluating chloride-induced cracking in newer, more resistant steel grades. The objective of this project is to conduct a systematic evaluation of the occurrence of chloride-induced stress corrosion cracking in austenitic and duplex stainless steels.

**State of progress:** Research completed; publication EUR N° 20328

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7210-PR/047	F3.2/97	953.000	571.800	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Improving fatigue life of special steels by modifying their inclusion engineering

**OBJECTIVES AND CONTENTS**

The main aim of this research project is to design and model a Si-deoxidation process that will provide steels with high plasticity inclusions (SiO<sub>2</sub>-rich), and hence fatigue performance, for use as high specification special steels for the automotive industry. The work programme will be based on SiCr spring steels for practical purposes, but the conclusions will be applicable to all high strength steels with high fatigue requirements for future use in the production of automotive components.

**State of progress:** Research completed; publication EUR N° 20316

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7210-PR/048	F3.3/97	890.000	534.000	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Influence of micromechanical mechanisms on strength and damage of tool steels under static and cyclic loading

**OBJECTIVES AND CONTENTS**

Tool steels have a wide range of applications such as hot and cold working of metal as well as injection moulding of plastics or light alloys. Increased tool performance is obtained through improved compromise between high wear resistance and steel toughness. This requires specific analysis of the relationship between chemical and microstructural parameters and their consequences in terms of toughness and fatigue resistance. The aim of this research project is an experimental and theoretical investigation of various tool steels, ledeburitic and non-ledeburitic tool steels, under static and cyclic loading, to understand the interaction between microstructural factors and fracture behaviour, and to derive new grades with higher performance.

**State of progress:** Research completed; publication EUR N° 21142 EN

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7210-PR/049	F3.4/97	990.500	594.300	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Development of steels for non-polluting manufacturing (DESTEMA)

**OBJECTIVES AND CONTENTS**

This research project is aimed at demonstrating how manufacturing processes can be optimised towards lower emissions of hazardous waste by selecting suitable steels. Disposal of cutting fluids is one of the major environmental problems of the metalworking industry. Therefore, steels with good mechanical properties will be developed that are specially adapted to being machined without the use of cutting fluids. The effects of different non-metallic inclusions on mechanical properties and dry machinability will be studied. If cutting fluids and the associated equipment can be dispensed with, reductions of the order of 15% may be achieved in the cost of finished components.

**State of progress:** Research completed; publication EUR N° 20374

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7210-PR/050	F3.5/97	694.000	416.400	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Alloy and process development support by means of dedicated thermodynamic database (ALLOYSUPPORT)

**OBJECTIVES AND CONTENTS**

The predictive capacity of the Thermocalc database will be evaluated in the alloying range which is relevant to the newly developed stainless steels as well as for standard grades. The main areas for investigation include:

- identification of inconsistencies in the existing thermodynamic descriptions;
- collection of data for modifying the existing database;
- adjustment of parameters in the relevant alloy systems;
- inclusion of new phases in the database;
- demonstration of the precision of the modified database.

The results will have a significant impact on calculations of the phase relations in stainless steels.

**State of progress:** Research completed; publication EUR N° 20315

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**Technical Group F3 : "Special and Alloy Steels"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/045	F3/F7.8/97	965.000	579.000	48 (Mths)		1/07/1997	31/12/2000	30/06/2001

**Title:** Assessment of plant and structure corrosion reliability by thin layer activation technique

**OBJECTIVES AND CONTENTS**

Thin Layer Activation (TLA) technique is expected to improve economy in materials and labour in industrial equipment by improving the efficiency of corrosion monitoring. Avoiding accidents such as leakage of toxic chemicals and unscheduled shutdown of large processing facilities are further benefits.

The objectives of this research project are:

- to develop the TLA technique for use in industrial applications in which the use of conventional methods is not possible;
- to improve the quality of corrosion monitoring by providing data concerning specific parts of a structure
- to improve reliability of steel structures by continuous monitoring, providing short and long time scale data.

**State of progress:** Research completed; publication EUR N°

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/101	F3.1/98	838.000	502.800	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title: Improvement of cleanability & disinfection of stainless steel surfaces for the food industry (dairy & meat)**

**OBJECTIVES AND CONTENTS**

New European hygienic standards are discussed by the EHEDG taking into account the material, the equipment design and the cleaning and disinfecting procedures. In the food and catering industry, the cleanability and the innocuousness of the stainless steel surfaces are becoming a decisive argument in choosing a material. The aim of this proposal is to promote wide-spread use of stainless steel as competitive material in the food-equipment industry. The important surface properties and biofouling phenomena will be studied as well as the new low-energy surfaces. The cleanability will be studied both at laboratory level and in model plants. Lastly, the innocuousness of stainless steel will be investigated in real conditions (measurement of chromium and nickel releases in meat and milk foodstuff before and after cooking .)

**State of progress:** Research completed; publication EUR N° 20476

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7210-PR/102	F3.2/98	627.500	376.500	42 (Mths)		1/07/1998	30/06/2001	31/12/2001

**Title:** Non polluting stainless steel descaling & pickling by use of high pressure water jets

**OBJECTIVES AND CONTENTS**

Due to the creation of acid vapours, pickling is one of the most important source of pollution during the fabrication process of stainless steels from hot band to finished product. Up to now, research has been devoted to find less polluting pickling solutions. This research aims to study a new descaling process using high pressure water jet with or without abrasive. In particular, great attention will be given to the new technology consisting in the use of very high pressure flat water jet. The advantages of high pressure water jet descaling are very numerous: suppression of pollution, improvement of security, improvement of working conditions and improvement of the surface quality and process stability of stainless steels.

**State of progress:** Research completed; publication EUR N° 21130 EN

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7210-PR/103	F3.3/98	1.236.500	741.900	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Development of carburizing steels for ultra high process temperatures

**OBJECTIVES AND CONTENTS**

The main objective of this project is to develop new steel grades containing special amounts of aluminium, nitrogen, titanium, niobium and different combinations of these in order to realise high temperature carburizing without grain coarsening. By this, the case hardening process is improved in terms of economy and the process will become more stable in terms of quality. Furthermore this will allow the reduction of the large number of case hardening steels existing today. New case hardening heat treatments, e.g. carburizing, will become possible. The new developed steel grade will be processed to gears, heat treated and tested in comparison with conventional processed gears.

**State of progress:** Research completed; publication EUR N° 20630

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7210-PR/173	F3.1/99	851.275	510.765	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Spray Formed States of High Alloyed Steels

**OBJECTIVES AND CONTENTS**

The new technique of "spray atomisation and compaction" fills the gap between casting and powder metallurgy having advantages like rapid solidification, fine-grained microstructure, absence of macro-segregation and structural homogeneity even in complex alloy systems and the possibility of forming primary shapes. The objective of the project is to define those categories of steel qualities for which spray forming leads to a significant improvement of value in competition to powder metallurgy and conventionally refined ingots. High carbon steels containing large carbide inclusions require expensive refining procedures that can be avoided by spray forming. For this reason, the research focuses on high alloyed steels where in-house spray forming experience already exists.

**State of progress:** Research completed; publication EUR N° 20948 EN

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7210-PR/174	F3.2/99	759.000	455.400	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Improvement in constitutive equations for forming of austenitic stainless steel sheets

**OBJECTIVES AND CONTENTS**

In Europe nearly 500 kT/year of austenitic sheet steels are cold formed to produce components. The tendency of final users to decrease the thickness of the sheet, to produce more complicated shapes in one step and to increase productivity make the forming often critical. Improvements are also possible through the optimisation of both, tooling design and pressing operation parameters. Aim of this project is the development of a constitutive equation able to describe the behaviour of austenitic stainless steel sheets at strains typical of complex forming operations, including that of strain induced martensite transformation.

**State of progress:** Research completed; publication EUR N° 21143 EN

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7210-PR/175	F3.3/99	924.500	554.700	42 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title:** Impact of scrap use on the properties of hot-work tool steels

**OBJECTIVES AND CONTENTS**

In the steelmaking process, increasing amounts of iron and steel scrap are recycled and re-used by re-melting. The large consumption of scrap will lead to a substantial increase of the level tramp elements, especially nickel and copper, in the steel produced in the next years. Objective of this research project is to expand the knowledge about the influences of these elements on properties of hot-work tool steels. The extended knowledge will help improve tool steel quality, guarantee and enlarge the fields of application for hot-work tool steels and serve to optimise steel production processes.

**State of progress:** Research completed; publication EUR N° 20906 EN

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7210-PR/176	F3.4/99	1.110.500	666.300	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Stainless steels in bus constructions

**OBJECTIVES AND CONTENTS**

Stainless steels could possibly make an entry in bus manufacturing. Their use could be based on their excellent corrosion properties. Longer lifetime with longer guarantee of corrosion protection is possible. This research intends to investigate the potentials of stainless steels as a possible structural material in the bus applications. It equally intends to develop new manufacturing and design solutions for the use of stainless steels in the bus construction by, amongst others, applying new joining and forming methods and by developing new stainless steel light structures.

**State of progress:** Research completed; publication EUR N° 20884 EN

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7210-PR/177	F3.5/99	842.800	505.680	40 (Mths)		1/09/1999	31/08/2002	31/12/2002

**Title:** Improvement of weld properties of high nitrogen alloyed stainless steels

**OBJECTIVES AND CONTENTS**

Nitrogen is today a common alloying element in stainless steels, which has both technological and economic advantages. Nitrogen alloyed duplex stainless steels present improved corrosion resistance increased strength and improved structural stability. However, during welding, micro-structural transformations and nitrogen loss from the weld pool can lead to reduction in corrosion resistance and strength. The objectives of the research are: understanding the role of the different micro-structural parameters in the reduction of corrosion resistance of high nitrogen stainless steels and increasing the reliability of welding of such steels by improving welding procedures and thereby avoiding nitrogen losses or excessive nitrogen uptake and porosity.

**State of progress:** Research completed; publication EUR N° 20949 EN

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Technical Group F3 has 34 Projects and 124 Partners

Total Projects: 246 - Total Partners: 926

**Technical Group F4 : "Thin Sheets"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-MB/604	F4.1/94	493.349	265.668	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Consumer-friendly non-circular easy opening systems for food cans

**OBJECTIVES AND CONTENTS**

The aim of the project is to investigate fundamental and practical aspects of a full aperture, non-circular, steel, easy-open end in order to determine consumer-friendly opening characteristics and thus improve the position of steel in this specific market segment.

The above-mentioned work will be carried out using fundamental finite element work. The computer model allows parameter studies which will determine an optimum full-aperture, non-circular end.

The optimum (computer-determined) end will then be tested in practice, in co-operation with a toolmaker.

**State of progress:** Research completed; publication EUR N° 18806

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7210-MB/413	F4.1/96	735.000	441.000	36 (Mths)		1/04/1996	31/03/1999	31/03/1999

**Title:** Improvement of thin sheet stamping operations to optimise in-service performance (OPTISTAMP)

**OBJECTIVES AND CONTENTS**

In order to achieve significant improvements in safety and weight reduction of automobiles, the optimal use of materials is vital. Design of automotive body components requires close cooperation between steel producers and car manufacturers. The main goals of this project are to identify and validate global criteria of optimisation of the thin sheet stamping operations based on the identification of appropriate mathematical functions derived from press shop practice, and to establish CAE procedures integrating numerical models, quality functions and experiments to optimise material forming operations.

**State of progress:** Research completed; publication EUR N° 19984

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**Technical Group F4 : "Thin Sheets"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-MB/821	F4.2/96	1.361.000	816.600	54 (Mths)		1/10/1996	31/03/2000	31/03/2001

**Title:** Investigations of the hydroforming process with a view to reducing weight in automobiles

**OBJECTIVES AND CONTENTS**

The focus of this project will be to investigate the potential for weight reduction by hydroforming automotive parts, compared with the use of conventional forming methods. Practical tests and computer simulations will be implemented to investigate the hydroforming of welded and unwelded blanks, hydroforming of high strength steels, the optimisation of the hydroformed component properties and to investigate cyclic properties, under service loading, of a hydroformed model part made from high strength steel.

**State of progress:** Research completed; publication EUR N° 20317

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**Technical Group F4 : "Thin Sheets"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-MB/822	F4.3/96	1.146.000	687.600	42 (Mths)		1/07/1996	31/12/1999	31/12/1999

**Title:** Stiffness, energy absorption, fatigue of high strength steel structures in relation to applied joining and forming technologies and mechanical properties

**OBJECTIVES AND CONTENTS**

Previous studies have shown the potential benefits of using high strength steels and continuous joining processes to achieve reduced weight and emissions in the automotive industry. Since the various elements of the vehicle have to satisfy different primary performance requirements, e.g. impact, fatigue, torsion, it is essential to establish the optimum steel strength/joining process designs. This research project will determine the most effective means of transmitting forces across structural elements from test data which will be incorporated into a FE model of both monocoque and space frame designs.

**State of progress:** Research completed; publication EUR N° 20320

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**Technical Group F4 : "Thin Sheets"**

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7210-PR/051	F4.1/97	1.353.000	811.800	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** In-service performance of hydroformed components

**OBJECTIVES AND CONTENTS**

In the design of automotive bodies there are many box section sub-assemblies built up from multiple stampings. By replacing stamping assemblies with hydroformed parts made from tubes, and thus eliminating the requirement for weld flanges, considerable reductions in mass can be achieved with improved structural rigidity.

The focus of this research project will be on the performance of hydroformed components by developing an understanding of the technical attributes of hydroformed tubes, including weight saving potential and suitable application areas. The results from these studies will enable guidelines to be developed for autobody structural design incorporating hydroformed tubes.

**State of progress:** Research completed; publication EUR N° 20321

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7210-PR/052	F4.2/97	1.458.000	874.800	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Optimization of steel properties and autobody structural designs for axial, side and off-set impact loading

**OBJECTIVES AND CONTENTS**

Steel properties currently used in FE modelling of automotive 'body in white' structures are generally based on information derived from quasi-static tensile tests, thus tending to neglect the strain rate hardening benefits associated with certain types of steels. This project will investigate the effect of both strain rate and temperature in the range -40 C to +80 C on the tensile properties of several mild and high strength steel grades. The data developed will also be used to ascertain the influence of materials properties on the formability, dent resistance and collapse resistance of these steels.

**State of progress:** Research completed; publication EUR N° 20325

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7210-PR/053	F4.3/97	561.000	336.600	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Steel shaped can (3 pieces)

**OBJECTIVES AND CONTENTS**

The steel packaging industry of tomorrow will evolve from the cylindrical can towards shaped cans. The main objective of this project is to propose complete steel solutions to the canmakers, allowing them to supply their customers with 3-piece shaped cans. The basic tasks involved in developing shaped cans are:

- the practical and basic characterisation of steels in view of the differing existing forming methods;
- the development of numerical models of forming, in order to assist with the different stages of forming;
- the development of new processes of forming for shaped cans.

**State of progress:** Research completed; publication EUR N° 20318

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7210-PR/054	F4.4/97	1.128.000	676.800	48 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Finite element analysis (FEA) on the forming and performance of laser-welded blanks

**OBJECTIVES AND CONTENTS**

This research project will investigate the formability of laser-welded tailored blanks, both practically and numerically. Suitable computer models will be developed to optimise the position of the weld and to determine optimum tool design. Practical guidelines will result, providing advice relating to optimum tool design and pressforming parameters for the utilisation of blanks. More extensive use of laser-welded blanks, together with high strength steel grades, makes reductions of up to 20% in weight possible in automotive car bodies with equivalent or improved dent resistance and crash worthiness. Investment in tooling can also be significantly reduced.

**State of progress:** Research completed; publication EUR N°

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7210-PR/055	F4.5/97	833.000	499.800	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Service improvement of high-strength formed sheet steel structures (BODYLIFE)

**OBJECTIVES AND CONTENTS**

The production of formed hot and cold rolled sheet steel structures is challenged due to lack of knowledge about material behaviour in the formed condition. Within this project the structural durability of formed hot and cold rolled sheet steel structures will be investigated for a selection of high strength steels, to demonstrate the potential of these materials for lightweight design and leading to service improvements. The results of this project will provide dimensioning methods with strength data and guidelines for high strength formed sheet steel structures.

**State of progress:** Research completed; publication EUR N° 20329

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7210-PR/056	F4.6/97	840.000	504.000	48 (Mths)		1/07/1997	31/12/2000	30/06/2001

**Title:** Fatigue behaviour of thin steel sheets and steel sheet constructions

**OBJECTIVES AND CONTENTS**

Work to be carried out under this research project will include fatigue strength tests on thin steel sheets and components of steel sheet construction in order to determine materials strength properties for calculation and design. The investigations involve unwelded sheets as well as tailored blanks. Soft and higher strength forming materials in a range of thicknesses from 1 to 2.5 mm will be considered. Topics to be investigated that influence fatigue behaviour will include secondary bending due to the thickness differences of the welded sheets, deformation of the weld due to the deep drawing process, and multiaxial stresses.

**State of progress:** Research completed; publication EUR N°

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7210-PR/057	F4.7/97	818.500	491.100	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Characterizing and optimizing the forming behaviour and joining parameters of post treated, metallic coated, high strength steel sheet for lightweight constructions

**OBJECTIVES AND CONTENTS**

The aim of this research project is to develop suitable post-treatments for electrogalvanised, hot-dip galvanised and galvanized high strength steels for use in the construction of modern, lightweight car bodies. Post-treatment systems to be used include phosphating, prelubes, weldable sealings and a non-weldable preprimed system. In addition to classical methods, the assessment of forming properties will be carried out on model parts and on real automobile panels. The geometrical accuracy, the strain distribution and joining behaviour will also be investigated.

**State of progress:** Research completed; publication EUR N° 20332

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**Technical Group F4 : "Thin Sheets"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/104	F4.1/98	1.217.500	730.500	54 (Mths)		1/07/1998	31/12/2001	31/12/2002

**Title:** Multiaxial fatigue in thin gauge high strength steels for automotive applications

**OBJECTIVES AND CONTENTS**

Most fatigue studies carried out to date have been based on uniaxial loading of the tested structure. The limited work that has been carried out on a multiaxial fatigue behaviour indicates that the uniaxial fatigue results can be conservative by a factor of up to twenty. In order to maximise the amount of weight reduction which can be achieved by down-gauging steel for future automotive applications, it is necessary to evaluate automotive components, laser welded blanks and bonded blanks under multiaxial load conditions. The results generated will be used to develop a general model in order to predict the likely performance of different steel types and joining methods under multiaxial fatigue conditions to enable the optimisation of designs for high strength steels in light weight automotive construction. Both uncoated and zinc coated steels will be used in this study.

**State of progress:** Research completed; publication EUR N° 20885 EN

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7210-PR/105	F4.2/98	500.000	300.000	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Low cost tooling for lean manufacture of automotive components

**OBJECTIVES AND CONTENTS**

The increase in automobile model variety, coupled with relatively small growth in vehicle sales, has led to a number of cost and time to market reduction technologies and processes designed to maintain profitability.

The aim of the project is to investigate the performance characteristics of a number of low cost tool materials. Practical tests and computer numerical simulations will be implemented to assess the wear coefficients, durability, galling tendencies and forming effects of each material. The results will define the specification of each tool material needed to meet certain press forming scenarios and production volumes for reducing the new vehicle time to market lead times.

**State of progress:** Research completed; publication EUR N° 20319

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7210-PR/106	F4.3/98	1.046.000	627.600	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Optimization of structure & texture of tinplate for easy-opening can ends

**OBJECTIVES AND CONTENTS**

The aim of the project is to optimise the metallurgical structure and the crystallographic texture of continuously-annealed steel sheets for highly competitive tinplate end tops of easy-opening full-aperture cans. The application requires the lowest resistance to tearing by shear normal to the sheet plane compatible with the required resistance to internal can pressure. Such compromise involves fracture and plastic properties of the material, related with structural parameters (inclusion contents, hardening state, crystallographic texture, etc.) which can be independently controlled during the metallurgical process. In particular, a fundamentally-based index for qualifying tin-plate for the application will be looked for. Such index will be used as a guide for the comparison of the relative aptitude of different steels grades, different continuous annealing cycles and different final (single or double) reduction states for making easy-opening can ends.

**State of progress:** Research completed; publication EUR N°

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**Technical Group F4 : "Thin Sheets"**

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7210-PR/107	F4.4/98	1.331.950	799.170	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Metallurgical aspects of fatigue resistance and cold work embrittlement of thin sheets

**OBJECTIVES AND CONTENTS**

Increasing demands on fuel efficiency have led to weight reduction in cars, made possible by the development of high strength steels. However, there are clear indications that some high strength steelgrades could perform badly under fatigue loads. The research proposed is aimed at the safer use of high strength thin sheet steels by the development of a suitable fatigue test, the definition of the relationship between the fatigue and the steel composition, microstructure and related processing conditions and, finally, by the assessment of the effects of various parameters on fatigue strength to enable a transfer from laboratory tests to automotive parts.

**State of progress:** Research completed; publication EUR N° 20475

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7210-PR/178	F4.1/99	1.025.000	615.000	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Clarification of hydrogen trap formation mechanism in Al-ki and IF steels for vitreous enamelling-Evaluation of analytical techniques for determination of fish scale susceptibility

**OBJECTIVES AND CONTENTS**

Al-killed type steels are used for the production of enamelling grade steels. To obtain a low fish-scale susceptibility of the Al-killed steels and good drawability properties, the main requirements are high temperature strip coiling and annealing in open-coil box. Though various types of enamelling sheet steels have been developed, it is difficult to produce sheet steels that combine deep drawability and good enamelling properties. The project intends to deal with the following objectives: optimise a new enamelling interstitial free steel produced by continuous annealing process line and prepare new measurements and quality control systems for the fish-scale susceptibility evaluation in enamelled, interstitial free, steel.

**State of progress:** Research completed; publication EUR N° 20950 EN

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**Technical Group F4 : "Thin Sheets"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/244	F4.3/00	621.500	372.900	30 (Mths)		1/07/2000	30/06/2002	31/12/2002

**Title:** Material parameters for sheet metal forming simulations by means of optimisation algorithms

**OBJECTIVES AND CONTENTS**

Forming simulations are necessary to prove the feasibility of the parts with steel sheets. The material models which are used in the moment are probably not optimised for new steel grades (DP, CP, TRIP), but there are no measurements to get the material parameters for more advanced and more appropriate material models. The objective of this project is to get the material parameters for advanced material models as simple and effective as possible by means of optimisation algorithms.

**State of progress:** Research completed; publication EUR N° 20907 EN

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Technical Group F4 has 17 Projects and 66 Partners

Total Projects: 263 - Total Partners: 992

**Technical Group F5 : "Mechanical Characteristics"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-KA/202	F5/F1.1/94	368.500	221.100	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Strength and toughness sensitivity to strain rate of modern structural steels

**OBJECTIVES AND CONTENTS**

An analysis of the relationship proposed in 1970 to take account of the strain rate in models of steel selection reveals that the grades between 400 and 500 MPa are not favoured by this law. There exist, however, experimental data contradicting this trend.

This research aims to quantify the strain rate sensitivity of high strength structural steels using small plain or notched specimens of base metal or heat affected zone in a large range of strain rates. Those steels investigated are processed by thermo-mechanical rolling, accelerated cooling, quenching and self tempering with a yield stress between 350 and 700 Mpa, and a thickness between 15 and 40 mm.

**State of progress:** Research completed; publication EUR N° 19392

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7210-MC/404	F5.1/95	1.276.500	765.900	54 (Mths)		1/07/1995	31/12/1998	31/12/1999

**Title:** High-strength steels in welded state for light-weight construction under high and variable stress peaks

**OBJECTIVES AND CONTENTS**

The main objective of the project is to establish the criteria that are needed to design lightweight welded constructions subject to high and variable stress peaks using new classes of high strength steels.

Within this context it is necessary to establish an investigation programme based on comparative testing of medium and high strength steel, distinguishing between crack initiation and crack propagation, to calculate stress concentrations for different joint types and to produce the results in the form of design codes.

**State of progress:** Research completed; publication EUR N° 19989

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**Technical Group F5 : "Mechanical Characteristics"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-KA/203	F5/F1.1/95	1.824.500	1.094.700	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** High strength steels and line pipe with optimized Y/T ratio

**OBJECTIVES AND CONTENTS**

Despite their advantages, high strength steels remain under-exploited as a result of the restrictions placed on the yield strength to tensile strength ratio (Y/T).  
 In this respect, the project aims to define the effect of Y/T on structural performance, to determine how Y/T can be controlled and to subsequently develop new High Strength Steels with the optimum defined ratio.  
 It focuses on structural, pipeline and steels for applications in areas such as crane and excavator construction with yield stress values ranging from 450 to 1000 Mpa and thicknesses between 10 and 60 mm.  
 This new generation of products will be achieved through a precise tuning of the chemistry and the thermal route and by iteration steps between: basic metallurgy, local properties and global properties.

**State of progress:** Research completed; publication EUR N° 19987

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**Technical Group F5 : "Mechanical Characteristics"**

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7210-KB/440	F5/F1.2/95	686.000	411.600	36 (Mths)		1/12/1995	30/11/1998	30/11/1998

**Title:** Role of residual stresses and microstructure on fatigue initiation and crack growth in welded rails (RESTRAIL)

**OBJECTIVES AND CONTENTS**

The main objective of the project is to establish the relationships between the fatigue behaviour of welded rails and the residual stresses, microstructure and defects of the welded joint. In order to fulfil this aim an experimental programme based on the comparative testing (on small laboratory specimens and on welded rail components) of different combinations of rail steels and welding techniques will be carried out. Moreover, engineering fracture mechanics models will be developed and applied to assess the importance of local residual stresses on the fatigue behaviour of welded rails.

**State of progress:** Research completed; publication EUR N° 19988

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7210-KA/824	F5/F1.1/96	1.189.000	713.400	42 (Mths)		1/07/1996	31/12/1999	31/12/1999

**Title:** Steel selection for fracture avoidance in steel ships

**OBJECTIVES AND CONTENTS**

The purpose of this project is to provide a modern fracture control methodology for welded steel ships which will be applicable to both new vessel construction and the extension of service life of existing vessels. A five part programme incorporating status surveys, fracture performance quantification using small scale testing, confirmation by large scale testing, procedure derivation and final practical implementation will be followed. The aim is to provide a method which will ensure satisfactory levels of safety without penalising modern steels or the continued use of existing vessels.

**State of progress:** Research completed; publication EUR N° 20048

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7210-KA/327	F5/F1.2/96	1.009.500	605.700	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Fracture toughness predictions for modern low carbon higher strength steels based on microstructural and micromechanistic approaches

**OBJECTIVES AND CONTENTS**

The overall aim of this project is to relate microstructural characteristics of modern, low carbon, high strength steels to their fracture toughness and to examine the brittle and ductile local fracture parameters for the new steels.

The project is divided into three parts: the first is to understand fracture mechanisms and to relate mechanical properties to microstructural constituents, the second is to determine local fracture criteria, the third is to apply local approach methodology to predict strain rates, size and constraint effects.

**State of progress:** Research completed; publication EUR N° 20093

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7210-KA/827	F5/F1.3/96	1.213.500	728.100	42 (Mths)		1/09/1996	29/02/2000	29/02/2000

**Title:** Improved grain size control in heat treated steels

**OBJECTIVES AND CONTENTS**

The objective is to identify compositional, processing and heat treatment variables controlling the austenitic grain size and the achievement of consistent processing and product properties, in plate, strip, billet, bar and rod derived products. Work will examine developments required to enable the application of modern or evolving process technologies (e.g. warm/cold forging, direct quenching, high temperature carburizing) for through process cost reductions in the final products.

**State of progress:** Research completed; publication EUR N° 20322

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7210-PR/044	F5.1/97	816.500	489.900	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Modelling of mechanical properties and local deformation of multiphase high strength steels

**OBJECTIVES AND CONTENTS**

Multi-phase steels, including dual-phase steels, show promise as high strength/high formability steels for the automotive industry. This research project will attempt to develop a design tool for producing multi-phase steels with desired mechanical properties. Experimental work will include elaboration of multi-phase steels with different microstructures mainly by hot rolling + cold rolling + continuous annealing, in combination with finite element calculations. This work will allow multi-phase steels with specific metallurgical features to be defined which have the desired mechanical properties.

**State of progress:** Research completed; publication EUR N° 20331

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7210-PR/058	F5.2/97	1.718.500	1.031.100	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Fracture properties of gas pipeline steels

**OBJECTIVES AND CONTENTS**

The aim of this project is to define safety criteria against fracture phenomena in large diameter, X100 SAW linepipe operating at 150 bar. Specific objectives include:

- ductile/brittle transition; extension of current criteria for X100 pipe;
- material requirements and new technological solutions for arresting fast propagating ductile fracture;
- defect tolerance requirements concerning initiation of fracture from axial flaws;
- effect of pipe forming on fracture properties.

**State of progress:** Research completed; publication EUR N° 20330

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7210-PR/108	F5.1/98	2.984.100	890.460	42 (Mths)		1/07/1998	30/06/2001	31/12/2001

**Title:** Prediction of structural behaviour on the basis of small scale specimen testing - press

**OBJECTIVES AND CONTENTS**

There is a large potential for the use of modern high strength steels in building and construction as well as offshore industry. Whilst the base material properties can be demonstrated to be superior, in general, the weakest link in the utilisation of high strength steels is the properties of their welds. The objective of this research project will be in the quantitative description of the transferability of small scale test results to welded structural components incorporating modified material models for brittle fracture, strength heterogeneity of the materials in welds and geometrical constraint. The economical aspects of the project are time and cost savings. They can be achieved by replacing full size fracture mechanics testing with testing of small scale specimens and by using newly established computer routines to transfer the results to a real weld situation in a structure.

**State of progress:** Research completed; publication EUR N° 20882 EN

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7210-PR/109	F5.2/98	1.012.775	607.665	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Efficient welding with advanced steels and high power energy beams

**OBJECTIVES AND CONTENTS**

Among the steel properties, the aptitude for welding has a paramount importance for markets such as earth moving vehicles, bridges, naval and offshore constructions and so on. The objective of this proposal is to demonstrate that welding under very severe and productive conditions is possible by using high quality steels associated to fine microstructures in the welds. The project aims, as well, to develop and demonstrate the feasibility of LASER and Electron Beam Welding welding techniques. In this respect, special steel compositions or innovative welding techniques will be investigated in order to get higher toughness properties without welding defects. The research will also contribute to a better definition of criteria for quality acceptance in high energy density welds.

**State of progress:** Research completed; publication EUR N° 20507 EN

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7210-PR/110	F5.3/98	1.447.500	868.500	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Application of new fracture mechanics concepts to hydrogen damage evolution

**OBJECTIVES AND CONTENTS**

The development of high strength steels for certain industrial applications is tempered by the requirement for adequate resistance to hydrogen-assisted cracking. Conventional embrittlement testing or stress corrosion cracking tests in various environments, provide limited information on hydrogen damage evolution or fitness for service, whereas further alloy development requires information of a more quantitative nature. This project aims to apply the local approach to fracture to describe failure in heterogeneous zones to the problem of hydrogen damage evolution. The objective is to develop a suitable failure criterion accounting for local stress and strain distribution, local hydrogen concentration and local microstructure with the express aim of applying such a criterion to the conventional methods of testing for resistance to hydrogen-assisted cracking and to the service conditions.

**State of progress:** Research completed; publication EUR N° 20588 EN

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**Title:** Optimisation of ductility of welded steel bars, ribbed coils and mesh fabric for reinforced concrete elements under severe seismic loads

**OBJECTIVES AND CONTENTS**

The research intends to deal with the following objectives: to optimise the ductility and strength requirements for reinforcing steel in presence of welded joints in order to meet the most critical working conditions of the plastic hinge in reinforced concrete structures subjected to severe seismic loading and to define metallurgical factors in order to assure the required levels of strength ductility and weldability for the industrial production. The expected technical results can be summarised as follows: technical findings and suggestions in order to increase the minimum values of ductility parameters of the actual production; technical guide lines in order to obtain welded joints in the plastic hinge zone which ensure the required strength and ductility and an analytical description of the reinforcing steel bar behaviour inside the plastic hinge capable of predicting possible failures.

**State of progress:** Research completed; publication EUR N°

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/180	F5.1/99	1.416.000	849.600	42 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title:** Contact fatigue of rails under severe conditions

**OBJECTIVES AND CONTENTS**

The aim of the project is to understand the phenomena of contact fatigue in rails under severe conditions, in order to build a model that allows evaluation of influence of the main parameters that affect fatigue strength of rails. Because of the traffic increases, rails are more and more stressed and subjected to heavier loads. Some years ago, most of the failures occurred on defects initiated in-depth of the rail. Moreover, the increase of the locomotives' weight causes surface plastification that leads to new damage phenomena. The risk of rail fatigue and hence derailment due to traffic increase and the cost of maintenance led rail producers to increase the strength of the rail steel grades. By understanding the contact fatigue phenomenon and by building a model, new optimised steel grades could be found.

**State of progress:** Research completed; publication EUR N° 21137 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/181	F5.2/99	1.264.000	758.400	42 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title:** Fracture avoidance in laser welded thick structural steel plates with yield strength between 235 MPa and 890 MPa

**OBJECTIVES AND CONTENTS**

For structural steels, laser welding of plates up to 10mm represents technologically the state of the art. However, in view of the great productivity gains, many industries are interested in laser welding of plates up to 25 mm thick. In parallel, safety relevant design characterisation of laser welds are needed and conventional design parameters cause problems which are due to crack deviation, unavoidable welding defects and to mismatch effect. In order to overcome these problems, the research will examine the true fracture and deformation behaviour of laser welded plates of structural steels with a strength range from 235 MPa up to 890 MPa and thickness comprised between 15 and 25 mm. The most promising welding technology for the investigation of the fracture and the deformation behaviour with large scale wide plate tests will be chosen from test welds with different combined laser welding technologies. A structural safety concept will be derived in combination with small-scale fracture mechanics and fatigue tests.

**State of progress:** Research completed; publication EUR N° 20951 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/182	F5.3/99	1.083.000	649.800	42 (Mths)		1/07/1999	31/12/2002	31/12/2002

**Title:** An energy balance approach for crack arrest

**OBJECTIVES AND CONTENTS**

A new energy balance approach has been developed for predicting crack arrest conditions that offer unprecedented accuracy and relative simplicity in comparison with previous methods. A major effect of the theory is that crack arrest cannot be predicted from the applied stress alone because the compliance or the length of the structure is involved. At present, the otherwise intractable behaviour of two steels has been successfully predicted. The objectives of the projects are: to confirm the viability of the approach for general structural applications; to provide a small scale test procedure to suit the requirements of the new approach; to provide initial guidelines on design and material property requirements to ensure structural safety.

**State of progress:** Research completed; publication EUR N° 20952 EN

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**Technical Group F5 has 16 Projects and 72 Partners**

**Total Projects: 279 - Total Partners: 1064**

**Technical Group F6 : "Steel Structures"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-SA/322	F6.1/94	1.258.723	743.100	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Partial safety factors for resistance of steel elements to EC3 and EC4. Calibration for various steel products and failure criteria

**OBJECTIVES AND CONTENTS**

The research project aims to justify, for Eurocode 3 and Eurocode 4, and before they reach EN status, lower values for strength partial safety factors as compared to present boxed values.

This research should result in more competitive, since lighter, steel constructions, a situation that will make steel products of western Europe more attractive to customers.

It will also help in achieving the European Community goal of facilitating the free circulation of goods and services within the European Market, by making it easier to adopt harmonised values of partial safety coefficients in EC3 and EC4 when they acquire EN status.

**State of progress:** Research completed; publication EUR N° 20344

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-SA/522	F6.2/94	1.677.055	958.800	48 (Mths)		1/07/1994	30/06/1998	30/06/1998

**Title:** Competitive steel buildings through Natural Fire Safety Concept

**OBJECTIVES AND CONTENTS**

The aim of this research is to collect and complete existing worldwide know-how in natural fire engineering in order to form a consistent state of the art Natural Fire Safety Concept (NFSC). This NFSC - including the performance of entire steel structures, natural fire curves and active fire protection measures - will then be applied to the design of real buildings throughout Europe. A design method will be established to provide the means of calculating natural heating conditions, function of the presumed fire load and rate of heat release, the ventilation conditions, the building or compartment geometry, the efficiency of sprinklers, the influence of automatic openings and compartmentation. Probabilistic procedures will also be established to quantify the fire danger which depends upon, on the one hand, the building contents, the type and use of the building, and on the other hand, on the active fire protection measures. This should lead to a classification defining either far more realistic requirements than the present ISO fire requirements (R30, R60 or R90), or the final natural fire curve which would have a greater probability of occurring.

**State of progress:** Research completed; publication EUR N° 20360

**Partners**

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7210-SA/523	F6.3/94	877.184	502.046	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Development of unified European design rules for steel sheet piles and introduction into part 5 of Eurocode 3

**OBJECTIVES AND CONTENTS**

The aim of this research project is to carry out experimental tests and numerical simulations on Steel Sheet Pile sections (SSP-sections), in order to determine the design resistances of SSP-sections, in accordance with the principles laid down in Eurocode 3, Part 1.1, and with respect to the interaction of local and global effects such as the soil-structure interaction, mentioned in Eurocode 7 (Action effects).

The basis for the development of principles and application rules for the design of SSP-sections in conformity with Eurocode 3, part 1.1 and Eurocode 7 will be established, based on the results of the experimental tests and numerical simulations and a code proposal will be worked out for introduction to CEN/TC250 for drafting Eurocode 3, Part 5 (Piling).

**State of progress:** Research completed; publication EUR N° 20034

**Partners**

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7210-SA/424	F6.4/94	1.536.000	921.600	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Composite bridge design improvement for high speed railways

**OBJECTIVES AND CONTENTS**

High speed railway trains bring new problems to bridge design which may limit the development of steel or composite railway bridges and may result in authorities selecting the concrete solution.

It is thus felt necessary to undertake a new research activity to remove technical drawbacks, to provide an answer to the objections raised by national authorities, and also to transfer the know-how available in various European countries in order to improve and promote the use of constructional steel in the European High Speed Railway System.

**State of progress:** Research completed; publication EUR N° 20035

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7215-CA/806	F6/T3.1/94	1.058.975	434.506	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Behaviour of a multistorey, steel framed building subjected to natural fire effects

**OBJECTIVES AND CONTENTS**

The aim of this proposal is to demonstrate to Regulatory Authorities in EC Member States and to the public at large, the inherent fire resistance and the true behaviour of Multistorey Steel Framed Buildings subjected to natural fire effects and to establish confidence in the Natural Fire Safety Concept to be used for the future designs of Multistorey Steel Framed Buildings, leading to an increased market share for steel in the construction sector.

**State of progress:** Research completed; publication EUR N° 20029

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7215-CA/405	F6/T3.2/94	6.292.938	2.493.300	54 (Mths)		1/07/1994	31/12/1997	31/12/1998

**Title:** Application of steel in urban habitats

**OBJECTIVES AND CONTENTS**

The main objective of the project is the design, construction, validation and demonstration of steel-intensive components and/or sub-assemblies as applied to urban habitats.

The innovative aspects consist in giving aesthetic/architectural/functional validity to the above-mentioned components, designed to be as modular and compatible as possible.

This project is a multipartner project based on three main lines: housing (low rise buildings), temporary architecture, refurbishment (high rise buildings). Demonstration constructions will be assembled on sites in different countries, and particular care will be taken in the proper reporting and dissemination of overall results.

**State of progress:** Research completed; publication EUR N° 20033

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7210-SA/902	F6.1/95	994.500	397.800	28 (Mths)		1/09/1995	31/01/1998	31/01/1998

**Title:** Low-energy steel house for cold climates

**OBJECTIVES AND CONTENTS**

The main objective of this project is to demonstrate by experimental buildings that steel can be used economically in low-energy housing in a cold climate using previously developed sections, components and solutions. The objective is to reduce the costs of heating energy in the experimental houses by about 50 % compared with conventionally constructed houses. The results of this demonstration project will be that:

- two experimental low-energy steel houses will be constructed (one with prefabricated components and the other with pre-cut sections);
- heating energy requirements for these houses will be of the order of 50 % compared with conventional housing;
- suitability for commercial production of certain components will be tested in practice;
- design and construction guidelines will be produced for architects, engineers

**State of progress:** Research completed; publication EUR N° 20031

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-SA/129	F6.1/96	1.144.500	686.700	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Use of high strength steel S460

**OBJECTIVES AND CONTENTS**

The main objective of this project is to overcome the obstacles to the use of S 460 steels through a research programme. The available design and execution rules based on research results and experience in fabrication will be checked. On the basis of this information, a test programme will be defined for areas not yet covered. Rules will be developed for areas where more detailed information is necessary.

**State of progress:** Research completed; publication EUR N° 20104

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7210-SA/525	F6.2/96	901.500	540.900	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Modelling and predesign of steel and composite structures

**OBJECTIVES AND CONTENTS**

Pre-design of structures is often based on the old allowable stress methods rather than the more efficient limit states laid down in Eurocodes 3 and 4 which will soon become obligatory in Europe. This research project intends to develop guidance on the use of Eurocodes: guidelines for the selection of the most appropriate solution, recommendations for structural modelling, for global analysis, checking of members, etc., and also to prepare practical tools (handbooks, design aids, tables, charts, software, etc.) for pre-design of steel and composite structures.

**State of progress:** Research completed; publication EUR N° 20323

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7210-SA/526	F6.3/96	1.093.000	655.800	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Development of a new soil investigation procedure determining the installation of piling and the impact on the environment

**OBJECTIVES AND CONTENTS**

The aim of this research project is to develop a comprehensive concept for the most efficient and environmentally friendly sheet pile installation method. Based on theoretical models and computer programs, new field testing procedures will be established which use specially developed equipment consisting of instrumented probes and driving units. The goal is to regain lost market share and to provide new applications for steel sheet pile structures resulting in higher demand and increased production of this important steel product.

**State of progress:** Research completed; publication EUR N° 20334

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7210-SA/842	F6.4/96	1.235.000	741.000	42 (Mths)		1/07/1996	31/12/1998	31/12/1999

**Title:** Development of the use of stainless steel in construction

**OBJECTIVES AND CONTENTS**

Stainless steel is gaining usage in the construction industry due to its durability, maintainability, fire resistance and aesthetic merits. However, design standards do not allow its full potential to be realised, leading to increased costs and restricted usage. This project intends to promote the use of stainless steel through the development of structural design guidance generated by research involving testing and numerical analysis. The research will produce design software and rules for inclusion in Eurocode 3: Part 1.4.

**State of progress:** Research completed; publication EUR N° 20030

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7210-PR/059	F6.1/97	1.489.000	893.400	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Design tools and new applications of cold-formed steel in buildings

**OBJECTIVES AND CONTENTS**

The rapid growth of the use of thin-walled steel in the building and construction sectors is predicted in Europe. The objective of this research project is to produce practical design tools for applications of cold-formed steel members and sheeting. The results of the project will promote the use of harmonised and reliable design aids and methods in Europe. It is estimated that in the medium term the project will lead to a potential increase of the market for cold-formed steel products up to 200,000 tonnes a year.

**State of progress:** Research completed; publication EUR N° 20324

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7210-PR/060	F6.2/97	1.425.500	855.300	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Natural fire safety concept: full scale tests, implementation in the Eurocodes and development of a userfriendly design tool

**OBJECTIVES AND CONTENTS**

A natural fire concept, instead of the usual procedure based on the ISO curve, taking into account the Active Fire Safety Measures is a global approach which will greatly increase the competitiveness of steel buildings because it enables the cost of insulating materials to be reduced or avoided. The objectives of this research are:

- to perform some tests to complete experimental data and to validate fully the Natural Fire Safety Concept;
- to include this Natural Fire Safety Concept in the Eurocodes;
- to produce a user-friendly design tool to disseminate use of the method.

**State of progress:** Research completed; publication EUR N°

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7215-PP/010	TF6.1/97	1.950.000	975.000	54 (Mths)		1/07/1997	31/12/2000	31/12/2001

**Title:** Demonstration of pre-fabricated modular steel construction in the renovation of multi-storey residential buildings

**OBJECTIVES AND CONTENTS**

The aim of this project is to demonstrate the use of steel-based products, especially modular units, in the renovation of existing concrete and masonry buildings. Aspects to be examined include economic, technical, social and environmental. Objectives will be achieved through documented experimental projects, dissemination material and presentation at technical exhibitions. Work will concentrate on the renovation of three multi-storey residential buildings, two in Finland and one in the UK. Final results will be presented as guidelines, models and forms by which advanced steel-based products and concepts can be used most competitively in such projects.

**State of progress:** Research completed; publication EUR N° 20595 EN

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7210-PR/112	F6.1/98	854.800	512.880	48 (Mths)		1/07/1998	30/06/2001	30/06/2002

**Title:** Design tools for the behaviour of multi-storey steel framed buildings exposed to natural fires

**OBJECTIVES AND CONTENTS**

Experience in real fires shows that the present assessment methods for the fire behaviour of supporting steelworks in modern steel framed structures is too conservative. This is confirmed by recent large scale fire tests, carried out in the scope of the Cardington LBTF Demonstration Project. Aim of the proposed research is to develop operational design rules and calculation models, which allow an easy and realistic assessment of the fire behaviour modern steel framed structures, taking full account of the beneficial effect of the inherent fire resistance of the complete load bearing structure.

**State of progress:** Research completed; publication EUR N° 20953 EN

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7210-PR/113	F6.2/98	1.354.275	812.565	42 (Mths)		1/07/1998	30/06/2001	31/12/2001

**Title:** Composite bridge design for small and medium spans

**OBJECTIVES AND CONTENTS**

The project aims at providing the basis for a new concept of composite bridges in the span range of 15 m that are attractive both for bridge authorities and for main contractors because they are easy to build, robust and durable. The works provided in the project comprise research activities to resolve outstanding problems concerning durability and fatigue, stability and interaction problems with full depth or partial depth prefabricated concrete elements. Their results would complete the necessary background for the design and detailing works that would result in a predesign software, a design guide and the design of standardised bridges documented in drawings and complete static analysis.

**State of progress:** Research completed; publication EUR N°

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7210-PR/114	F6.3/98	1.035.000	621.000	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Roadsteel - improvement of collapse behaviour of all-steel road safety barriers

**OBJECTIVES AND CONTENTS**

The increasing emphasis on the safety plays an even more important role in the general concept of the quality of life. In this context the safety of transportation involves, among others, the aspect of the passive safety given by road barriers. To maintain and possibly increase the use of all-steel barriers some work must be done in order to optimise their performances guaranteeing the requested containment capacities and limiting at acceptable values the weights and hence the costs. This project focuses on the following goals: propose a simulation protocol for the design of safety features in order to give a simplified approach of a complex phenomena; to study the modifications of some all-steel solutions commonly used in order to obtain an in-service acceptable behaviour with respect to the draft CEN specification; to investigate and validate a totally new type of barrier produced with steel-based multilaminate materials.

**State of progress:** Research completed; publication EUR N°

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7210-PR/115	F6.4/98	1.464.000	878.400	42 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Development of dry composite construction systems based on steel for residential applications

**OBJECTIVES AND CONTENTS**

The proposal concerns the composite or combined action of steel components with other materials in residential construction. This action is in the form of structured improvements, but also in the building physics performance such as thermal and acoustic insulation. The work is presented in various sub-packages which address the development of advanced steel building components, the overall performance of complete buildings and the preparation of design tools and recommendations based on the information gained in the research. The project will lead to a greater acceptance of the benefits of steel by improved technical information for designers and users. The design tools will take the form also of design tables and typical details and possibly software for specialist applications.

**State of progress:** Research completed; publication EUR N° 20375

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7210-PR/116	F6.5/98	1.108.850	665.310	43 (Mths)		1/06/1998	31/12/2001	31/12/2001

**Title:** Life cycle assessment (LCA) for steel construction

**OBJECTIVES AND CONTENTS**

This project has the objective of developing components for LCA tools that can be used by steel manufacturers and by the steel construction sector. These will help provide environmental information within a buildings full life-cycle, i.e. from the cradle to the gravel. This will help improve steels market share in the various competitive sectors of construction and help sell steel as a sustainable construction material. The project will proceed from the recently developed elaboration undertaken by the IISI to develop accurate data on all inputs (materials, energy, etc.) and all outputs (products, emissions to air, water) associated with the production of steel. Data and information will be collected and developed in 12 life-cycle topic areas stretching from the assessment and development of selected data to the maintenance, repair replacement, adaptability of steel buildings, re-use of steel components; recycling of steel and disposal of it.

**State of progress:** Research completed; publication EUR N° 20570 EN

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7215-PP/025	TF6.1/98	734.400	367.200	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Demonstration of real fire tests in car parks and high buildings

**OBJECTIVES AND CONTENTS**

Researches have demonstrated that in case of fire in car parks or in high buildings it is generally not necessary to insulate the steel section (beams and/or columns) to obtain a satisfactory level of safety.

In order to fully convince authorities that this kind of buildings need not to be subjected to any large duration fire resistance requirements, real fires, in really unprotected steel buildings, will be carried out. These fires will be performed in three different configurations: a large high compartment with a local fire; an open car parks with a fire scenario involving several cars; a closed car park with an adequate fire scenario.

For each of these demonstration fires, a preliminary test is planned in order to fully check the relevant parameters before inviting observers to the second test.

**State of progress:** Research completed; publication EUR N° 20466

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7210-PR/183	F6.1/99	1.240.500	744.300	36 (Mths)		1/09/1999	31/08/2002	31/08/2002

**Title:** Lateral torsional buckling in steel & composite beams

**OBJECTIVES AND CONTENTS**

Lateral torsion buckling is a complex instability phenomenon that is likely to occur in members subject to predominant bending about the strong axis of their cross-section. Though this phenomenon is likely to occur once the constructions are completed, it is mostly of paramount importance during the erection phases. At present, design of steel and composite structures for lateral torsion buckling is far from being satisfactory. It is of major importance to improve the knowledge in the field and provide the designer with easy-to-use rules. The research aims at improving the check of lateral torsional buckling compared to existing standards. This improvement would increase competitiveness of steel and composite structures. Exploiting the available results with a view of establishing easy and simple design rules will attain this goal.

**State of progress:** Research completed; publication EUR N° 20888 EN

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7215-PP/042	TF6.3/99	317.000	158.500	12 (Mths)		1/07/1999	30/06/2000	30/06/2000

**Title:** Natural fire safety concept

**OBJECTIVES AND CONTENTS**

A complete new Fire Safe Concept has been developed in the ECSC project 7210-SA/522. The aim of this project completed in June 1998, was to achieve a breakthrough in the natural fire safety concept thus leading to safer and more economical steel buildings. This concept based on Natural Fire instead of the ISO-Curve is a new global approach designed to strongly increase the competitiveness of steel buildings as it reduces or avoids the costs of the insulating materials. This valorisation project intends to translate the key conclusions of the "Natural Fire Safety Concept" into 5 European languages and to diffuse this report to experts in the field.

**State of progress:** Research completed; publication EUR N° 20349

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7215-PP/043	TF6.4/99	280.000	140.000	24 (Mths)		1/07/1999	30/06/2001	30/06/2001

**Title:** Valorisation project on steel in housing

**OBJECTIVES AND CONTENTS**

The main objective of this project is the dissemination of the results of the ECSC project: "Application of Steel in Urban Habitat Part Housing" at European level and at national level and to collect the key results and the knowledge acquired into a European short publication and European video. The technical, scientific, innovative, economic and commercial experiences gained in the demonstration project, in the participating countries, will be critically evaluated so that information and experiences can be shared thus increasing the European market for steel in housing.

**State of progress:** Research completed; publication EUR N° 20569 EN

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7215-PP/056	TF6.1/00	390.653	195.327	30 (Mths)		1/07/2000	30/06/2002	31/12/2002

**Title:** Development of the use of stainless steel in construction

**OBJECTIVES AND CONTENTS**

Existing guidance for the structural design of stainless steel is based on a carbon steel rules, modified as necessary where stainless steel test data indicated different behaviour.

A multi-partner ECSC project Development of the Use of Stainless Steel in Construction was conceived. Efficient design methods of stainless steel structures have been developed using the extensive data generated by the project.

This project will disseminate the technical knowledge resulting from the above research by the publication of a Design Manual and by the creation of a web site

**State of progress:** Research completed; publication EUR N° 21134 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/057	TF6.2/00	215.500	107.750	18 (Mths)		1/07/2000	30/06/2001	31/12/2001

**Title:** Competitive steel buildings through natural fire safety concept

**OBJECTIVES AND CONTENTS**

A complete new Fire Safety Concept has been developed in the scope of an ECSC project. In order to disseminate the concept and to increase the chances of this new approach to be accepted, the essentials of the final report of research Natural Fire Safety Concept (NFSC) will be translated into German and Dutch. Some 1600 copies of the translated final reports will be distributed to engineering offices and architects. This constitutes a second phase of the first NFSC valorisation project with the aim to provide publication in English, French, Italian and Spanish. Furthermore 3.000 copies of a CD-ROM, in all the 6 languages will be distributed.

**State of progress:** Research completed; no publication

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Technical Group F6 has 25 Projects and 121 Partners

Total Projects: 304 - Total Partners: 1185

**Technical Group F7 : "Surface Characteristics"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-TS/401	F7.1/94	2.040.258	1.200.000	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Development of continuous dry coating processes for steel strip

**OBJECTIVES AND CONTENTS**

This research project is intended to thoroughly investigate various physical vapour deposition (PVD) techniques, namely Electron Beam Evaporation, Induction Heating Evaporation, Cathodic Arc Ion Plating, and Ion Beam Assisted Deposition, to assess the transferability of the respective process parameters to continuous modes of operation for the coating of steel strip. It is also proposed to define corresponding practical working conditions leading to an optimized combination of metallurgical features and users' properties. High performance anti-corrosion and anti-oxidation protective coatings are obtained by the various PVD techniques on steel substrates. The coatings under investigation are Al and Zn + X systems, where X = Al, Mg, Cr, Ti, Mn, etc.

**State of progress:** Research completed; publication EUR N° 18865

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-TS/301	F7.2/94	1.477.832	805.362	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** New surface treatment to improve adhesion of organic coatings and corrosion. In situ methods for the characterization of Zn/polymers coatings

**OBJECTIVES AND CONTENTS**

This proposed multinational project incorporates several complementary objectives:

- to develop coil-coated sheets and panels with improved properties (adhesion, corrosion resistance, formability);
- in view of future environmental regulation, to develop combinations of new top coat with chromium-free primers and new chromium-free surface treatments;
- to develop new Zn-Ni/organic coating types without Cr;
- to develop new in-situ methods of characterization of metal/polymer behaviour in order to better understand the mechanisms of degradation.

In view of the fact that this project is devoted to different applications such as automotive, building industry and appliances, different substrates are to be considered: hot dip galvanized products (HDG), pure zinc, galfan, galvalume, electrodeposited Zn and Zn-Ni.

**State of progress:** Research completed; publication EUR N° 20047

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7210-KB/825	F7/F2.1/94	1.302.572	708.898	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Prevention of low-water corrosion on steel piling structures due to microbially-induced corrosion mechanisms

**OBJECTIVES AND CONTENTS**

A collaborative ECSC project has shown that severe corrosion of steel piling structures at the low-water level in tidal waters is principally caused by microbially induced corrosion (MIC). Steel piling walls on quays, harbours, jetties, etc, are having to be replaced after as little as 20 years and this is leading to a loss of confidence and a potential loss of market.

Although it was clearly essential to establish the cause of this problem, steel end-users are only concerned with methods of prevention. This project is therefore concerned with:

- . development of methods of assessing the risk of excessive low-water corrosion at any specific site;
- . testing of possible methods of protection against MIC at the low-water level.

A coordinated research programme has been assembled which will involve:

- . Sampling and characterisation of biofilms and corrosion products from selected locations, leading to identification of the key microbial species;
- . Statistical analysis leading to a predictive model of risk;
- . Cathodic protection in MIC conditions;
- . Protective coatings, including biodegradability;
- . Use of alloy steels in MIC conditions;
- . Use of high pressure water cleansing;
- . Methods of protecting existing structures.

**State of progress:** Research completed; publication EUR N° 20043

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7210-TS/403	F7.1/95	574.000	344.400	36 (Mths)		1/07/1995	30/06/1998	30/06/1998

**Title:** New aluminized steel strip with improved hot oxidation and corrosion performances

**OBJECTIVES AND CONTENTS**

The purpose of this project is:

- to obtain new coatings on ferritic stainless steel strip which have improved performance in terms of resistance to oxidation and corrosion;
- to reduce production costs by studying the possibilities offered by tertiary or quaternary alloying Al-Si-X molten bath, to raise the level of alloying through an improved understanding of the chemistry of modified Al baths.

**State of progress:** Research completed; publication EUR N° 20049

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7210-TS/404	F7.2/95	1.623.000	973.800	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Development of galvannealing for the domestic appliance, construction and other markets

**OBJECTIVES AND CONTENTS**

The excellent performance of galvannealing (GA) is recognized by the automotive industry and it is now logical to search for new applications, such as in the home-appliance and construction markets.

Therefore, with the intention of forecasting and supporting the technical evolution of domestic and construction industries, GA shall be assessed to:

- identify those process parameters which need to be optimized in order to achieve uniform and thinner coating, and to allow cost reductions;
- define product specifications in terms of coating thickness, composition range, and surface appearance for using thin GA for home appliance manufacturing, for coil-coating and laminated steel sheet in the construction industry.

**State of progress:** Research completed; publication EUR N° 20041

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7210-TS/101	F7.3/95	733.500	440.100	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** New functional coating on steel sheet obtained by metallic pre-coating followed by galvannealing

**OBJECTIVES AND CONTENTS**

The aim of this project is to produce pre-finished steel sheet with metallic coatings and - compared with conventional materials - significantly improved application-related properties (corrosion, forming, and joining behaviour and paintability) by means of galvannealing steel sheet with metallic pre-coatings. Since the influence of the selection of the pre-coating and the galvannealing processing parameters on the resulting application related properties is essentially unknown, the investigations will focus on three "model-materials" each of them being intended for improvement of distinct properties [a) corrosion resistance; b) phosphatability, paintability, corrosion resistance; c) weldability, formability, phosphatability, paintability, corrosion resistance]. Substrates of different steel grades will be pre-coated by electrogalvanizing and PVD. The galvannealing process will be carried out on a laboratory scale with a hot dip galvanizing simulator but under process conditions which are comparable with industrial hot dip galvanizing lines.

**State of progress:** Research completed; publication EUR N° 20044

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7210-TS/803	F7.4/95	940.500	564.300	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Role of physical and chemical characteristics of steel substrate and metallic coating on adhesion and appearance of painted hot dip galvanized and galvannealed products

**OBJECTIVES AND CONTENTS**

The primary objectives of the proposed research are to gain an improved understanding and practical control of steel and strip processing factors in the manufacture of full-finish galvanized and galvannealed products that critically and adversely affect the performance (powdering and flaking), surface quality (aesthetic appearance), and integrity (adhesion) of the zinc or iron/zinc alloy coatings, as produced and in their final painted form. These aspects are currently of major concern in manufacturing galvanneal products to the full-finish surface quality standards required for visible car-body panels.

**State of progress:** Research completed; publication EUR N° 20045

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7210-TS/102	F7.5/95	663.500	398.100	48 (Mths)		1/10/1995	30/09/1999	30/09/1999

**Title:** Crystallographic texture and microstructure at the surface of steel substrates and metallic coatings

**OBJECTIVES AND CONTENTS**

This research project will investigate:

- the interaction between steel surface characteristics and the formation of the electrolytic zinc coating as well as the formation of the Fe<sub>2</sub>Al<sub>5</sub> inhibition layer;
- influence of the steel surface texture and chemistry on the ZnFe-alloying reaction in the early stages of annealing;
- the adhesion properties of the brittle ZnFe-coating;
- the influence of the conditions of the continuous hot dip galvanizing process;
- the development of an analysis technique for the aluminium and zinc oxide layer at the zinc surface;
- the optimization and study of the potential of state-of-the-art characterization techniques such as EBSD, TEM, GDOS and GDMS for thin layers.

**State of progress:** Research completed; publication EUR N° 20042

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7210-KB/937	F7/F2.1/95	594.500	356.700	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Factors influencing the corrosion behaviour of coated steel sheets in lap joints

**OBJECTIVES AND CONTENTS**

Steel sheets assembled using lap joints are prone to suffer accelerated corrosion processes at the joints: premature deterioration of the finishing paint film and accelerated metallic corrosion at the base (steel + metallic coating).

There is relatively little research concerning this topic, particularly into the basic understanding of primary factors involved.

The following objectives will be pursued:

- to identify the most influential intrinsic factors related to the system (steel/metallic coating/organic film);
- testing panels for accelerated evaluation and electrochemical sensors.

Once these factors have been established the methodology for optimal selection of the substrate, pretreatments and organic films will be defined.

The research will be mainly focused on industrial systems currently in use: zinc, aluminium-zinc, zinc-nickel, etc. Electrochemical techniques will be completed with conventional atmospheric outdoor tests, accelerated tests in climatic chambers and surface analysis techniques.

**State of progress:** Research completed; publication EUR N° 20067

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-TS/203	F7.1/96	990.500	594.300	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** Galvannealing of high strength steels

**OBJECTIVES AND CONTENTS**

The project aims to develop galvannealing for high strength steels in a wide range of steel grades in order to meet the demands of the automotive industry. Two types of applications are involved: deep drawing grades with yield strength in the range 200-300 MPa obtained from rephosphorized interstitial-free and bake-hardenable steels, and strip with yield strengths from 300 to 500 MPa for reinforcing parts made from micro-alloyed steels. Two galvannealing cycles are to be investigated; the normal cycle corresponding to gas and medium frequency induction heating and the square cycle with large heating and cooling rates.

**State of progress:** Research completed; publication EUR N° 20337

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-TS/106	F7.2/96	944.500	566.700	42 (Mths)		1/07/1996	30/06/1999	31/12/1999

**Title:** Investigation of the delamination of polymer-coated zinc and steel surfaces with the scanning Kelvinprobe in a climatic cycle test

**OBJECTIVES AND CONTENTS**

Much work has been carried out by the steel industry to develop a corrosion test which is able to simulate the long term corrosion behaviour of polymer-coated zinc and steel surfaces. These investigations have been of limited success due to a lack of understanding of the many parameters involved in the delamination kinetics. This multi-national research project will investigate the influence of relative humidity of the gaseous phase, the number of wet/dry cycles, the length of the wet and dry period, the concentration of salt on the surface and the temperature of the sample on the corrosion kinetics in a fundamental manner, by using a new experimental technique: the scanning Kelvin microprobe.

**State of progress:** Research completed; publication EUR N° 20348

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-TS/805	F7.3/96	1.332.500	799.500	42 (Mths)		1/07/1996	31/12/1999	31/12/1999

**Title:** Enhancement of pre-treatment technology to improve performance of metallic coated sheet steels

**OBJECTIVES AND CONTENTS**

The aim of this project is to develop pretreatment technologies for steel surfaces which are specifically designed for adhesives. Commercially available "paint" pretreatment systems will be studied and novel chemistries will be developed for promoting bond strength and durability of adhesives. Environmental concerns will be respected and the work should also improve coating quality and extend bath efficiency and life using selective elemental extraction.

**State of progress:** Research completed; publication EUR N° 20036

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-TS/807	F7.4/96	987.500	592.500	42 (Mths)		1/07/1996	31/12/1999	31/12/1999

**Title:** Investigation of the enamelling characteristics of IF steels

**OBJECTIVES AND CONTENTS**

The objective of this project is to investigate the enamelling characteristics of IF steel grades. The effects of steel chemistry, annealing variables and surface chemical and physical modifications on enamel/metal adherence will be studied, and a range of chemical and physical surface treatments will be evaluated. This will lead to the production and supply of an IF grade ideally suited to the requirements of enamelling, possibly based on chemical and physical surface engineering techniques.

**State of progress:** Research completed; publication EUR N° 20339

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7210-TS/808	F7.5/96	787.000	472.200	42 (Mths)		1/10/1996	31/03/2000	31/03/2000

**Title:** Characterisation of heavy gauge galvanized strip

**OBJECTIVES AND CONTENTS**

The overall objective of this project is to gain a greater understanding of galvanized products and to improve 'on-line' production control. Two approaches will be adopted in the research work: a "mechanical method that will evaluate the application properties of galvanized material, based on the study of heavy gauge products, as used within the automotive sector, and a continuous optical method that will measure surface parameters of the iron-zinc alloy coated steel. Current on-line methods are based on X-ray diffraction techniques. The new method will be calibrated using materials utilised in the development of a powdering/flaking test.

**State of progress:** Research completed; publication EUR N° 20335

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7210-TS/809	F7.6/96	610.500	366.300	42 (Mths)		1/07/1996	31/12/1999	31/12/1999

**Title:** Elevated and low temperature performance of coated strip steel products

**OBJECTIVES AND CONTENTS**

The aim of this project is to investigate the behaviour and to establish quantitative mechanical and corrosion performance data for commercial coated steel strip comprising metallic and organic coated steel products exposed to environments with extremes of temperature and humidity in internal and external applications. The work will include investigation of the durability of zinc-coated steel in domestic and over-clad building environments in the UK, Finland and Portugal. It is proposed to generate a new test for organic coatings in which the extremes taken into consideration include UV radiation, humidity, temperature changes and freezing.

**State of progress:** Research completed; publication EUR N° 20037

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7210-TS/408	F7.7/96	827.000	496.200	36 (Mths)		1/07/1996	30/06/1999	30/06/1999

**Title:** NOCHROME: Cr-replacing coatings obtained by physical vapour deposition

**OBJECTIVES AND CONTENTS**

This research is aimed at investigating the properties of thin layers of transition metal coatings such as Ti, Mn, Ni, and Cu as alternatives to the Cr-based passivation/conversion layers. The coatings will be deposited on Zn base coated carbon steel strip substrates by "dry coating technologies", in particular electron beam physical vapour deposition (EB-PVD). Successful development of these coatings will enable existing chromate solutions used in conventional treatments to be replaced and thus alleviate concerns over the carcinogenic properties of Cr.

**State of progress:** Research completed; publication EUR N° 20040

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7210-KB/443	F7/F2.3/96	612.000	367.200	30 (Mths)		1/07/1996	31/12/1998	31/12/1998

**Title:** CORRONOISE - Electrochemical noise for field corrosion measurement

**OBJECTIVES AND CONTENTS**

The objective of the project is to design and construct a field monitoring system based on the technique of electrochemical noise for monitoring corrosion rate and mechanism of steel materials in natural environments. This information is essential in determining the most appropriate material for a specific usage, and in optimizing maintenance and component replacement schedules. It is considered that enormous financial savings in corrosion costs could be made if it were possible to correlate knowledge of corrosion mechanisms with diagnostic techniques in order to define degradation levels.

**State of progress:** Research completed; publication EUR N° 20046

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7210-PR/061	F7.1/97	1.206.000	723.600	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Scanning electrochemical techniques to investigate the edge creep mechanisms on coil-coated materials with chromium- free primers

**OBJECTIVES AND CONTENTS**

The main objective of this research project is to increase understanding of the mechanisms of corrosion at the edges of coil-coated materials with Cr and Cr-free primers. Coil-coated materials with Cr-free primers will be exposed to different weathering conditions. The degradation at the edges of coil-coated materials will mainly be studied by means of new scanning electrochemical techniques, e.g. Scanning Kelvin Probe, Scanning Vibrating Electrode and Scanning Impedance Spectroscopy. The results obtained will be used to:

- develop new environmentally friendly products;
- develop new applications for coil-coated materials in different industrial sectors.

**State of progress:** Research completed; publication EUR N° 20346

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/062	F7.2/97	1.162.500	697.500	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Galvanising of hot rolled steel strip

**OBJECTIVES AND CONTENTS**

Quality problems of coating: namely weak adhesion and blistering, are sometimes encountered with hot-dip galvanised, hot rolled strip. This project will carry out a systematic study in order to assist in guaranteeing high and consistent product quality. The influence of surface chemistry oxides or of possible hydrogen pick-up after pickling and annealing on the final quality will be investigated. Steel grade, surface pre-treatment before annealing, and galvanising conditions will also be taken into account. The research work should improve understanding of the metallurgical reactions during the whole galvanising process and lead to advances which will provide the same coating quality as for cold rolled strip.

**State of progress:** Research completed; publication EUR N° 20345

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7210-PR/063	F7.3/97	965.500	579.300	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Development of environmentally friendly organic coatings for the automotive industry

**OBJECTIVES AND CONTENTS**

Value can be added to metallic coated steel by applying organic coatings with the aim of making sealing measures obsolete for the automotive producer or by substituting for ED-paint and filler. The main objectives for this project are substituting environmentally hazardous Cr(VI) pre-treatments and optimising formability, weldability and corrosion protection by the introduction of Cr-free permanent lubricant primers. These primers will allow:

- lubricants and their vapours to be avoided on the production line;
- a decrease in the use of Cr(VI) containing primers which may set free Cr(VI) to the environment;
- Cr-acid treatment during the production of coated steel products to be avoided.

An evaluation of alternative joining concepts for non-weldable systems, factors governing corrosion resistance on cut edges and adhesion of subsequent layers will be carried out.

**State of progress:** Research completed; publication EUR N° 20568 EN

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7210-PR/064	F7.4/97	1.298.500	779.100	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Influence of segregated tramp elements on the surface of cold rolled sheet with regard to the metallic coating process and application properties

**OBJECTIVES AND CONTENTS**

This research project plans to study the surface condition at various steps of the processing sequence in relation to tramp element content. This will be carried out for conventional aluminium-killed steel grades as well as modern steel chemistries such as Ti-IF. The surface reactivity will be studied using laboratory simulation experiments as well as some real time reactivity assessments (electrochemical measurements). The characterisation work will focus on surface defect and coating aspects, and include important application properties such as corrosion and painting behaviour.

**State of progress:** Research completed; publication EUR N° 20336

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/065	F7.5/97	1.408.500	845.100	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Improvements in hot dip galvanising and galvannealing processes and product properties

**OBJECTIVES AND CONTENTS**

The prime objective of this research project is to develop a process enabling continuously produced hot dip galvanised (HDG) and galvannealed (GA) materials to be produced using the same bath chemistry. The second objective is to investigate a variety of additives in the spelter during manufacture of full-finish and general purpose continuously produced HDG and GA products in order to enhance their properties and performance. The effects of these additives on performance (powdering and flaking), surface quality and integrity (adhesion and corrosion resistance) as well as effects on the galvanising/galvannealing process will be assessed. Implementation of the results of this research work is expected to reduce air pollution both around the plant and in the workplace.

**State of progress:** Research completed; publication EUR N° 20465

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7210-PR/066	F7.6/97	985.000	591.000	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Environmentally friendly pretreatment technologies for multi-substrate applications

**OBJECTIVES AND CONTENTS**

The aim of this research project is to develop an environmentally friendly pre-treatment system for both coated and uncoated steel substrates. The substrate materials will be cold rolled steel (CRS) and CRS coated with Zn, Zn-Al, Zn-Fe and Al metallic coatings. Current pre-treatment technology based on chromium compounds can represent an environmental hazard. Commensurate with this objective is the aim of developing a fundamental understanding of the chemical processes occurring at the substrate/pre-treatment and the pre-treatment/organic coating interfaces and how they affect the in-service performance, with particular regard to adhesion and corrosion resistance. The elimination of chromium-based pre-treatments will improve air quality in the workplace and also reduce the hazards during welding operations.

**State of progress:** Research completed; publication EUR N° 20338

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/067	F7.7/97	980.000	588.000	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Phosphating the bare surface of one side electrocoated high strength steels

**OBJECTIVES AND CONTENTS**

The increased use of single sided galvanised high strength cold rolled steel sheet is being hampered due to problems involved in phosphating the bare side. This research project is aimed at:

- achieving basic knowledge of phosphating of high strength steel; including the development of a specific test aimed at predicting the phosphatability of a given steel strip;
- understanding the causes of poor phosphatability on the bare side of single sided galvanised high strength steel sheet;
- defining the limits and optimisation of the steel processing route and of phosphating parameters to ensure trouble-free operations.

**State of progress:** Research completed; publication EUR N° 20347

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7210-PR/117	F7.1/98	1.107.000	664.200	42 (Mths)		1/07/1998	30/06/2001	31/12/2001

**Title:** Multilayer coatings with improved performance for construction applications

**OBJECTIVES AND CONTENTS**

The projects aims to the development of environmentally friendly multilayer coil coated products by combining conventional and novel coating and application techniques, the focus being on the reduction of the production costs via energy savings and efficient use of materials by increasing the product recyclability.

Improved mechanical properties and durability will be achieved by three layer thick film coatings. Depending on placement of an additional intermediate organic layer, the coil will serve either as a corrosion inhibitor, barrier for gases, or as a top or a clear coat. Potential replacement for conventional thermal curing may be offered by electron beam or ultraviolet curing, possibly in combination with pre- or after heating the paint film by induction heating.

**State of progress:** Research completed; publication EUR N° 20508 EN

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7210-PR/118	F7.2/98	1.248.667	749.200	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Enhanced hot dip galvanizing by controlled oxidation in the annealing furnace

**OBJECTIVES AND CONTENTS**

High strength steel strip will find in the future more and more applications. In many of these new applications, high strength steel is hot-dip galvanised to resist corrosion. Having experienced quality problems of the coating, a systematic study is needed in view to guarantee high and consistent quality of the galvanised and galvanized high strength steel strip. This project will examine the influence of surface preoxidation by changing the non-oxidising furnace control on the final quality. The following reduction section will also be adapted to optimise strip surface composition. Steel grade and surface pre-treatment, before annealing, will also be taken into account. The correlation of the different process parameters and the surface final quality should lead to a better understanding of the metallurgical reactions during the whole galvanising process.

**State of progress:** Research completed; publication EUR N°

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7210-PR/119	F7.3/98	1.324.000	794.400	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Influence of strip surface texture and microstructure in hot dip galvanizing

**OBJECTIVES AND CONTENTS**

The research is aimed at optimising the processing route of galvanised and galvanized sheet steels by: better understanding of the influence of strip surface texture and microstructure on the very first reaction between Fe Zn and their correlation with the quality of the coated final product: final aspect, spangle size, surface flaws, resistance to abrasion, coating adhesion correlation with strip processing parameters and possibly introduction of guidelines for product final quality. The program includes the development of analytical procedures for EBSD and STEM; the modification of superficial microstructure by appropriate thermal treatments, rolling, polishing and grinding; the correlation with product quality, the first correlation with strip processing parameters and the investigation of possible ways to create beneficial texture effect.

**State of progress:** Research completed; publication EUR N° 20502 EN

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7210-PR/120	F7.4/98	880.500	528.300	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Coated steel strip for fuel tanks

**OBJECTIVES AND CONTENTS**

The traditional lead-tin coated steel has been partly displaced by plastics for the manufacture of fuel tanks. However the situation is evolving and new issues are to be considered in which steel performs much better than plastics. The objective of this project is to develop a coated steel strip dedicated to fuel tanks. The aimed features are: corrosion resistance, improved shape flexibility and recyclability. Several coated materials will be analysed: terne sheet as a reference, materials which have already been considered for fuel tanks and which must be optimised and new coating formulas. The research will include the selection of coated steel materials, laboratory tests as well as construction and evaluation of actual fuel tanks.

**State of progress:** Research completed; publication EUR N°

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7210-PR/121	F7.5/98	807.000	484.200	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** New chromium free thin organic coatings for Z, ZA and ZF

**OBJECTIVES AND CONTENTS**

Hot dip galvanised sheet and increasingly Galfan are used for numerous applications in construction and domestic appliances industry. The processing of these sheets includes mostly forming and painting procedures. To avoid additional lubrication, the processing industry asks for new functional coatings which are in line with those applied by the steel industry. These coatings should be the base for paintings to substitute customers pre-treatment completely. The aim of this project is the development of new Cr-free thin organic coated sheets with special view to corrosion resistance and processing.

**State of progress:** Research completed; publication EUR N° 20729 EN

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7210-PR/185	F7.1/99	995.100	597.060	36 (Mths)		1/09/1999	31/08/2002	31/08/2002

**Title:** Influence of surface characteristics of tinplate for food cans on adhesion properties of coating

**OBJECTIVES AND CONTENTS**

The organic coating laid on internal and external surfaces of metallic cans for foodstuff release during the lacquering volatile organic compounds that add pollution load to the atmosphere. To reduce this kind of pollution, the lacquer industries are developing coatings with a lower percentage of volatile organic compounds, water based, high solid and UV curing. This type of lacquer chemical composition presents the disadvantage of unsatisfactory adhesion. The purpose of the project is to study the interface tinplate/organic coating and to improve the passivation treatments of tinplate for the traditional EP lacquers and UV lacquers adhesion.

Moreover, the research will test an experimental method to achieve the optimisation of characteristics of tin plate passivation films in terms of composition and surface properties.

**State of progress:** Research completed; publication EUR N° 20908 EN

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7210-PR/186	F7.2/99	830.700	498.420	36 (Mths)		1/09/1999	31/08/2002	31/08/2002

**Title:** Improvement of resistance to stress corrosion of tinplate cans for foodstuff

**OBJECTIVES AND CONTENTS**

The stress corrosion problems of tin plate cans for foodstuff have lately increased. For the external corrosion higher tin coating weights and/or additional external can lacquering are commonly employed to prevent the problem. For stress corrosion phenomena, however, no practical countermeasures exist. The objectives of this research are: to define chemical composition and mechanical characteristics of tinplate in order to eventually estimate causes of stress corrosion phenomena for shaped cans; to study the relationship between stress corrosion sensitivity and can shape for different surface and toughness tinplate grades, with particular attention to thinner coatings and tougher materials.

**State of progress:** Research completed; publication EUR N° 20909 EN

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**Technical Group F7 : "Surface Characteristics"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/188	F7.4/99	987.000	592.200	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Influence of additive elements on galvanising of high strength steels

**OBJECTIVES AND CONTENTS**

Strength and ductility are of primary importance for steel users, especially in automotive industries, where safety and fuel efficiency can be improved by reducing vehicle weight. Coated strips for the automotive applications become thinner and thinner. This practice requires the production of growing amounts of high strength steels that are known for presenting galvanising problems. The purpose of this research is to determine to what extent it is possible to galvanise, in current galvanising lines, hot rolled high strength steel (Dual Phase and TRIP steel) by adapting their composition and the process parameters.

**State of progress:** Research completed; publication EUR N° 20954 EN

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**Technical Group F7 : "Surface Characteristics"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/189	F7.5/99	1.360.500	816.300	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Investigations of damaging mechanisms of coil-coating steel sheet during forming in order to enhance the performance predictability of finished parts

**OBJECTIVES AND CONTENTS**

Coil-coated sheet has a large potential in the automotive industry. However, several shortcomings like reduced corrosion resistance due to cutting and forming processes have to be overcome to meet customers' demands. To improve the processing of coil-coated steel, there is a strong need for a better understanding of the mechanisms that lead to failure of the coating systems and the application of computer simulation of the processing itself. In this research a Finite Element Method is applied in order to simulate processing steps such as cutting and forming of coil-coated material. This computational method is combined with an advanced experimental system analysis. Modern electrochemical and surface analysis techniques will be applied to detect crucial defects in the coating after the processing step. The results obtained will be compared with those resulting from the evaluation of standard corrosion tests to generate reliable critical values and a mechanistic understanding.

**State of progress:** Research completed; publication EUR N° 21135 EN

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**Technical Group F7 : "Surface Characteristics"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/190	F7.6/99	783.500	470.100	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Investigations of the kinetics of surface treatments by advanced methods

**OBJECTIVES AND CONTENTS**

In order to optimise surface treatment lines it would be useful to understand the kinetics of the surface treatment process. However, using standard electrochemical technique alone, kinetic measurements are ambiguous due to the complexity of the surface treatment mechanisms. The project proposes to develop innovative new "advanced" methods of following the surface treatment reaction. These methods will include atomic emission spectroscopy to follow anodic dissolution and Raman spectroscopy to monitor film formation and identify its nature. These techniques will be combined with the electrochemical quartz crystal microbalance with which the total mass changes at the surface can be monitored. These measurements will be performed in real time so as to give true kinetic information.

**State of progress:** Research completed; publication EUR N°

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/191	F7.7/99	896.000	537.600	42 (Mths)		1/07/1999	31/12/2002	31/12/2002

**Title:** Development of alternative technologies for off-site applied intumescent coatings

**OBJECTIVES AND CONTENTS**

Intumescent coatings are applied to steel to provide insulation in the event of a fire and are usually applied on-site. The application of the coating, however, is on the critical construction path and there is a trend towards off-site application. The current generation of thin film intumescent coatings has a number of weaknesses for off-site application and these are in part inhibiting the use of steel in the construction industry. The principle objectives of the project are: to develop alternative resin technologies for the production of thin films intumescent coatings with superior fire resistance, and durability; to undertake full scale fire tests to validate the performance of the new systems; to understand the mechanisms by which intumescent coatings degrade during both storage and usage; to audit the application, transportation and construction phases of intumescent coated steelwork; to assess the effect of any coating damage on the fire resistant properties of the steelwork.

**State of progress:** Research completed; publication EUR N° 21216 EN

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7210-PR/193	F7.9/99	1.235.500	741.300	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Environmentally friendly coated tinplate for food cans

**OBJECTIVES AND CONTENTS**

Chromium based treatments are currently used for the passivation of tinplate and have a major influence on the quality and performance of the product. The problem for tinplate producers is the substitution of chromate-based tinplate passivation processes with innovative Cr-free, environmentally friendly, passivation solutions. The project will address this industrial problem to find adequate technical and economic solutions in the whole tinplate-can manufacturing cycle. The objective of the project is the development of innovative Cr-free tinplate with Cr-free passivation and possibly Cr-free lacquers while taking into account all the phases of the food-can production process. This will achieve better ecological results and, at least, equal product properties with respect to the current tinplate.

**State of progress:** Research completed; publication EUR N° 21129 EN

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**Technical Group F7 : "Surface Characteristics"**

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Technical Group F7 has 36 Projects and 134 Partners

Total Projects: 340 - Total Partners: 1319

**Technical Group T1 : "Iron and Steelmaking"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-AA/303	T1.1/94	8.873.357	2.288.535	42 (Mths)		1/04/1994	30/09/1997	30/09/1997

**Title:** Demonstration of artificial intelligence applied to the blast furnace

**OBJECTIVES AND CONTENTS**

While awaiting the arrival of new melting-reduction processes, the ore-coke-iron chain requires a continuous evaluation of costs. The restriction in the number of blast furnaces requires exemplary operational regularity. Artificial intelligence techniques based on industrial know-how should contribute to the control of processes. After several years of study and preliminary feasibility analyses, Sollac has envisaged equipping two blast furnaces with an industrial system integrating all the blast furnace operating know-how of the group based on AI techniques. The aim of the project is to create a long-lasting open-ended data processing system, composed of modules which can be re-used on other processes, and which can be supported by various hardware environments.

**State of progress:** Research completed; publication EUR N° 18809

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7215-AA/203	T1.1/95	1.008.500	403.400	48 (Mths)		1/07/1995	30/06/1999	30/06/1999

**Title:** Production of low sulphur sponge iron using coal as a reducing agent

**OBJECTIVES AND CONTENTS**

The objective of this project is to design, implement and test at pilot scale a novel technology for producing low sulphur sponge iron in a stationary bed using coal as a reducing agent and limestone or lime as a desulphurising agent. The new process is based on a rotary hearth furnace. A first layer, consisting of a blend of pulverized coal and limestone (or lime), is charged on the rotating hearth. Then, a second layer consisting of iron ore fines is fed on top of the first layer. The furnace is heated to 1200-1400°C. The carbon of the pulverized coal reacts with CO<sub>2</sub> and generates the CO which reduces the iron oxides. The sulphur released by the coal is fixed by the limestone (or by the lime). Due to the high temperature, the reduced iron layer is sintered; this allows an easy separation of the DRI layer from the powdered bottom layer containing coal ashes and CaS. Experiments carried out at laboratory scale based on this new process show excellent results: the DRI produced in a relatively short processing time (<= 15 minutes) has a high level of metallization (>90%) and a low sulphur content (< 0.02%).

**State of progress:** Research completed; publication EUR N° 19418

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**Technical Group T1 : "Iron and Steelmaking"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-AA/403	T1.2/95	1.000.000	400.000	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Economic advantages of integrated processing of steelworks EAF wastes, mainly containing Zn,Pb,Cd,FeOx,Zn ferrite and others, with total recovery

**OBJECTIVES AND CONTENTS**

The aim of this project is to determine the conditions for total recycling of dusts produced in steelshops associated with electric furnaces. The research will be carried out to treat dusts and extract highly pure zinc (99.5%) in the form of cathodes, and Pb and other heavy metals in the form of cements to be marketed, and also to recover the iron contained in the dusts through electric furnace treatment.

**State of progress:** Research completed; publication EUR N° 19393

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-AA/404	T1.3/95	6.606.000	2.642.400	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Contiarc DC electric arc furnace

**OBJECTIVES AND CONTENTS**

It is intended to develop on demo-pilot scale (25 t/h), a new technology of Electric Arc Furnace (CONTIARC) based on the following main characteristics:

- D.C. single electrode;
- continuous annular scrap charging;
- scrap preheating directly in the furnace;
- electrical arc shielded by scrap;
- sealed vessel.

Technical advantages expected as compared with the current conventional technologies are:

- higher productivity;
- lower energy consumption;
- lower electrode and refractory consumption;
- lower environmental impact.

**State of progress:** Research completed; publication EUR N° 18814

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7215-AA/701	T1.1/96	1.387.500	555.000	36 (Mths)		1/04/1996	31/03/1999	31/03/1999

**Title:** Construction of a pilot plant for the treatment of iron-containing steel mill solid wastes from continuous pickling line and production of iron oxides

**OBJECTIVES AND CONTENTS**

This project will design, construct and run a pilot line with a nominal capacity of 1 tonne per day (at 20% humidity) of iron-rich waste from the steel industry. After drying, deferrization and mixing the product will be fed to a pre-heater and on to a rotary kiln. It is then cooled and packaged for use as red pigments in ceramic glazes, in the cement industry, and in the manufacture of roof tiles. The whole process will be automated to ensure that a consistent product with closely defined composition is always produced.

**State of progress:** Research completed but stopped; no publication

**Partners**

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-AA/903	T1.2/96	1.780.500	890.250	24 (Mths)		1/07/1996	30/06/1998	30/06/1998

**Title:** The in-plant by-product melting (IPBM) process

**OBJECTIVES AND CONTENTS**

The "In Plant By-Product" (IPBM) process is a new concept for the total transformation of steel plant slags and all other in-plant by-products into value-added products, which has the potential to achieve a "zero-waste" steel plant. The concept is based either on slag reduction or on utilizing smelting and vitrification. The reactor used is a DC hollow electrode furnace, where slag is added in the liquid or solid state together with other by-products and modifying agents. Pilot plant tests will be carried out on a 5 ton scale, mathematical modelling will be performed and vitrification for product valorization will be studied.

**State of progress:** Research completed; publication EUR N° 20068

**Partners**

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7215-AA/803	T1.3/96	1.642.000	821.000	48 (Mths)		1/07/1996	31/12/1999	30/06/2000

**Title:** Improved cleaning of waste gases and recycling of BOF dusts

**OBJECTIVES AND CONTENTS**

The objective of the project is to utilise results from previous research work on the use of X-ray fluorescence (XRF) techniques to measure dust concentrations in gas streams, and to improve the effectiveness of the waste gas cleaning system; it also aims to demonstrate improved techniques aimed at reducing fume losses from the BOF in an on-line plant application. Zinc levels will be monitored and used to indicate optimum time to divert slurry stream in order to maximise recycling potential of low-zinc slurry solids to a sinter plant.

**State of progress:** Research completed; publication EUR N° 20286

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7215-AA/408	T1.4/96	1.661.000	664.400	24 (Mths)		1/07/1996	30/06/1998	30/06/1998

**Title:** Analysis of thermal and chemical relationships between cyclone and converter in a one-reactor smelting reduction Process Development Unit (PDU)

**OBJECTIVES AND CONTENTS**

This pilot project is a continuation of an existing project based on a smelting reduction rig using a convertor/cyclone assembly with a production capacity of 3 to 5 tonnes per hour of hot metal. This plant is the only such plant operating within the European Union. The first trials performed showed that there are various problems still to be tackled. They concern both start-up procedures, as well as stable operation when the convertor and the cyclone

**State of progress:** Research completed but stopped; no publication

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7215-CA/116	T1/T3.2/96	1.856.500	742.600	48 (Mths)		1/04/1996	31/03/2000	31/03/2000

**Title:** Pilot and demonstration project for upgrading iron oxides to a high quality raw material

**OBJECTIVES AND CONTENTS**

This project aims to develop a concept which will, by means of chemical precipitation reactions, reduce the companion elements in iron oxide which is recovered from regeneration of hydrochloric acid baths, to below 700 ppm. This will make it possible to produce a high-grade iron oxide with stable technical properties which is in demand as an industrial raw material for the production of high quality soft ferrite. The project will also devise testing and standards for the end product.

**State of progress:** Research completed; publication EUR N° 20287

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7215-CA/118	T1/T3.3/96	2.123.500	1.061.750	48 (Mths)		1/07/1996	30/06/2000	30/06/2000

**Title:** Pilot and demonstration project for processing iron oxides derived from HCl regeneration through rapid thermal treatment in a vertical shaft furnace

**OBJECTIVES AND CONTENTS**

Large quantities of calcined iron oxide are obtained as a by-product of the regeneration of hydrochloric acid pickling solution and are currently used as an input material for producing hard or soft ferrites and paint pigments. Initial examinations have demonstrated the possibility of transforming this material into a high quality product for the production of hard ferrite by means of a short heat treatment in a vertical shaft furnace.

**State of progress:** Research completed; publication EUR N° 20290

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7215-PP/001	T1.1/97	1.554.500	777.250	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Improvement of blast furnace pellet quality through an integrated analysis of the production chain and process modelling

**OBJECTIVES AND CONTENTS**

The overall objective of this project is to establish a production practice for iron ore pellet production, ensuring a higher and more consistent pellet quality for the European steel industry. It includes improving the controlling technical parameters in the total pellet production chain and the development of model-assisted operation of an induration plant. This project will provide the European steel industry with a better knowledge of the influence of pellet quality parameters that affect blast furnace operation.

**State of progress:** Research completed; publication EUR N° 20291

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7215-PP/002	T1.2/97	1.976.500	988.250	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Blast furnace tuyere injection of iron and steelmaking by-products

**OBJECTIVES AND CONTENTS**

Blast furnace tuyere injection of materials into the raceway is able to accommodate the co-injection of a wide range of oily, wet and dry by-products. However, some by-products have physical properties which result in handling problems for blast furnace operation. This project will combine laboratory and pilot plant investigations with demonstration scale trials on a blast furnace where the by-products will be blended with oil and injected over extended periods. This will result in full characterisation of a range of iron and steelmaking by-products and also determine their effect on blast furnace operation when oil is injected.

**State of progress:** Research completed; publication EUR N° 20288

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7215-PP/011	T1.1/98	3.716.200	1.858.100	24 (Mths)		1/10/1998	30/09/2000	30/09/2000

**Title:** Demonstration of the "CONTIARC" technology

**OBJECTIVES AND CONTENTS**

This project intends to demonstrate the technical, economical and environmental advantages and the reliability of the new technology for the electric arc furnace (CONTIARC) on an industrial scale installation. The CONTIARC technology is based on the following main characteristics: DC single electrode; continuous scrap charging; scrap preheating directly in furnace; permanent scrap preheating; electric arc shielded by scrap and furnace equipped with efficient sealing systems to minimise the amount of off-gases and emissions. The technical advantages expected as compared with the up-to-date conventional technologies are: higher productivity, lower energy, electrode and refractory consumption and lower environmental impact.

**State of progress:** Research completed; no publication

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7215-PP/012	T1.2/98	2.522.500	1.261.250	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** High purity zinc and ferroalloys recovery from EAF dusts through a combined pyro-hydrometallurgical treatment

**OBJECTIVES AND CONTENTS**

This demonstration project is meant to develop a technology for the treatment of EAF dusts whose products can either be recycled in the EAF (ferroalloy) or resold on the market (HG or SHG-quality metallic Zn) or are inert (slag). Dusts to be treated are those arising from the manufacture of carbon and special steels - especially stainless steel - at the electric-arc furnace. This technology would be characterised by low environmental impact and would be developed on a highly innovative pilot line including a pyrometallurgical treatment followed by hydrometallurgical process with final electrolysis. Particular aspects of this technology are: the ability to thermally destroy any dioxin that may be present in the dusts, to generate intermediate by-products that do not need an additional processing at the EAF, to produce high purity metallic zinc, to treat other residuals (in solid, liquid form) that contain metals.

**State of progress:** Research completed; publication EUR N° 20505 EN

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7215-PP/026	T1.1/99	1.524.000	762.000	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Foaming of the slag and recycling of stainless steel dusts by injection into the electric arc furnace for stainless steels

**OBJECTIVES AND CONTENTS**

The EAF dust generated in the European high alloy steels and stainless producing plants represents an annual amount of 100.000 t. The recycling of these dusts in the EAF is only partially realised, generally after pelletisation. The recycling by injection, studied and applied for the production of carbon steels, is not yet practised in stainless steelmaking. The project aims to realise the following two objectives together: recycling of dust and the operation with foaming slags in the EAF stainless steelmaking, by injection of a mix of Zn rich dust and carbon. This will lead to very important improvements on the technical and economical performances of the EAF stainless steelmaking process, on the treatment and valorisation of the by-products, EAF dust and slag and, in particular, strongly reduce the disposal of hazardous dusts.

**State of progress:** Research completed; publication EUR N° 20926 EN

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7215-PP/027	T1.2/99	1.498.000	599.200	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Scrap continuous charging to EAF

**OBJECTIVES AND CONTENTS**

Steel production via the EAF is becoming more and more relevant. During the last years, EAF technology has also been aimed at increasing the productivity by decreasing the specific electric energy consumption. An important route to reach this aim is scrap preheating. Presently, a new way of continuously charging the scrap is emerging, tightly bound to the post-combustion of process gas. This project involves the post-combustion optimisation of a gas flowing in a lateral continuous system of charging scraps. This objective will be attained through the management of post-combustion in the preheating tunnel and a rational choice of scrap type charging sequence; the environmental impact of this technology will be investigated.

**State of progress:** Research completed; publication EUR N° 20883 EN

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7215-PP/028	T1.3/99	1.538.500	769.250	48 (Mths)		1/07/1999	30/06/2002	30/06/2003

**Title:** Innovative use of iron and steel making by-products for the sealing and securing of steel industry deposits

**OBJECTIVES AND CONTENTS**

Recycling of a large variety of by-products and residues has always been a major target of the steel industry. This project aims to recycle and use different by-products as secure sealing materials to cover iron and steel deposits. In agreement with existing and discussed environmental regulations and after detailed characterisation of by-products and residues, the most suitable materials, single or mixtures, will be investigated in laboratory tests and in pilot/demonstration field tests. The results of this project are expected to have a favourable effect on ground water quality.

**State of progress:** Research completed; publication EUR N° 21361 EN

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7215-PP/029	T1.4/99	1.235.000	494.000	36 (Mths)		1/07/1999	30/06/2001	30/06/2002

**Title:** Implementation of a continuous pretreatment and injection process of pulverized coal on a blast furnace

**OBJECTIVES AND CONTENTS**

To improve the oxidation conditions of injected pulverised coal, different processes, like high oxygen enrichment of the blast and the use of different designs of the injection lances, are applied. In spite of all those measures an ignition directly at the tip of the lance could not be achieved. The oxidation process only starts when the injected pulverised coal enters the raceway. This is too late because, in the raceway, coke is a strong competitor for free oxygen and the pulverised coal cannot be oxidised directly. The oxidation of the pulverised coal injected in the blast furnace tuyeres and raceway has to be accelerated and intensified to achieve its complete oxidation in this area. Higher injection rates of pulverised coal and stable blast furnace operating conditions as well as lower coke rates can be expected.

**State of progress:** Research completed; publication EUR N° 20633

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**Technical Group T1 has 18 Projects and 52 Partners**

**Total Projects: 358 - Total Partners: 1371**



**Technical Group T2 : "Hot Rolling Continuous Casting"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-AA/801	T2.1/94	1.265.569	448.800	42 (Mths)		1/07/1994	31/12/1997	31/12/1997

**Title:** Application of vacuum tundish technology to production plant slab casting machine

**OBJECTIVES AND CONTENTS**

During this demonstration project the main objectives are to design, install and operate a low pressure system to control the liquid metal flow from the outlet of the tundish of a slab caster machine to demonstrate the benefits in terms of product surface quality and cleanliness. In addition, the engineering and process control aspects will be studied and optimised to work in harmony with specific plant production requirements.

**State of progress:** Research completed; publication EUR N° 18808

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-AA/802	T2.1/95	800.000	320.000	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Pioneer production unit for near-liquidus casting of bloom sections

**OBJECTIVES AND CONTENTS**

Previous ECSC supported projects have demonstrated that near-liquidus casting promotes a finer, more homogeneous 'as cast' structure and disperses central segregation, providing quality benefits, as well as the potential to increase casting speed and to continuously cast 'difficult' grades.

The aim of this project is to develop equipment capable of routine production use. The equipment will be validated in production casts to assess its suitability and operating performance as a routine production unit, together with extensive product evaluation.

Trials would be carried out for high carbon grades on a four strand bloom machine. Single and twin strand demonstration casts will be undertaken, using conventional strands for comparison.

**State of progress:** Research completed; publication EUR N° 20300

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-AA/304	T2.2/95	1.013.500	506.750	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Pilot ultrasonically-assisted continuous billet casting machine

**OBJECTIVES AND CONTENTS**

This project concerns the construction of a demonstration pilot continuous casting machine for billets with assistance by ultrasonics either alone or in combination with other technologies (e.g. through-wall mould lubrication, modular ingot moulds, etc.). The primary objective is to improve as-cast product surface quality and the effects on the final product. Initial trials will concern spring steels.

The project will be carried out in two stages: first the design and construction of the prototype ingot mould or moulds and, secondly, industrial testing. The effect of ultrasonics used either alone or in combination with other technologies will be quantitatively evaluated by inspection of the surface quality of products and by measuring various parameters such as the frictional force between product and mould, heat transfer in the mould, etc.

**State of progress:** Research completed; publication EUR N° 20072

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**Technical Group T2 : "Hot Rolling Continuous Casting"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-AA/106	T2.3/95	1.416.500	708.250	36 (Mths)		1/04/1995	31/03/1998	31/03/1998

**Title:** Development of a highly productive strip casting concept

**OBJECTIVES AND CONTENTS**

The main objective is to develop a highly productive strip casting process for any steel grade, which can produce hot strip of a quality which is as good as or better than that of conventional strip produced today, and which has the economical advantages of the near net shape casting process.  
 The process consists of a single belt caster with in-line rolling to allow for the minimum hot reduction required to produce strip from low carbon steel grades.  
 One advantage of this is the high productivity rate achieved when casting strip of 5 to 15 mm in thickness. Another advantage is the possibility of in-line rolling with hot reduction to improve the structure and to eliminate geometrical defects.

**State of progress:** Research completed; publication EUR N° 18918

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-AA/305	T2.1/96	4.183.500	2.091.750	48 (Mths)		1/04/1996	31/03/1999	31/03/2000

**Title:** Development of a fully closed continuous casting machine for the high speed casting of prime quality steels

**OBJECTIVES AND CONTENTS**

This project is the second phase of the development of a fully closed, continuous casting machine for high-speed casting of prime quality steels. It is intended to perform industrial trials on existing casters to prove the durability and capability of the new technology, and to continue to develop the concept for industrial application. The four main phases are: preliminary industrial trials; development tests on pilot and laboratory units; optimization of the feed head design; and test campaigns on two industrial casters.

**State of progress:** Research completed; publication EUR N° 20070

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/004	T2.1/97	1.366.000	683.000	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Optimal strategy to minimise central segregation during billet casting of high carbon grades

**OBJECTIVES AND CONTENTS**

The aim of this P/D project is the minimisation of central segregation to enable the production of high carbon, quality critical, wire rod grades, such as tyre wire through the billet casting route. For some steelmakers, this would enable the transfer of such steel grades to be moved from the higher cost large bloom process route. In addition, the development of a suitable route will provide the data necessary for the casting of proposed new generation steels for tyre cord and engineering applications.

**State of progress:** Research completed; publication EUR N° 20299

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7215-PP/005	T2.2/97	871.000	348.400	54 (Mths)		1/07/1997	31/12/2000	31/12/2001

**Title:** Development of a pioneer production unit incorporating vacuum tundish technology for commercial slab casting operations

**OBJECTIVES AND CONTENTS**

Previous ECSC research projects have shown that the application of vacuum tundish technology provides a more streamlined and reduced velocity of liquid steel flow entering the slab caster mould, giving potential for improved cast product quality, particularly surface quality and steel cleanness. The aim of this project is to develop further the equipment, instrumentation, and control mechanisms to be capable of routine production use in different slab caster designs.

**State of progress:** Research completed; publication EUR N°

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7215-PP/006	T2.3/97	2.743.000	685.750	12 (Mths)		1/04/1997	31/03/1998	31/03/1998

**Title:** Development of the direct strip casting process

**OBJECTIVES AND CONTENTS**

The aim of this project is to develop a high productivity near net shape strip casting process which can be applied to the production of hot rolled strip for the majority of steel grades and which offers improved economic benefits. The potential capacity of the process shall be comparable with large slab casting machines and product quality shall be similar to conventionally produced material. The process involves liquid steel being fed on to a water-cooled moving belt. The as-cast thickness is about 10 mm, and to obtain the necessary technological properties hot rolling has to be performed in-line.

**State of progress:** Research completed; publication EUR N° 19384

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/013	T2.1/98	3.990.200	1.995.100	39 (Mths)		1/04/1998	30/06/2000	30/06/2001

**Title:** Further development of the direct strip casting process

**OBJECTIVES AND CONTENTS**

The general objective of the project is to develop a highly productive strip production process for all relevant steel grades. In this process the steel is cast on a moving belt cooled from below by water. After solidification and partial cooling in a protecting atmosphere, the steel strip with an as cast thickness of about 10 mm is continuously in-line hot rolled.

**State of progress:** Research completed; publication EUR N° 20598

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**Technical Group T2 : "Hot Rolling Continuous Casting"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/014	T2.2/98	2.635.400	1.317.700	48 (Mths)		1/07/1998	30/06/2001	30/06/2002

**Title:** Development of high productivity casting of bars with ultrafine solidification microstructure

**OBJECTIVES AND CONTENTS**

The final industrial goal of the present project is to develop a technology for high productivity casting of small round section bars with ultra fine solidification structure which means equiaxed structure with very low segregation. The final target is to reach a productivity per strand of 30 t/h for a small diameter of 85 mm which means a casting speed of 12 m/min about twice faster than the present achievable speeds for long products. This project should pave the way to the near net shape casting for long products with a strand productivity level corresponding to that of the most modern continuous casters. To achieve this objective, two main technologies will have to be combined: a technology that leads to precisely control the initial solidification of the shell without being affected by hydrodynamic turbulence in particular, level variations of the meniscus; a technology that refines the internal structure of the product by inoculating the liquid metal with steel powder injected through a nozzle such as the Hollow Jet Nozzle.

**State of progress:** Research completed; publication EUR N° 21140 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/015	T2.3/98	2.540.626	1.270.313	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** A new system for pouring steel from ladle to the tundish

**OBJECTIVES AND CONTENTS**

The proposed project concerns the transfer of the liquid steel from the transport ladle, bringing the liquid steel from the melting shop to the casting shop, into the tundish, which is used as a buffer to dispatch the liquid steel to the strands of a continuous casting installation. The existing technology to control the steel flow and protect the liquid metal from air contact is the result of several historical evolutions in the steelmaking process that were invented and developed separately and reveal now conceptual limitations. The objective of the project is to re-engineer, develop and test a new system to pour liquid steel from the ladle into the tundish that would provide steelmakers with an improved steel quality, a global cost reduction and an improvement of the safety and the working conditions for the workers due to the elimination of the difficult task to change nozzles in a hostile environment.

**State of progress:** Research completed; publication EUR N° 20301

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7215-PP/019	T2/T3.4/98	1.793.500	717.400	36 (Mths)		1/07/1998	30/06/2001	30/06/2002

**Title:** Rolling and coiling technology for production of thin strip for direct use

**OBJECTIVES AND CONTENTS**

The objective of the project is to introduce and optimise a new rolling and coiling technology for thin strip production in the course of the running-in phase. The work will be executed as follows: testing of the strip production using the new components in the finishing mill, optimisation of design of plant components; extension of the product range in terms of steel quality and surface finish

**State of progress:** Research completed; publication EUR N° 20925 EN

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**Technical Group T2 : "Hot Rolling Continuous Casting"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/030	T2/T3.1/99	2.002.000	800.800	30 (Mths)		1/07/1999	30/06/2001	31/12/2001

**Title:** Control of the temperature of the bar on entry to the finisher

**OBJECTIVES AND CONTENTS**

The aim of this project is to design, build and test, in the normal operating conditions of the hot strip mill, a new short cooling equipment placed between the roughing and the finishing mill, in order to cool, in a very fast and controllable way, the bar coming out of the roughing mill. As far as the products are concerned, the effect of the bar cooling strategy will be assessed for different steel grades. Laboratory trials will be conducted in parallel to the industrial trials. With regard to the process, the following aspects will be analysed, among others: cooling rate, homogeneity, possibility of reduction of though thickness heterogeneity, efficiency of the descaler after bar cooling.

**State of progress:** Research completed; publication EUR N°

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7215-PP/034	T2/T3.5/99	1.128.000	564.000	42 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title:** Performance of reheating furnaces equipped with highly preheated air combustion technology (HPAC)

**OBJECTIVES AND CONTENTS**

Uniform temperature distribution and heating rates are of great importance to any re-heating process. The aims of this project are to test the effectiveness and long-term reliability of burners employing "Highly Preheated Combustion Air" technology (HPAC) in an industrial re-heating furnace and specify optimal conditions for the installation of HPAC in industrial furnace using off-line simulation techniques. The project will also give some estimates of the maintenance cost for the burner and the regenerator. The improved heating efficiency of the furnace will reduce the energy consumption and the production of CO2.

**State of progress:** Research completed; publication EUR N° 21147 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/047	T2.3/00	3.197.500	1.598.750	36 (Mths)		1/04/2000	31/03/2003	31/03/2003

**Title:** Development of meniscus free casting for flat products

**OBJECTIVES AND CONTENTS**

The Meniscus Free Casting technology was developed for long products within the framework of two ECSC Pilot projects that had proven that the technology leads to drastic improvements of the surface and subsurface quality of the long products. The objective of the project is to apply the feed head technology of the continuous casting of flat products in order to improve the surface and subsurface of the cast products. The work programme is split into three parts, oriented developments to adapt the technology from long to flat products, specifications establishment, design and manufacturing of the industrial pilot mould and industrial trials, and associated metallurgical and process results.

**State of progress:** Research completed; publication EUR N° 21243 EN

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**Technical Group T2 : "Hot Rolling Continuous Casting"**

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Technical Group T2 has 15 Projects and 43 Partners

Total Projects: 373 - Total Partners: 1414

**Technical Group T3 : "Cold Rolling and Product Treatment"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-EA/801	T3.1/95	1.245.000	622.500	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title: Shape and metallurgical control in skin pass rolling of hot rolled coil**

**OBJECTIVES AND CONTENTS**

This project is aimed at developing and demonstrating the full range of control of skin pass and tension levelling operations on hot rolled coil to give good coil presentation with control of total strip shape, consistency of strip surface quality requirements, and maximise the mill scheduling flexibility. The proposal has 5 main objectives:

- to establish a monitor of skin pass and tension levelling operational performance and strip quality, against which the partners can assess progress in fulfilling objectives;
- to develop shape control systems which minimise the manifest and latent shape in the hot rolled coil with feedback measurements from a shapemeter roll, whilst maintaining the required elongation for strip metallurgical and surface requirements;
- to compare roll bending and controlled selective roll heating as a means of roll crown control, and hence strip shape control, during skin pass rolling;
- to establish the relative contribution of skin pass rolling and tension levelling, or a combination of both, in fulfilling both strip, shape control and strip metallurgical/surface quality consistency requirements;
- to develop the maximum scheduling flexibility whilst maintaining strip quality requirements.

The proposed programme of work will be carried out at two hot mill finishing departments with different control equipment. Thereby comparisons will be possible on shape, elongation and surface quality and consistency control from the different facilities for a range of different hot rolled coil qualities.

**State of progress:** Research completed; publication EUR N° 20080

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**Technical Group T3 : "Cold Rolling and Product Treatment"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-EA/802	T3.2/95	920.500	460.250	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Pilot Demonstration of use of ultrasonic activation in the pickling process

**OBJECTIVES AND CONTENTS**

This project is aimed at expanding previous laboratory studies to plant scale and demonstrating the benefits of ultrasonics in the pickling process on a pilot pickling line. The proposal has six main objectives:

- to construct large-scale laboratory equipment capable of simulating full scale pickling tank depth to measure the characteristics of ultrasonics designed for "beams" of sound suitable for treating wide strip, and to establish the optimum positioning of adjacent beams;
- to demonstrate on large samples, the reduction in acid volume, temperature or strength that is possible when using ultrasonic transducers on a continuous basis and when using short bursts of ultrasound;
- to develop a full-size design capable of retro-fitting the transducers to existing pickling lines;
- to install ultrasonic transducers on a narrow strip pilot pickling line to obtain operating data;
- to determine the costs of a full-size ultrasonic installation;
- to estimate the reduction in environmental impact, particularly from reduction in acid fume emission in the context of rust prevention of inter-process stock.

**State of progress:** Research completed; publication EUR N° 20079

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7215-EA/803	T3.3/95	1.000.000	500.000	42 (Mths)		1/07/1995	31/12/1998	31/12/1998

**Title:** Straightening of large beams

**OBJECTIVES AND CONTENTS**

In order to extend the range of size and gauge of structural H sections which can be rectified by roller straightening and to reduce the need to gag press larger sections - a much slower rectification process - alternative methods of applying straightening loads are to be examined. The work will include mathematical modelling and pilot plant trials to test and optimise the straightening system, culminating in the demonstration of a full-scale production machine.

**State of progress:** Research completed; publication EUR N° 20078

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7215-CA/605	T3.1/96	4.807.500	1.923.000	63 (Mths)		1/04/1996	31/03/1999	20/01/2001

**Title:** Implementation of a new technology for thickness, flatness and crown control in the finishing section of a hot strip mill: the dynamic shape roll

**OBJECTIVES AND CONTENTS**

In this pilot project, the capability, suitability and reliability of dynamic shape roll (DSR) in a hostile environment of the finishing section of a conventional hot steel strip mill will be tested. After the design, construction and installation of the DSR, tests will be carried out to define the control capabilities for product shape, profile and thickness. Results will also be used to fine tune the on-line and off-line process control models. Finally, the reliability of the whole unit, including lubrication and hydraulics will be evaluated.

**State of progress:** Research completed; publication EUR N° 20359

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7215-CA/309	T3.4/96	550.500	220.200	36 (Mths)		1/07/1996	30/06/1998	30/06/1999

**Title:** Improvement in working conditions, productivity, and safety in the cold rolling of stainless steels

**OBJECTIVES AND CONTENTS**

Stainless steels are cold rolled with mineral oils as a lubricant. These oils partially vaporize during the storage of the coils which are still hot and are a source of pollution in the workshops. The project aims to suppress this pollution by constructing a pilot plant which isolates the storage zone to a chamber designed to ensure easy handling of the coils, and is also purifies the chamber atmosphere using a mixture of newly-developed zeolites which traps the rolling oil contaminants. This project will improve working conditions, safety and also increase productivity.

**State of progress:** Research completed; publication EUR N° 20081

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**Technical Group T3 : "Cold Rolling and Product Treatment"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-CA/310	T3.5/96	2.400.000	960.000	48 (Mths)		1/04/1996	31/03/1999	30/09/2000

**Title:** Investigation of a novel technique for controlling flatness in cold rolling and skin pass mills

**OBJECTIVES AND CONTENTS**

A DSR (Dynamic Shape Roll) will be installed on the final stand of a tandem cold mill in order to explore and validate the performance of this flatness actuator. Its ability to improve flatness will be tested, roughness variations across the width of the strip will be studied and homogeneity of the repartition of the forces will be investigated. Efficiency of operation will be compared with that of other actuators and rolling tests will be carried out with the aim of achieving a flatness of approximately 5 I-units for common steel grades and some 10 I-units for high strength steels. The reliability and industrial economics of the installation will also be studied in depth.

**State of progress:** Research completed; publication EUR N° 20303

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7215-CA/204	T3.6/96	3.188.500	1.275.400	28 (Mths)		1/07/1996	30/06/1998	31/10/1998

**Title:** Ultra fast cooling in the hot strip mill (stage 1)

**OBJECTIVES AND CONTENTS**

The aim of this project is to design, build and test novel cooling equipment based on recent research work, to be installed immediately behind the last stand of a hot strip mill to provide very fast and controllable cooling of the exiting strip. Optimized cooling patterns will be defined for the differing steel grades and products rolled in a modern hot strip mill. The unit will be designed so that 1.5 to 15 mm strip can be handled without any loss of speed or material, and with all the strip achieving the required mechanical properties.

**State of progress:** Research completed; publication EUR N° 20077

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7215-PP/007	T3.1/97	800.000	320.000	42 (Mths)		1/04/1997	30/09/2000	30/09/2000

**Title:** Test of high speed fully multiroller tension leveller on tin plate coating lines

**OBJECTIVES AND CONTENTS**

Flatness of tin plate and tin-free steel products are major requirements of end-users. The aim of this project is to implement a unique multiroller tension leveller for tin plate coating lines operating at speeds up to 55 m/min. Different presettings of the machine will be investigated in order to minimise final flatness, bow and internal stresses. Mechanical behaviour of the leveller will also be tested under industrial conditions.

**State of progress:** Research completed; publication EUR N° 20293

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7215-PP/003	T3/T1.3/97	1.652.000	660.800	54 (Mths)		1/07/1997	31/12/2000	31/12/2001

**Title:** Continuous regeneration plant for exhausted solutions from stainless steel pickling process (HNO3-FREE)

**OBJECTIVES AND CONTENTS**

Traditional stainless steel pickling plants have now been superseded by nitric acid-free plants which greatly reduce pollution problems associated with toxic vapours and waste solutions. The aim of this research project is to design and install a continuous treatment plant to handle the exhaust solutions typical of the new pickling process based on sulphuric/hydrofluoric acids and hydrogen peroxide to recover and recycle the acids and ferric iron. The increase in pickling efficiency, improvement in product quality and the cost savings involved would allow this technology to be extended throughout the European steel industry, without requiring large investment to modify existing pickling lines. As a result, these installations will become more environmentally friendly (no toxic effluents or dumping) and the elimination of HNO3 will significantly contribute to improving air quality in the workplace.

**State of progress:** Research completed; publication EUR N° 20302

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**Technical Group T3 : "Cold Rolling and Product Treatment"**

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7215-PP/016	T3.1/98	3.697.520	1.848.760	17 (Mths)		1/07/1998	30/06/2001	1/12/1999

**Title:** Hot rolling to thin strips for direct use, through a high threading speed coiler, with advanced temperature and flatness control

**OBJECTIVES AND CONTENTS**

The proposal is aimed at realising a new hot strip rolling technology for producing thin and ultra thin strips (thickness < 1.00 mm) with high geometrical properties. Low C steel strips for direct use (commercial mild steel for forming use, structural use and piping or tubing use) will be achievable through hot strip rolling, pickling and skin pass rolling. The cold rolling and the annealing processes are thus eliminated.

Significant cost benefits can be recognised. They are related to: the elimination of the cold rolling and annealing costs; the reduction of the investment costs and of the maintenance costs; the elimination of the intermediate hot rolled coil storage, the energy saving and the just in time production. Once this new technology is tested and installed on the finishing mill of a compact strip mill, it will be applicable on any conventional hot steel strip production line.

**State of progress:** Research completed but stopped; no publication

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/017	T3.2/98	2.154.000	1.077.000	48 (Mths)		1/07/1998	30/06/2001	30/06/2002

**Title:** Pilot section of reactive continuous annealing

**OBJECTIVES AND CONTENTS**

The present project aims at producing steel sheets with exclusive properties by carburizing IF strips during continuous annealing. Carbon will be introduced in the strip when the texture is fixed, in order to combine deep drawing quality and improved mechanical properties. In particular, BH capability, low sensitivity to SCWE associated with DDQ and EDDQ texture will be achieved. Special surface properties such as a more homogeneous reactivity with zinc during galvanising and higher surface hardness are also expected. For this purpose, the project is intended to implement a specific closed reactive zone inside the annealing furnace of the CRM's pilot line in order to perform the sheet steel recrystallization, its carburizing and a diffusive post-treatment.

**State of progress:** Research completed; publication EUR N° 20910 EN

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7215-PP/018	T3.3/98	2.867.000	1.433.500	30 (Mths)		1/07/1998	30/06/2000	31/12/2000

**Title:** Ultra fast cooling in the hot strip mill (Phase II)

**OBJECTIVES AND CONTENTS**

The present proposal is phase II of a currently running Pilot and Demonstration project. It is focused on the application of ultra fast cooling to thin strip. The work programme of the project includes the design, building and testing in the normal operating conditions of the hot strip mill, of a novel short cooling equipment, placed immediately behind the last rolling stand. It allows to cool the strip in a very fast and controllable way. One of the main objectives is to first design, build and test a pinch roll, placed at the exit of a cooling equipment in order to avoid the flying of the thinner strips under the influence of the cooling water pressure. This will allow to apply the cooling from the head end of the strip on and hereby to improve the temperature control in the strip and to ensure a constant cooling temperature and consequently consistent mechanical properties over the whole length of the hot strips.

**State of progress:** Research completed; publication EUR N° 20304

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**Technical Group T3 : "Cold Rolling and Product Treatment"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/020	T3.5/98	1.793.500	896.750	42 (Mths)		1/07/1998	31/12/2001	31/12/2001

**Title:** Controlling the geometry of work hardened strip in annealing lines using specially designed pilot equipments and developing an optimised control system for strip geometry

**OBJECTIVES AND CONTENTS**

This project concerns the targeted control of the geometry of work hardened strip by plastic roll-bending. In this project, two different strategies of influencing the strip geometry in annealing lines are going to be employed. In a first case, based on existing investigations, the strip is measured and corrected before entering the furnace; this technique has to be applied to special steel strips with a brilliant surface which require coated rolls that cannot support high temperatures. The alternative strategy aims at measuring and influencing the strip within the furnace, this applies for carbon steels. The main task of this project is: the design of a sensor roller for the on-line measurement of strip shape in a continuous furnace; the design, installation and test of special, industrial scale equipment for targeted control of the shape of work hardened strip by plastic bending outside the furnace.

**State of progress:** Research completed; publication EUR N°

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7215-PP/033	T3.4/99	990.500	495.250	42 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title:** Investigation for improving process reliability and strip quality during cold rolling of slit strip

**OBJECTIVES AND CONTENTS**

It is often difficult to cold roll slit strip and uniform strip quality cannot always be guaranteed, the reason being the wedge-shaped or asymmetrical cross-section of the slit strip. Several studies, evaluations and assessments have shown that slit strip with asymmetrical thickness profile will drift sideways on the coiler during coiling until the weight has balanced out. On the other hand, this leads to undesired telescoping of the coiled strip and to stress-related warping in the strip. Pilot trials using a specially designed guide roller system were planned in view of counteracting these disruptive effects during the slit strip rolling process. This control system which has to be optimised as to geometry and roll operation during the pilot trials, will be subsequently verified for suitability in an industrial slit strip rolling mill.

**State of progress:** Research completed; publication EUR N° 20924 EN

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7215-PP/052	T3.5/00	1.057.384	528.692	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Descaling of high alloy steels with electric descaling technology (EDT)

**OBJECTIVES AND CONTENTS**

The available chemical and mechanical processes for descaling of high alloy steels and tool steels take up a great deal of space, are expensive and time-consuming, present health hazards for the workforce and severely pollute the environment. Also, the surface quality of the descaled materials often no longer satisfies the more demanding requirements of manufacturing. EDT is an innovative solution to these problems. The EDT process removes the oxides from the surface of the material under vacuum through the action of current and voltage together with lengthways movement of the scale-coated rod or bar. To validate an industrial mode of operation, industrial field tests of scale removal will be carried out on selected high alloy steels and tool steels. Improvement of the properties in subsequent mechanical treatment is a further object of the study.

**State of progress:** Research completed but stopped; no publication

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Technical Group T3 has 15 Projects and 35 Partners

Total Projects: 388 - Total Partners: 1449

**Technical Group T4 : "On-line Control"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-EB/105	T4.1/94	1.133.614	447.000	48 (Mths)		1/07/1994	30/06/1998	30/06/1998

**Title:** On-line inspection of welds using novel X-ray sensitive linear sensors

**OBJECTIVES AND CONTENTS**

The objective of the project is the development of a pilot installation for on-line inspection of the welding process in the production of line pipe for flammable liquids and gases. The testing system to be developed enables the immediate inspection of the welding process through the early recognition of systematic defects as well as facilitating the fast resetting of welding equipment after dimensional changes to ensure optimal welding parameters. In this way, in addition to a considerable improvement in the weld quality, a distinct increase in productivity (approx. 10%) can be expected, notably in the manufacture of smaller lots.

**State of progress:** Research completed; publication EUR N° 20073

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7215-EB/106	T4.2/94	2.564.308	1.003.405	48 (Mths)		1/07/1994	30/06/1998	30/06/1998

**Title:** Development, realization, installation and validation of a flatness measuring system for the control of hot rolling of plates

**OBJECTIVES AND CONTENTS**

The flatness is for the customer and the plate manufacturer an essential part of plate quality.

Improvement of process models and plant control affords steady measurement of achieved flatness at mill exit, but the equipment required is not available.

The purpose of this project is to develop, realize, install in the rolling line of a plate mill, and validate an industrial pilot plant providing a quantitative measurement of plate flatness directly after hot rolling; this value will be fed into the process control systems.

**State of progress:** Research completed; publication EUR N° 19350

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**Technical Group T4 : "On-line Control"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-ZZ/609	T4.3/94	555.409	265.769	30 (Mths)		1/04/1994	30/09/1996	30/09/1996

**Title:** Industrialisation of a sensor for the continuous measurement of the zink layer thickness of hot dip galvanised wires

**OBJECTIVES AND CONTENTS**

**State of progress:** Research completed; publication EUR N° 18791

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-ZZ/611	T4.4/94	110.000	110.000	18 (Mths)		8/09/1994	7/03/1996	30/09/1996

**Title:** Prototype system for on-line surface inspection

**OBJECTIVES AND CONTENTS**

The aim of this project is to develop a reliable technology for automatic inspection of stainless strips by means of linear silicon sensors and image processing, screened by data concentrator and treated by a computer. Unlike other metallic materials, the manufacture of cold rolled stainless steel flat products is made unique by the need to supply surfaces of very high quality. The requirements of the end user are becoming increasingly stringent as they aim for higher quality in their finished products and reduced manufacturing costs.

The aim of this joint effort is to replace current visual inspection methods of surface quality assessment by more reliable automatic system of monitoring quality at the different stages of the production process.

The work will be shared between the two partners as follows :

- Terni Acciai Speciali will place its inspection system at the end of the first processing line (hot rolled, annealed and pickled strips)
- Ugine Aciers de Chatillon & Gueugnon will place its system at the end of the final processing line (colled rolled, annealed strip).

**State of progress:** Research completed; no publication

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-GB/314	T4/E1.1/96	1.517.500	910.500	42 (Mths)		1/07/1996	30/06/1999	31/12/1999

**Title:** Improvement of automatic surface inspection in flat steel products

**OBJECTIVES AND CONTENTS**

The aim of this research project is to enhance performance of automatic strip inspection equipment for continuous steel strip mills by improving the sensitivity of image acquisition devices, the accuracy and precision of detection modules, and the reliability of recognition modules in order to reduce confusion ratios and increase long term stability. A common database of defects will be established and used to test new algorithms.

**State of progress:** Research completed; publication EUR N° 20082

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-GB/125	T4/E1.2/96	844.500	506.700	45 (Mths)		1/10/1996	30/09/1999	30/06/2000

**Title:** Development of a prototype facility for non-destructive magneto-inductive determination of direction-dependent mechanical/technological sheet properties

**OBJECTIVES AND CONTENTS**

A magnetic induction measuring technique using twin coils with distinct magnetic orientation will be constructed and calibrated by reference to static test results. Further experimentation will allow this equipment to determine dynamic boundary conditions under continuous rolling mill operations. A prototype of this contactless measuring system will be installed and run in a production unit.

**State of progress:** Research completed; publication EUR N° 20314

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7215-PP/008	T4.1/97	2.009.000	1.004.500	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Development and implementation of intelligent systems for real time optimisation of product quality in rolling and process lines

**OBJECTIVES AND CONTENTS**

Engineering and control principles developed in a Brite-Euram project in the field of rolling for monitoring and diagnosing process parameters are to be demonstrated involving a full evaluation of these techniques in two steel industry application areas. Integration of these techniques with process control will be demonstrated at a hot strip mill and will be utilised to optimise an electrolytic processing line in real-time.

**State of progress:** Research completed; publication EUR N° 20305

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7215-PP/009	T4.2/97	735.000	367.500	42 (Mths)		1/07/1997	31/12/2000	31/12/2000

**Title:** Pilot plant for the contactless detection of internal and surface flaws in hot steel products

**OBJECTIVES AND CONTENTS**

Reliable, non-destructive testing to detect internal and surface flaws prior to further processing is crucial to ensuring the quality of wire products. Previous research work has led to the development of an electro-magnetic ultrasonic transducer system using guided waves. This technique is contactless and can inspect hot wire at high speeds for internal and surface flaws. It has a greater detection capacity than conventional eddy current and ultrasonic systems. A pilot plant will be constructed under this project to test in-process conditions.

**State of progress:** Research completed; publication EUR N° 20294

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/021	T4.1/98	1.442.500	721.250	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Roll surface monitoring in the hot strip mill

**OBJECTIVES AND CONTENTS**

The aim of this Pilot and Demonstration project is to develop an on-line inspection system for automatic full width work roll observation with an integrated image analysing system, based on a prototype CCD camera inspection system already developed in a previous ECSC project. The system will be used to define objective criteria for intermediate roll change. This way, strip surface defects caused by work roll surface degradation will be anticipated. Together with the rolling data it will also lead to a better understanding of the parameters influencing the work roll surface degradation.

**State of progress:** Research completed; publication EUR N° 20462

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7215-PP/022	T4.2/98	1.430.000	715.000	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** On-line slabs surface inspection in continuous casting using novel conoscopic holography (SURFIN)

**OBJECTIVES AND CONTENTS**

The aim of the project is the development and implementation of an on-line Quality Control System capable of inspecting automatically and in real-time 100% of the produced slabs. This will improve the inspection of the continuous cast products and, in particular, the detection of surface cracks or other defects in the surface of the slabs. This system will be able to determine, on-line, whether a slab can be rolled, must be repaired or should be dedicated to lower quality level applications.

**State of progress:** Research completed; publication EUR N° 20461

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/023	T4.3/98	1.036.500	518.250	48 (Mths)		1/07/1998	30/06/2001	30/06/2002

**Title:** Hot rolling of heavy plates: thickness measurement

**OBJECTIVES AND CONTENTS**

The aim of this pilot and demonstration proposal is to develop and to test on-line a prototype of a new generation of optical thickness gauge able to measure the thickness of a plate from 100 to 500 mm with a global uncertainty of 0.1 mm.

An optical version of the calliper will be used : two optical range meters are mounted on a O or C frame and measure the distance to the upper or lower surface of the plate relative to their reference support frame. A new generation of phase modulation laser distancemeters allows the use of the same sensor to simultaneously or separately measure the distance to the product and the position of its counterpart on the opposite arm of the mechanical support. This in order to make a calibration between plates and to minimise the main cause of imprecision on the thickness.

**State of progress:** Research completed; publication EUR N° 20799 EN

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7215-PP/024	T4.4/98	1.152.400	576.200	36 (Mths)		1/07/1998	30/06/2001	30/06/2001

**Title:** Validation of simulation models of dust & gas ventilation for the design & self-control of iron & steelmaking shops

**OBJECTIVES AND CONTENTS**

The project aims at validating, in the field, ventilation techniques using 3D numerical codes for typical iron and steelmaking shops ( blast furnaces, steelmaking plants, coil-coating shops, rolling mills). The main steps foreseen are: choice of numerical codes of interest; choice of typical iron and steelmaking plants; determination, by physical measurements, of the boundary conditions that depend on the situation and the configuration of the shop; computing of the ventilation and validation of the results obtained by physical measurements in the field. It is expected that the results of this project will largely contribute to the improvement of both the technical efficiency of the ventilation systems and, consequently, the salubrity of work places and to the energy/cost efficiency of the ventilation of iron and steelmaking shops.

**State of progress:** Research completed; publication EUR N°

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7215-PP/036	T4.3/99	1.412.000	706.000	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Characterisation of segregation with a mapping OES apparatus

**OBJECTIVES AND CONTENTS**

The objective of the project is to provide the metallurgists with a fast method and apparatus for process segregation evaluation. The first step will be to develop an apparatus able to treat large samples (400 mm x 150 mm). The second step is to improve the resolution to obtain an apparatus and a technique whose performances can be compared with those of the chemical techniques currently applied. The third step deals with the information and the improvement of the process. The last part of the project concerns the application of this technique in industrial environment for some usual steel grades on billet or slab forms. A round robin test will define the real possibilities of such a new technique. The final goal will be an on-site apparatus able to quantify, in a short time, segregations in slabs and billets. This new technique will allow the minimisation of problems of pollution and safety due to the use and the elimination of chemical products.

**State of progress:** Research completed; publication EUR N° 21139 EN

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7215-PP/037	T4.4/99	1.715.200	857.600	48 (Mths)		1/07/1999	30/06/2002	30/06/2003

**Title:** 2nd generation automatic steel inspection for hot rolled products

**OBJECTIVES AND CONTENTS**

The objective of this proposed project is to develop new algorithms and mechanical/technical solutions that meet the current and future production and market requirements by improving the present automatic surface inspection system (SIS) capabilities. The project, combined with intensive pilot tests, intends to show the feasibility of 100% automatic on-line and real-time inspection of hot rolled products' surface without human intervention. The project will investigate existing solutions based on modern matrix camera and software technology with respect to the optimal used of collected data for quality improvement of hot rolled strip by controlling the pickling line. Two pilots for 2nd generation hot mill inspection systems for stainless steel and heavy plate will also be implemented. The project intends to use a 100% software solution solely based on the use of off-the-shelf-components.

**State of progress:** Research completed; publication EUR N° 21244 EN

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7215-PP/038	T4.5/99	1.054.800	421.920	42 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title:** Pilot plant for contactless internal and surface on-line detection of stainless steel strips

**OBJECTIVES AND CONTENTS**

Reliable and non-destructive testing for the detection of possible internal and surface flaws prior to further processing is crucial to ensure the quality of strip products. However, until now, there is no testing technique available for the in-line detection of internal flaws. In the course of previous research projects, a new technique was developed for internal and surface defects in strips by means of electromagnetic ultrasonic transducers using guided waves. Starting with the existing laboratory tests, a pilot system for strips with a thickness between 2 mm and 3 mm, suitable for industrial use, is to be constructed. This pilot plant will subsequently be tested under in-process conditions in order to demonstrate the performance capability of the technique in industrial practice.

**State of progress:** Research completed; publication EUR N° 21425 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/039	T4.6/99	1.372.500	686.250	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** On-line diagnosis system to detect the influence of the rolls stack over the strip in a hot strip mill

**OBJECTIVES AND CONTENTS**

The aim of this research proposal is to diagnose on-line the possible causes of failures of thickness quality in the products manufactured in hot strip mills. This proposal is oriented towards the installation, completion and improvement of a laboratory prototype developed under the Esprit 8169 project and validated by simulation techniques. The research work will be carried out in several complementary ways: assessment of the laboratory prototype after its integration in the real mill; improvement of the mathematical models and the pattern recognition techniques used in the system, development of a strategy to exploit the information generated by the system for the current automation system of the mill; evaluation of aspects not yet considered.

**State of progress:** Research completed; publication EUR N° 20896 EN

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**Technical Group T4 : "On-line Control"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/041	T4.8/99	509.500	254.750	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Hot strip mill: camber measurement

**OBJECTIVES AND CONTENTS**

Camber is a geometrical defect that causes difficulties in guiding the product and can cause cracks in the tail ends of coils in finishers. Several causes can be the origin of this defect. Camber measurement in rolling mills does not exist, presently. Deviation measurement cannot give sufficient data because it does not take into account the possible uncontrolled movements of the product. This project intends to develop continuous camber measurements at the exit of the rougher, with a resolution of <2.5 mm/m, using several successive deviation measurement devices.

**State of progress:** Research completed; publication EUR N° 20644 EN

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7210-PR/171	T4/E1.1/99	1.372.500	823.500	36 (Mths)		1/07/1999	30/06/2002	30/06/2002

**Title:** Implementation of an assessment and analysing system for the utilisation of a factory wide product quality database

**OBJECTIVES AND CONTENTS**

This project intends to implement a system for the detection of relationships between process data and the quality of the final product. A database, based on existing data acquisition systems, will be generated. This will include quality and process data of all production facilities of a whole steel production line on a "per-metre" base. "Toolboxes" consisting of all available modern technologies will be realised for the purpose of data evaluation. By means of those centralised data and the implemented tools, dependencies between process/plant parameters and product quality shall be detected and single and whole process chains will be optimised.

**State of progress:** Research completed; publication EUR N° 20927 EN

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7210-PR/172	T4/E1.2/99	522.000	313.200	48 (Mths)		1/07/1999	30/06/2002	30/06/2003

**Title:** Surface inspection of hot rolled rails

**OBJECTIVES AND CONTENTS**

The aim of the project is to develop test and measure, on-line, the performance of a system designed for on-line hot rails surface inspection. The design of the system will be based on advanced computer-assisted vision-techniques. The system will be built around high-speed CCD cameras and, specifically designed, lighting and image processing. The following performances of the system will be evaluated: image quality of the travelling rail obtained through the system, visibility of defects in the image and their automatic detection and classification. Generally, two types of rolling mills can be found in rail rolling mills: the conventional and the universal. Both types of mill will be considered, hence, specific defects or rolling conditions originated from either one or the other mill will be taken into examined.

**State of progress:** Research completed; publication EUR N° 21145 EN

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7215-PP/054	T4.1/00	528.500	211.400	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Stamping reading by laser technology

**OBJECTIVES AND CONTENTS**

The punching of red-hot rails does not produce perfect markings. The numbers and figures punched into the rail web are not complete and the depth of punching is not constant along the contour of the punched number or letter. Their readability is therefore only possible for experienced operators. An automation of the reading if the markings would lead to an important improvement of the reliability in rail tracking and strongly reduce the stress of the workers of the inspection. Therefore a rapid and robust method for the automatic reading of markings on rails based on laser geometry measurement and neuronal algorithms shall be developed.

**State of progress:** Unknown type of status (NA)

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Technical Group T4 has 20 Projects and 60 Partners

Total Projects: 408 - Total Partners: 1509

**Technical Group TGS1 : "Ore agglomeration and Ironmaking"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/126	B.5/99	1.504.500	902.700	42 (Mths)		1/07/1999	31/12/2002	31/12/2002

**Title:** Continuous raceway monitoring by advanced methods

**OBJECTIVES AND CONTENTS**

The economic production of hot metal with consistent quality requires a stable and smooth operation of the blast furnace. The continuous observation of the raceway can make a considerable contribution to the monitoring and prediction of the state of progress. The aim of the project is to investigate and develop new raceway monitoring systems that will enable continuous control on a significant number of tuyeres. Emphasis will be laid on the use of visual observations, image analysis, raceway temperature monitoring and various spectrographic analysis systems. Using furnace operating data and invasive techniques like core drilling will allow correlating raceway observations with furnace behaviour. The expected improved process prediction will assist the BF-operators in identifying the major factors controlling the uniformity of furnace operation and provide the basis for advanced operational control systems.

**State of progress:** Research completed; publication EUR N° 21337 EN

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**Technical Group TGS1 : "Ore agglomeration and Ironmaking"**

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7210-PR/127	B.6/99	1.336.000	801.600	42 (Mths)		1/07/1999	31/12/2002	31/12/2002

**Title:** Influence of sinter mix materials on the environmental impact of high productivity iron ore sintering

**OBJECTIVES AND CONTENTS**

Sinter plants have an important role to play in the conservation of raw materials through the use of fine irons and the recycling of ferruginous by-products from iron- and steelmaking processes. The research intends to: determine the optimum materials composition and process conditions to minimise the formation of trace organic pollutants (polycyclic aromatic hydrocarbons and polychlorinated dibenzo-p-dioxins and dibenzofurans) without sacrificing productivity or product quality; to develop methods for treating revert materials so that they can be recycled in the sintering process with minimal environmental impact; to investigate the use of selective catalytic reduction of nitrogen oxides with ammonia. The results of this project are expected to favourably influence the environmental impact of sinter plant effluents.

**State of progress:** Research completed; publication EUR N° 21429 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/194	B.1/00	1.348.374	809.025	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Optimisation of sinter plant operating conditions and BF burden material resources using advanced multivariate statistics

**OBJECTIVES AND CONTENTS**

The project aims at developing an overall iron making production strategy that will minimise the cost of sinter material blends and coking coal blends whilst maintaining production and quality targets. The effects of sinter and coke quality on abnormal BF operation will be established and used to define sinter productivity and quality requirements, together with coke quality requirements. Classification methods will be used to classify sintering ores according to mineralogy and chemistry to improve confidence in blend selection and for use in generic models. Fuzzy linear programming will allow the cost minimisation of blends whilst maintaining the sinter productivity and quality demanded by the BF.

**State of progress:** Research in progress

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7210-PR/196	B.3/00	1.192.975	715.785	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Productivity & quality of pulverized coal for increasing blast furnace injections

**OBJECTIVES AND CONTENTS**

In recent years, there has been a significant increase in the use of coal in blast furnace injection systems. Due to these successful high levels of injection, the grinding plants generally experience an increased demand for pulverised coal. The main aim of the project is to determine the effects of specific coal properties and of the operating conditions of coal milling systems on the plant throughput, in order to improve their performance and their product consistency. The project will also consider the pulverised coal quality such as the flowability and the combustion. Standards will be established to select the most suitable raw coals and operating parameters.

**State of progress:** Research completed; publication EUR N° 21728 EN

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7210-PR/197	B.4/00	1.019.575	611.745	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title: Optimisation of blast furnace raceway at high injection rates: formation & stability of the raceway, effect on blast furnace operation**

**OBJECTIVES AND CONTENTS**

The project will focus on the raceway behaviour and its influence on blast furnace process. The objective is to clarify raceway behaviour at high coal injection rate and to determine its influence on the whole blast furnace operation. The research work will be carried out at the following scales: industrial testing, physical model and numerical models. The obtained knowledge will highlight ways to enlarge and improve the stability of the raceway. The results will contribute to optimise the blast furnace performance at high PCI and high productivity level.

**State of progress:** Research completed; publication EUR N° 21691 EN

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7210-PR/198	B.5/00	883.500	530.100	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title: Pre-processing of metallurgical wastes by direct reduction for recovery of iron, zinc and lead**

**OBJECTIVES AND CONTENTS**

The project aims at developing a recycling route for the various metallurgical wastes that would require no or limited pre-treatment steps of waste materials before processing. The production of a pre-reduced and agglomerated material strong enough to be readily charged to existing melting units such as BF, cupola furnace, EAF or SAF for the recovery of its iron content and recovering high time and lead metals as a separate saleable by-product are further aims. Pre-processing of wastes using the COMET direct reduction process will allow fulfilling all the objectives of the project. The results of this project will minimise the cost of wastes treatment and recycling and also will reduce the amount of waste materials to be dumped.

**State of progress:** Research completed; publication EUR N°

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7210-PR/199	B.6/00	1.485.500	891.300	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Investigation of accretion formation in blast furnace shaft

**OBJECTIVES AND CONTENTS**

Accretions on the blast furnace wall have significant influence on the furnace performance and on the service life of the refractory lining and the cooling system. The objective of this project is to analyse the formation mechanisms of accretion layers. Process data and extended measurements from four different blast furnaces shall be acquired. The role of the various parameters governing the accretion formation shall be cleared. This knowledge shall be utilised for the development of advanced models to identify the actual accretion condition and to predict their future behaviour. The project will contribute to a reliable control of accretion layers.

**State of progress:** Research completed; publication EUR N° 21433 EN

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7210-PR/262	B.1/01	911.000	546.600	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Extended blast furnace permeability monitoring

**OBJECTIVES AND CONTENTS**

Blast furnace performance is essentially determined by a proper gas distribution control. In daily practice there are used measuring devices that furnish radial furnace information, like e.g. radar profile measurement and in burden temperature. In the present project a mathematical model will be established to calculate gas distribution all over the lump zone using the just mentioned measurements for model fitting. Moreover extra measurements like He-tracing and multi-point vertical probing (MPVP) will be carried out in order to get information on burden permeability (He-tracing) and on the thermal and chemical profiles in the shaft, and hopefully on cohesive zone characteristics. All the measurements will be used for model fitting. The model will then be used for the prediction of charging programs with reference to a desired gas distribution in the blast furnace.

**State of progress:** Research technically completed; publication in hand

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7210-PR/263	B.2/01	1.194.500	716.700	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Performance enhancement by measures of bulk mechanics and granulometry on sintering of iron ore

**OBJECTIVES AND CONTENTS**

The aim is to improve the sinter plant efficiency by adapting the bulk mechanical and granular properties of the sinter raw mixture at sinter plants with frequently changing composition of the raw mixture. The subject will be the investigation of the pre-treatment of the raw mixture and the segregation of the particles and the agglomerate during the feeding process with respect to the increase of the permeability and also the propagation of the flame front. The propagation of the flame front will be modelled considering the implication of the pre-treatment and of the bulk properties.

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7210-PR/264	B.3/01	1.295.000	777.000	42 (Mths)		1/07/2001	30/06/2004	31/12/2004

**Title:** Improved permeability of sinter mix by combined optimisation of feeder system, permeability bars and charging monitoring

**OBJECTIVES AND CONTENTS**

The main aim of the project is to study and to optimise the sinter strand charging device as well as the feeding practice, in order to improve bed homogeneity and permeability. The first new aspect of this project is to explain the complex phenomena occurring during the strand feeding operation and to propose simple and cheap ways to optimise "classical" feeding device such as permeability bars. The second innovative aspect concern the development of an on-line measurement of crude bed permeability, allowing early feed back adjustment of operating parameters. The project leads to an improvement of both bed permeability and homogeneity. Thus, depending of the industrial context of each company, we can expect to increase productivity of sinter plant (5 to 10%), or to decrease sinter cost through a lower burnt lime ratio (5 to 10%) or a cheaper iron ores mixture.

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7210-PR/265	B.4/01	2.258.900	1.355.340	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Investigation of 3d charging dissymmetries and influence on the blast furnace condition

**OBJECTIVES AND CONTENTS**

A proper gas distribution control in the blast furnace is of essential importance for an optimised working. Among other parameters, the material distribution at the blast furnace top affects seriously the gas distribution. So far only 2d measurements were performed and corresponding models of layer build up constructed. In this project 3d measurement of the material surface at different blast furnaces are carried out. Mathematical modelling will then be included. Moreover more sophisticated statistics (e.g. neural networks) will be included to interpret burden dissymmetric distributions against blast furnace condition.

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7215-PP/059	T1.1/01	3.066.172	1.533.086	42 (Mths)		1/07/2001	31/12/2003	31/12/2004

**Title:** The injection of ultrahigh rates of reducing gases into a modern blast furnace

**OBJECTIVES AND CONTENTS**

In the pilot/demonstration project the technology of the injection of reducing gas into the blast furnace is developed and injection rates are maximised. The goal is to achieve a specific injection rate of 330 Nm<sup>3</sup>/tHm reducing gas, which is an increase of 20% when compared to the injection rate of 260 Nm<sup>3</sup>/tHm for natural gas as state-of-the-art. The main emphasis in this project lies on the use of the by-product gases from the BOF process and coke production. They shall substitute alternative reducing agents, which are purchased from outside sources. The work program in this multi-partner/multi-national project focuses on the development, design and installation of a pilot plant for injecting 25,000 Nm<sup>3</sup>/h BOF gas and coke oven gas into the blast furnace 5 at VASL. The influence of ultrahigh injection rate of reducing gas on the output and consumption figures of the blast furnace will be investigated.

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**Technical Group TGS1 : "Ore agglomeration and Ironmaking"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/060	T1.2/01	5.044.700	2.522.350	42 (Mths)		1/07/2001	30/06/2004	31/12/2004

**Title:** Direct ironmaking via rotary hearth furnace and new smelting technology

**OBJECTIVES AND CONTENTS**

In an integrated blast furnace-based iron and steel plant, ironmaking cokemaking and sintering is the process step with the highest impact on environment and natural resources and which has the highest operating and capital costs (over 56% of cost of hot rolled coils via BF-BOF route). The aim of this demonstration project is to develop and test a two-step alternative ironmaking process, called "Redsmelt NST" (New Smelting Technology) based on iron oxide pre-reduction in a Rotary Hearth Furnace (RHF) and smelting of the hot DRI in a coal-and-oxygen-blown converter. The major tasks of the project concern the design, construction and testing of a demonstration plant of a size large enough to provide experimental results directly transferable to the commercial size.

**State of progress:** Research in progress

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Technical Group TGS1 has 13 Projects and 50 Partners

Total Projects: 421 - Total Partners: 1559

**Technical Group TGS2 : "Steelmaking processes"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/129	C1.1/99	981.700	589.020	48 (Mths)		1/07/1999	30/06/2002	30/06/2003

**Title:** Improved control of electric arc furnace operations by process modelling

**OBJECTIVES AND CONTENTS**

The control of the process in a modern electric arc furnace (EAF) is becoming an increasingly complex task because of high productivity requirements, low energy consumption and production of different high quality steel grades. Presently, control of the EAF operations is mostly based on analytical models that only take into account those parameters that have the strongest influence on the process and can be measured with reasonable accuracy. The project, by combining three modelling approaches, aims at the improved knowledge and control of the complete steel making process in an EAF. It will try to combine three different approaches to a process model. An "objective" metallurgical model, using energy mass and chemical balance; a "subjective" model based on a method called "perception and reasoning in industrial and human systems" and a neural network and fuzzy rules based model that uses the information from the subjective model and process data.

**State of progress:** Research completed; publication EUR N° 21411 EN

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**Technical Group TGS2 : "Steelmaking processes"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/137	C2.3/99	632.175	379.305	48 (Mths)		1/07/1999	30/06/2003	30/06/2003

**Title:** Improvement of special steel production by use of "endless lining" system for monolithic ladle linings

**OBJECTIVES AND CONTENTS**

Endless lining of a ladle in steel mills means casting a refractory material to receive a monolithic-working lining instead of a brick lining. At the end of the service life, the residual layer of the working lining remains in the ladle in contrary with other monolithic lining. On this remaining material, the original material will be cast again and the lining will be restored. The objective of the project is to introduce the endless lining system in the production of special steels. For these steel grades, the introduction of this system is much more difficult because of higher treatment temperatures, more intensive ladle metallurgical work, longer treatment times that produce higher stress of the refractory material. The research will contribute to the improvement of the working conditions, to the elimination of emissions during drying and heating up, to energy savings, to the reduction of debris material up to 90%.

**State of progress:** Research completed; publication EUR N° 21634 EN

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**Technical Group TGS2 : "Steelmaking processes"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/200	C1.1/00	1.426.500	855.900	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Effects of operational factors on the formation of toxic organic micropollutants in EAF steelmaking

**OBJECTIVES AND CONTENTS**

The EAF process plays a crucial role in the control of waste materials because of the large tonnages of steel scrap that are recycled by this route. It may be anticipated that European legislation will impose tighter limits on emissions of toxic organic micro-pollutants from steelworks. The research will develop practical knowledge and the technical means on the prevention of formation, collection and thermal destruction of toxic organic compounds in modern EAF steel making plants either with or without scrap preheating plants. The work is essential for the continued future of EAF plants within the requirements of environmental legislation and to capitalise on their benefits for steel recycling.

**State of progress:** Research completed; publication EUR N° 21432 EN

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**Technical Group TGS2 : "Steelmaking processes"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/202	C1.3/00	845.325	507.195	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Evaluation of air tight furnace technology (reduction of air ingress in EAF)

**OBJECTIVES AND CONTENTS**

The project will study specific lancing devices allowing really tight Electric Arc Furnace operation through its door suppression. It will determine the resultant benefits in energetic consumption by measuring the losses reduction through exhaust system an exhaust gas. The concept is based on sealing the slag door and reducing all other air entries, while testing alternate solutions for carbon and oxygen input. Different operating conditions will be tested and selected in an instrumented pilot-EAF thereby reducing the need for extensive full-scale experimentation.

**State of progress:** Research completed; publication EUR N° EUR 21692

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/203	C1.4/00	1.565.500	939.300	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Efficient utilisation of waste products from secondary steelmaking as flux materials for electric arc furnace

**OBJECTIVES AND CONTENTS**

The objective of the project is to increase the use of waste products (slag and spent refractory) as flux material in the electric arc furnace process. Different ways of recycling will be investigated with the aim to improve the internal material recycling both for the carbon and stainless steel production. A decrease in the amount of wastes obtained from steelmaking and a general improvement of the electric arc furnace metallurgy is expected. By reducing the cost for raw materials and decreasing the amount of wastes to be stored at dumped sites, economical and environmental benefits are expected.

**State of progress:** Research completed; publication EUR N° 21343 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/204	C1.5/00	936.069	561.641	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Innovative continuous on-line determination of steel melt temperature by direct optical measurement in the melt

**OBJECTIVES AND CONTENTS**

The control of the liquid steel temperature is very important with regard to a better product quality and an energetically optimised metallurgical process at various stages of the process line. A new method for a continuous temperature measurement of liquid steel by pyrometer with optical fibre measurement technology will be developed. The main idea of the new technique is to feed a consumable optical fibre into the liquid steel. The new system will be tested and optimised on several steel plants including EAF furnaces, BOF converters, ladles and tundishes. It will allow a continuous control of the melt temperature, which will be less energy-intensive and will provide better quality than present practice.

**State of progress:** Research completed; publication EUR N° 21428 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/205	C1.6/00	1.026.454	615.872	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Characterisation of the scrap density

**OBJECTIVES AND CONTENTS**

The objective of the project is to develop a technique for assessing the scrap density charged in the EAF. Parameters will be put in relationship with the scrap behaviour in the furnace in order to optimise the charging practice. The work will be performed at the scrap yard directly at the basket-charging stand in the steelshop. To estimate the scrap density it is necessary to measure the evolution of the scrap volume inside the basket during the charging operation. For this purpose a level measurement technique based on an optical sensor will be developed. A digital camera and computer based system will record images of every charged layer of the scrap in order to collect continuous information about scrap composition and size distribution.

**State of progress:** Research completed; publication EUR N° 21628 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/261	C1.7/00	1.318.371	791.023	42 (Mths)		1/12/2000	30/11/2003	31/05/2004

**Title:** Bath stirring and injection of solids in the BOF using coherent jet technology

**OBJECTIVES AND CONTENTS**

The project aims are to investigate the implementation of coherent jet technology from the top lance during BOF steel making and to establish improved bath stirring together with the ability to inject solid materials, especially fluxing agents and/or carbon with improved dissolution characteristics and recovery efficiencies. The operating parameters associated with the implementation of coherent jet technology for improved bath stirring will initially be established from modelling studies thereafter verified and extended during hot metal trials. Once the parameters for coherent jet technology are established, the work will be extended to incorporate top lance injection of solid materials into the steel making process.

**State of progress:** Research technically completed; publication in hand

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**Technical Group TGS2 : "Steelmaking processes"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/206	C2.1/00	1.174.122	704.473	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title: The determination & elimination of the effect of anti-oxidants in magnesia-carbon bricks on steel composition and inclusion formation**

**OBJECTIVES AND CONTENTS**

The aims of the project are twofold. Firstly establishing the extent to which trace elements such as Al, Mg and Ca transfer into liquid steel, either from the magnesia itself or from the anti-oxidants which are added to magnesia-carbon refractories. Secondly specifying and testing refractory compositions consistent with minimising the formation of undesirable inclusions which originate, either directly or indirectly, from the trace elements. Complementary work will provide a means of accurately measuring the concentrations of trace elements in steels. The optimum levels of anti-oxidant additions to restrict the rate of transfer of the trace elements will be specified, different refractories will be developed and tested. Thermodynamic and kinetic models describing the transfer processes of the trace elements will also be developed.

**State of progress:** Research completed; publication EUR N°

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7210-PR/207	C2.2/00	1.229.643	737.786	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Operation and control of vacuum circulation (RH) process with lance oxygen input

**OBJECTIVES AND CONTENTS**

Currently many Vacuum Circulation plants for the production of ultra-low carbon steel grades are equipped with an oxygen top lance. The additional oxygen supply is used, to reduce the decarburisation time, to reduce the energy losses in the vessel and to improve the long-term plant operation by decreased skull formation. The project objective is to improve the oxygen lance operation with respect to productivity, production costs, energy consumption and steel cleanliness. For on-line process control of the main lance operation parameters, model-based setpoint calculations will be developed. Therefore existing process models for decarburisation and steel temperature will be extended to the metallurgical effects of lance oxygen input.

**State of progress:** Research completed; publication EUR N° 21435 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/208	C2.3/00	889.500	533.700	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Advanced strategies for alloying processes in steelmaking ladles

**OBJECTIVES AND CONTENTS**

Ladle design and operating methods could still be further optimised. Different rate determining steps, e.g. mixing by turbulent flow or melting/dissolution of charged or injected alloying materials, contribute to the success of ladle metallurgy treatment. In the course of the project different alloying strategies will be elaborated. Operational data will prove possible process improvements and utilisation of the models in operational praxis. The project will contribute to yield, quality and cost improvements as well as to environmental aspects of steel making.

**State of progress:** Research completed; publication EUR N° 21344 EN

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7215-PP/044	T1.1/00	1.341.598	670.799	48 (Mths)		1/07/2000	31/12/2003	30/06/2004

**Title:** Chrome immobilisation in EAF slags from high alloy steelmaking - Development of a slag treatment process

**OBJECTIVES AND CONTENTS**

The chrome content in the slags from stainless steel making is one of the limiting factors for their further utilisation. The lack for further utilisation is their environmental behaviour, due to the leaching of chrome. In the previous project (7210-CB/124) the fundamentals of the chrome reduction in EAF slags and the stable binding of chrome into slag's spinel phases has been investigated. The aim of this research programme is to verify these results by industrial scale tests in steel works, by varying the slag composition, increasing spinel forming slag compounds, by developing effective reduction techniques, increasing the ability for slag foaming and binding the remaining chrome into stable spinel phases in the slag by treatment of the slag outside the melting furnace.

**State of progress:** Research technically completed; publication in hand

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**Technical Group TGS2 : "Steelmaking processes"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/266	C1.1/01	1.023.000	613.800	24 (Mths)		1/07/2001	30/06/2003	30/06/2003

**Title:** Radioactive sources in the steelmaking process - Simulation of the distribution of radioactivity having accidentally entered into a steelmaking shop

**OBJECTIVES AND CONTENTS**

The ambition of this project is the characterisation of the distribution of relevant radioactive isotopes between metallurgical phases for scrap-consuming metallurgical processes (EAF, BOF). Therefore, thermodynamic equilibrium calculations together with experimental investigations are planned to determine the expected distributions of radioactive isotopes between metal melt, slag, gas phase, dust, and the refractory materials for the case of accidentally feeding them to the furnaces with the scrap. The results of these investigations, summarised in a "guidebook", are intended to inform the steelmaker about the individual behaviour of relevant radioactive isotopes when they happen to get into the steelworks with the scrap. Recommendations will also be given at which points in the steel shop regular monitoring should be carried out.

**State of progress:** Research completed; publication EUR N° 21342 EN

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7210-PR/268	C1.3/01	1.031.000	618.600	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** New cooling panels for reduction of heat losses in EAF steelmaking

**OBJECTIVES AND CONTENTS**

Water-cooled panels currently used in the EAF (Electric Arc Furnace) for upper side wall and roof linings show several drawbacks. The objective of the present project is to develop new water-cooled panels for both the upper side wall and the roof that allow reducing heat losses (and thus the overall energy consumption in EAF steelmaking) and increasing panels service life. The basic idea is to hang relatively small refractory parts on the water-cooled panels. These refractory parts will first act as slag holders with improved retaining capacity. Moreover, the refractory parts will stand heat and protect steel panels in case of slag removal. Such refractory parts should thus greatly lower thermal losses, thermal stress in the panels and maintenance work.

**State of progress:** Research in progress

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7210-PR/269	C2.1/01	1.196.500	717.900	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Improvement of process control and refractory performance of the AOD converter

**OBJECTIVES AND CONTENTS**

This project has the aims to improve and to extend the process observation and control system from a nearly terminated ECSC project on AOD converter control, as well as to extend and to apply refractory wear modelling from an earlier ECSC project on refractory performance in the AOD converter. The optimal time for switching the inert gas from nitrogen to more expensive argon shall be determined by on-line simulation of nitrogen pick-up and prediction of subsequent denitrogenation, in order to decrease the argon consumption and to adjust the final steel nitrogen content more accurately. The knowledge of the development of different kinds of refractory wear in the converter will allow to build a model which enables to find the best set of refractory materials and to define converter operating practices with reduced refractory consumption.

**State of progress:** Research in progress

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7210-PR/270	C2.2/01	1.192.597	715.558	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Improvement of inclusion flotation during RH treatment

**OBJECTIVES AND CONTENTS**

The general objective of this multi-national multi-partner research project is to develop a validated model of prediction of the evolution of the inclusion population during RH treatment, to evaluate the effect of ladle slag composition on the capture of inclusions and finally to propose an optimised flotation process at the RH unit. A chemical engineering model will be developed and associated to fluid dynamic computations to predict the evolution of inclusion size distribution during RH treatment of various steel grades (ULC and special alloyed Al killed steels). It will take into account the agglomeration of solid inclusions, the reoxidation phenomena by slag or air intakes and the ability of slag to entrap inclusions as well as thermal effects. Final validation of the models will be done from experimental characteristics of liquid steel cleanliness obtained on industrial RH.

**State of progress:** Research in progress

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7210-PR/271	C2.3/01	1.464.400	878.640	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** In situ, quick sensing system for measurements of process-critical components in steelmaking slags (INQUISSS)

**OBJECTIVES AND CONTENTS**

The aim of this project is the adaptation and optimisation of laser-based sensing (LIBS) in plant processing conditions, to develop a quick/on-line, in-situ, integrated inference system for the measurement of process-critical components of molten slags. Different metallurgical slags in steelmaking (EAF, Converter and Ladle) will be used and the determination of the main systems oxides concentration as well as other components will be targeted through detection of their elemental concentration. The operative parameters of slag processing, needed or being useful for taking correction measures and for intervention on-line, as oxidation potential, basicity, recycling capacity will be determined through integrating sensing and advanced process modelling, to ensure representativity of measurements and transferability of results.

**State of progress:** Research in progress

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7210-PR/275	C3.4/01	1.535.821	921.493	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Definition of ladle change strategy to avoid slag entrapment and to control inclusion population

**OBJECTIVES AND CONTENTS**

The general objectives of this project, focused on ladle change period, is to quantify the inclusion size distribution originating from ladle and tundish slags, to define a ladle change strategy in order to minimise ladle and tundish slag and finally to develop an on-line quality rating model for internal cleanness. The several axes of work and tools proposed by the partners, the combination of physical modelling, numerical modelling and in-situ trials are key-points for the success of present project. It is foreseen that the combination of the different approaches will lead to the definition of optimised process.

**State of progress:** Research technically completed; publication in hand

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**Total Projects: 439 - Total Partners: 1636**

**Technical Group TGS3 : "Casting, reheating and direct rolling"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/140	C3.2/99	1.096.300	657.780	48 (Mths)		1/07/1999	31/12/2002	30/06/2003

**Title:** New secondary cooling patterns for peritectic and micro-alloyed steel

**OBJECTIVES AND CONTENTS**

Although a significant amount of work has already been undertaken to understand the initiation and propagation of cracks on the surface of the continuous casting strand and develop casting equipment and practices to reduce the problem, cracks remain a major concern for steel producers, especially for sensitive steel grades like Al grain refined, micro-alloyed and peritectic steels. This research aims to reduce the cracking proneness of sensitive steel grades by applying, during secondary cooling, a thermal treatment (intense cooling and self-tempering) to the strand in order to modify in-line its surface and sub-surface microstructure with the purpose of improving hot ductility and, in so doing, the surface quality. Modification to be brought to the secondary cooling systems will be investigated by means of numerical modelling and laboratory simulations. Plant trials will be performed for assessing the achievable surface quality improvements.

**State of progress:** Research completed; publication EUR N° 21445 EN

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**Technical Group TGS3 : "Casting, reheating and direct rolling"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/145	D1.3/99	625.000	375.000	48 (Mths)		1/07/1999	30/06/2002	31/12/2003

**Title:** Scale control when direct rolling

**OBJECTIVES AND CONTENTS**

The emergence of the direct rolling process has highlighted the enhanced risk of surface defects due to an insufficient descaling of the semis before rolling. The problem is further exacerbated when EAF steels with high residual contents are processed. A different thermal path and a modified chemical composition favour the formation of an adherent scale difficult to remove. The project aims to understand the formation mechanisms of the scale layer formed on products directly rolled either through a thin slab or through a conventional slab casting route; to define the potential ways for avoiding its strong adherence and to make descaling easier. The scale formation and adherence will be studied through laboratory simulation of re-heating and descaling with detailed characterisation of the scales.

**State of progress:** Research completed; publication EUR N° 21417 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/209	C3.1/00	1.802.564	1.081.538	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Improving surface quality of continuously cast semis by an understanding of shell development and growth

**OBJECTIVES AND CONTENTS**

The overall objective of this project is to establish reproducible conditions for defect-free casting of low carbon peritectic, hyper-peritectic and some grades of silicon alloyed steels. This will be achieved through a better understanding of the early solidification and cooling of the shell as well as the influence of chemical and process parameters. The investigation will be supported by the modelling of thermal and mechanical aspects of the early solidification in the mould.

**State of progress:** Research completed; publication EUR N° 21340 EN

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7210-PR/210	C3.2/00	1.462.580	877.548	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Developm. of a model predicting inclusion precipitation in nozzles based on chemical compos. & process parameters such as casting rate, liquid temper., nozzles design and slag comp

**OBJECTIVES AND CONTENTS**

During continuous casting of Al killed steel, nozzle clogging occurs due to aluminous precipitation. This phenomenon is highly detrimental to the casting reliability and the quality of cast products. Calcium treatment has been successfully tested to solve clogging problems by modification of aluminium inclusions into low melting point calcium aluminates. The aim of the project is to develop a mathematical model in order to supply steel makers with a reliable tool for a correct calcium treatment and for improving steel cleanliness. The model will be tested and validated by means of experimental data on industrial scale. The influence of nozzle design and casting parameters on nozzle clogging and steel cleanliness will also be investigated.

**State of progress:** Research completed; publication EUR N° 21442 EN

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7210-PR/211	C3.3/00	1.339.000	803.400	36 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Quality improvement for continuously cast steel products by swirling flow strategies

**OBJECTIVES AND CONTENTS**

The project's aim is to enhance as-cast product quality via design and direct application of innovative feeding systems. Which are used managing and inducing swirling flow in tundish and mould, being either passive (i.e. devices to break vortices) or active system (i.e. nozzles able to cause liquid steel to swirl passing from the tundish to mould). As a result, benefits in term of as-cast internal and surface quality are expected. Numerical and physical simulation approaches will be applied. Plant validation and application will be made on long products and slabs.

**State of progress:** Research completed; publication EUR N° 21447 EN

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7210-PR/212	C3.4/00	1.138.000	682.800	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Investigation on the mechanisms of gas bubbles/inclusions entrapment in the solidified steel shell

**OBJECTIVES AND CONTENTS**

A major problem related to the production of ultra low carbon steel is the formation of blister and sliver defects. These appear in the final product after the cold rolling and annealing operations. These defects originate during the solidification in and below the mould where both non-metallic inclusions and gas bubbles can be entrapped in the solidifying shell. The project aims at identifying and assessing the influence of different casting parameters on the trapping mechanisms of the argon bubbles in the solidifying steel shell. Trials with liquid steel, with a hot hydraulic model and a full characterisation of numerous industrial samples will be made.

**State of progress:** Research completed; publication EUR N° 21422 EN

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7210-PR/213	C3.5/00	1.636.000	981.600	48 (Mths)		1/07/2000	31/12/2003	30/06/2004

**Title:** Precipitation of nitrides and carbides during solidification and cooling

**OBJECTIVES AND CONTENTS**

The project investigates the precipitation of nitrides and carbides at the early stages of solidification cooling. The physical properties and the microstructures of steels are controlled by precipitate particles. Effects of casting and cooling conditions on their formation will be studied through laboratory investigations and on-plant measurements will be carried out. Advanced mathematical models will be developed. A set of relevant steels will be selected covering both conventional casting and new strip casting techniques. Improved insight and modelling capabilities thus recommending strategies for improved product quality are expected results of the

**State of progress:** Research technically completed; publication in hand

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7215-PP/045	T2.1/00	2.031.748	1.015.874	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Visualisation and control of the steel flow pattern in the tundish pouring nozzle (SEN/SES)

**OBJECTIVES AND CONTENTS**

Control of steel delivery to the casting mould is critical to ensure the stability of the meniscus and satisfactory mould flow patterns, which in turn are determinant of steel cleanness and surface quality. The aims of the project are to develop real-time techniques to visualise or determine the steel flow patterns in the tundish pouring nozzle (SEN/SES), and establish the intensity of nozzle clogging. The influence of casting parameters on the steel flow patterns will be established and the effect of the different flow types on the conditions in the casting mould and hence product quality will be investigated.

**State of progress:** Research completed; publication EUR N° 21247 EN

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7215-PP/046	T2.2/00	1.307.000	653.500	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title: Improvement in billet & bloom surface quality through developments in mould level & powder depth measurement & control, including automatic power feed**

**OBJECTIVES AND CONTENTS**

Initial solidification in the casting mould has an enormous impact on surface quality. Uniform heat transfer and good lubrication are of vital importance and these are affected by the efficient delivery of mould powder and the stability of the steel meniscus. The project will aim to demonstrate techniques to improve the delivery and utilisation of powder and to stabilise the mould level. Intelligent automatic powder feed systems will be developed and mould thermal conditions will be modified by adjusting casting parameters. A novel mould level measuring device will be used to demonstrate improved mould level control.

**State of progress:** Research completed; publication EUR N° 21248 EN

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7210-PR/272	C3.1/01	1.273.500	764.100	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Advanced methods for an improved mould heat transfer control

**OBJECTIVES AND CONTENTS**

The mould heat transfer conditions are a decisive key factor for a stable casting process and optimal product quality. Many individual parameters influencing the mould heat transfer have been subject of detailed studies in the past. However, only few attempts have been made to correlate the heat transfer with a combined detailed investigation of the main process parameters like casting powder/lubrication, mould taper/air gap, mould coating, oscillation strategies, friction forces and mould wear. It is therefore the aim of this research to investigate and improve the mould heat transfer conditions for the continuous casting of slabs and long products by optimisation of the above mentioned parameters. As an outcome of this research concrete process engineering measures for an improved mould heat transfer control are expected.

**State of progress:** Research technically completed; publication in hand

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**Technical Group TGS3 : "Casting, reheating and direct rolling"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/273	C3.2/01	1.840.000	1.104.000	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Mould powder consumption, melting & lubrication and its effect on mould heat transfer & subsequent surface quality of continuously cast slab

**OBJECTIVES AND CONTENTS**

The aim of this study is to develop an understanding of the collective effects of mould powder performance and aspects of mould design on heat transfer and slab surface quality. The work programme will be a combination of laboratory, plant and model work studies designed to improve the understanding of these interrelated factors and their influence on the surface quality of the as cast slab semi.

**State of progress:** Research technically completed; publication in hand

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/274	C3.3/01	933.500	560.100	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Mathematical description of flow and heat transfer in continuous casting machines

**OBJECTIVES AND CONTENTS**

Having a stable process is a key figure to control uniform solidification and cleanliness of product in a continuous casting mould. Unfortunately, the flow in a continuous casting (CC) mould can naturally oscillate. Nowadays, there is no validated mathematical model to describe flow oscillation in a CC mould and it is not acceptable to limit the CFD results only to steady state situations when new configurations have to be numerically tested. The aim of this project is to extend the use of recent commercial packages in Fluid Dynamics to unsteady situations, so it will become possible to quantify the influence of some modifications on the process stability. The industrial objective is to limit by about 20% undergraded steel due non-symmetrical and unstable flows in CC moulds.

**State of progress:** Research technically completed; publication in hand

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7210-PR/276	C3.5/01	989.000	593.400	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Improving the properties of near net shape cast strip containing copper and tin from scrap

**OBJECTIVES AND CONTENTS**

The project aims to reduce or eliminate the deleterious effects of copper and tin arising from the use of recycled scrap by making use of the special features of near net shape casting together with direct in-line hot rolling. These tramp elements are known to influence the steel through processes controlled by diffusion and oxidation. By applying new knowledge and technical advances - high cooling rates and keeping a protective atmosphere - these problems can be overcome and, furthermore, the copper content can be utilised as an alloying element to raise the strength. Twin roll cast strip (1-5 mm thick) and DSC strip (8-15 mm thick) will be produced, their properties will be studied and compared with those from conventional production.

**State of progress:** Research technically completed; publication in hand

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7210-PR/277	C3.6/01	1.275.500	765.300	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** In-time rating of continuously cast semis by means of hybrid quality models

**OBJECTIVES AND CONTENTS**

The in-time prediction of the product quality becomes more and more important in continuous casting due to the high demands on product quality and the reinforced trend to hot-charging. The aims of the project are to improve the accuracy of the quality prediction by combining different types of quality models and to make this "hybrid" solution available for the daily operation at the plants. Therefore quality models like analytical, statistical and knowledge based have to be integrated in one overall system. Such "hybrid models" will be able to predict the slab or billet quality during its production or immediately afterwards better than existing systems. The on-line visualisation of the predicted quality to the operators and a tool for the data-based analysis of the reasons for quality deviations will also be features of the overall system.

**State of progress:** Research technically completed; publication in hand

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7210-PR/278	D1.1/01	964.500	578.700	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Rules base systems for improved monitoring and guidance of reheating furnaces

**OBJECTIVES AND CONTENTS**

The objective of the project is to develop and implement intelligent monitoring and guidance of re-heating furnaces for optimised operation. The systems will be able to prevent and diagnose malfunctions in the furnace, and monitor the re-heating process providing the operator with guidance when deviating from correct behaviour. The innovative idea of the project is to extend the conventional process control techniques by combining the results of on-line physical models calculations with expert system rules and statistical methods.

**State of progress:** Research technically completed; publication in hand

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**Technical Group TGS3 : "Casting, reheating and direct rolling"**

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7215-PP/061	T2.1/01	2.055.500	1.027.750	48 (Mths)		1/07/2001	31/12/2004	30/06/2005

**Title:** Development of high productivity casting of conventional and thin slabs

**OBJECTIVES AND CONTENTS**

The final goal of the present Pilot/Demonstration project is to allow conventional continuous slab casters to reach the highest possible casting speed, compatible with their current metallurgical lengths, and to demonstrate the possibility for thin slab casters to reach casting speeds higher than 10m/mn. The study will focus on the medium carbon steels (0,1% equivalent carbon) and austenitic stainless steels. For thin-slab casters it is of the first importance to prove that it is possible to directly connect one strand caster with the rolling mill. For this, it is necessary to cast higher than 10m/min for all steel grades. This project proposes some very new approaches for the feeding of metal and the cooling of the thin slab.

**State of progress:** Research in progress

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**Technical Group TGS3 has 16 Projects and 63 Partners**

**Total Projects: 455 - Total Partners: 1699**

**Technical Group TGS4 : "Hot and cold rolling processes"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/155	D2.10/99	1.235.500	741.300	54 (Mths)		1/07/1999	31/12/2002	30/06/2003

**Title: Improvement of rolled strip surface & geometry by advanced automatic diagnosis of surface defects & optimisation of friction in the roll gap**

**OBJECTIVES AND CONTENTS**

The objectives of the project are to determine ways of improving rolled strip surface quality and geometry. Mathematical modelling will be applied to track the evolution of surface defects and evaluate alternative rolling sequences. An automatic, on-line system for surface defect diagnosis will be developed, installed and assessed in a hot strip mill. Friction, descaling practices, secondary scale formation, roll gap lubrication and strip surface cooling will be investigated by means of laboratory experiments and mill trials in order to determine the optimum conditions. The influence of friction on rolling load and, hence, on strip geometry will be investigated

**State of progress:** Research completed; publication EUR N° 21333 EN

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**Technical Group TGS4 : "Hot and cold rolling processes"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/156	D2.11/99	886.500	531.900	48 (Mths)		1/07/1999	31/12/2002	30/06/2003

**Title:** The design & control of strip cooling systems by use of advanced modelling techniques allied to practical measurements

**OBJECTIVES AND CONTENTS**

Mechanical and physical properties of final cold coil directly from hot flat mills vary throughout the length and the width of the strip. This variation is dependent upon material and strip geometry. It is generally considered that this variation could be minimised by controlling strip temperature variations along the run-out-table (ROT) before entering the coilers. The aim of the project is to investigate how to control these variations of temperature. Hot and cold model work will be used to provide data for advanced modelling packages which will be employed to design and test a flexible cooling and control system which takes into account such aspects as strip quality, geometry, speed, inlet conditions and properties. Improved product quality, yield and better water use are the expected benefits.

**State of progress:** Research completed; publication EUR N° 21246 EN

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7215-PP/031	T2/T3.2/99	2.116.500	1.058.250	48 (Mths)		1/07/1999	30/06/2002	30/06/2003

**Title:** Hot rolling lubrication for improved product properties

**OBJECTIVES AND CONTENTS**

The "Ferritic Rolling" practice is very well suited for processing different products. The production of low cost CQ grades from low C steel is already under control. However, it appears clearly, from laboratory scale simulation, that a very efficient lubrication in the HSM is needed in order to improve quality, to extend production to DQ or DDQ and to develop new grades. The aim of the project is to develop and test a hot rolling lubrication strategy in order to improve the mechanical properties of the steel products after hot rolling at low temperature in the "ferrite" region. Fundamental and complementary aspects of product and process developments will be covered in this project. As far as the process is concerned, the plan includes the development of the lubrication strategy in order to decrease the friction coefficient to very low values. Concerning the products, the effect of the new lubrication strategy will be assessed on products (ULC-IF), not rolled in the ferrite region.

**State of progress:** Research completed; publication EUR N° 21441 EN

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7215-PP/040	T4.7/99	1.304.500	652.250	54 (Mths)		1/07/1999	30/06/2002	31/12/2003

**Title:** Hot rolled plate surface inspection

**OBJECTIVES AND CONTENTS**

Automatic surface inspection systems have been and are the subject of important developments, due to the ever-increasing requirements for higher production quality and better process controls. Only recently, these systems have reached a level of performance high enough to allow their use routinely, with some success, on different manufacturing lines ranging from pickling lines, through hot-dip galvanising lines to tin plate lines. The project intends to develop and to test, on-line, a surface inspection system for hot-rolled plates after the levelling process. The bottom side should be inspected over a limited width of about 1 meter. The goal is to detect, automatically, periodic defects in order to react more quickly on the process by, for example, grinding levelling rolls or, by changing the work rolls. In addition to this, the project will try to detect typical random defects like shells and longitudinal or transversal cracks

**State of progress:** Research completed; publication EUR N° 21424 EN

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7210-PR/214	D1.1/00	1.270.253	762.151	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Tailoring scale characteristics during steel processing

**OBJECTIVES AND CONTENTS**

The aim of the project is to improve the surface quality of carbon and low alloy steel products to meet increasingly stringent customer requirements by tailoring the scale characteristics to the ideal requirements of each stage of the steel processing route and controlling the nature of the scale on the final product. Laboratory, pilot plant and works trials will be performed using material subjected to various processes on selected types of steel with different initial surface conditions. Scale adhesion will be assessed by hydraulic descaling and hot bend and cold bend tests, aided by acoustic emission, and it will be related to visual, instrumental and metallographic observations. The project will also identify potential improvements to the hydraulic descaling process when removing primary scale formed during reheating and the

**State of progress:** Research completed; publication EUR N° 21427 EN

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7210-PR/215	D1.2/00	1.070.356	642.213	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** New thermo-mechanically processed wire rods for drawing and cold heading applications (Thermorod)

**OBJECTIVES AND CONTENTS**

Recent advances in wire rod manufacture technologies allow the introduction of a thermo-mechanical control process (TMCP) and precision rolling, expanding the range of steel wire rods, suitable for simplified production routes or direct processing. The aims of the project are to assess the TMCP potential for achieving microstructures suitable for simplification/elimination of softening annealing of wire rods made of low - C steel for drawing and medium - C low alloy steel for cold heading. To design and develop steel chemistries, mill lay-out and hot rolling schedules for TMCP of wire rods, in order to improve metallurgical properties, without detrimental effects on dimensional accuracy is a further aim.

**State of progress:** Research completed; publication EUR N° 21633 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/216	D2.1/00	1.515.000	909.000	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Investigation into processing changes at the hot mill coiler entry & when coiling to improve visual & latent shape in the final cold coil

**OBJECTIVES AND CONTENTS**

Shape and residual stresses of the cold coil directly from the hot mill is usually not satisfactory for shape critical direct sales, although the shape has been measured flat at the exit of the finishing mill. The aim of this project is to develop a strategy for cooling, strip tension and final finishing in order to improve the strip condition entering the coilers. Feasibility studies will be carried out on introducing a further process at the coiler entry to produce the required standards of strip condition entering the coilers. By linking shape measurements at various points through the process, recommendations for shape targets at each process will be recommended in order to produce a more consistent cold coil product.

**State of progress:** Research technically completed; publication in hand

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/217	D2.2/00	1.243.375	746.025	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Assessment and synthesis of the most relevant tribological tests for the characterization of cold rolling lubricants

**OBJECTIVES AND CONTENTS**

The heart of the cold rolling process is a lubricated tribo-system and lubrication is the key to performance. The cold rolling industry has to progress continuously in terms of productivity, product quality, reduction of production cost, and robustness of the process. Therefore the main objective of the project is to set up the most relevant tribological approach for the characterisation of cold rolling lubricants combining several different tribometrical tests, using experimental and theoretical knowledge in rolling and lubrication.

**State of progress:** Research technically completed; publication in hand

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7210-PR/219	D2.4/00	1.424.900	854.940	48 (Mths)		1/07/2000	30/06/2003	30/06/2004

**Title:** Sticking & scratching problems after batch annealing, including coil compression stresses effects

**OBJECTIVES AND CONTENTS**

In batch annealing two of its major problems are sticking and scratches both defects of surface aspect unacceptable for the automotive industry. The objectives of the project will be to enlarge the scope of previous studies on sticking, both with other parameters and by changing the size of samples. The final objective is to determine a "technological window" from all the results obtained to optimise the strip coiling process after cold rolling thus minimising or preventing stick-slip phenomena.

**State of progress:** Research technically completed; publication in hand

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7210-PR/220	D2.5/00	1.210.500	726.300	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Characterisation and control of roughness transfer in temper rolling of HSS grades

**OBJECTIVES AND CONTENTS**

The surface texture of coated and uncoated steel sheet is in general of decisive importance for further processing. Until now, no acceptable on-line way of estimating the roughness transfer and its time evolution, in both cases of deterministic and stochastic textures, has been used with sufficient success. The aim of the project is to develop such means for characterising the roll/strip textures on-line, to build models for describing the roughness transfer, to correlate the observed evolutions with off-line predictive models, and to gain knowledge concerning the behaviour of these new steel grades during temper milling.

**State of progress:** Research completed; publication EUR N° 21416 EN

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7210-PR/221	D2.6/00	1.142.500	685.500	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Diagnosis assistance for process performance, dynamic plant condition and periodic quality defects in the cold rolling area

**OBJECTIVES AND CONTENTS**

The aim of the project is to better meet strip quality demands with regards to periodic defects through intelligent and automated monitoring and diagnosis support. To this algorithms for automatic detection of quality defects, analysis of process and plant degradation, methods and rules to diagnose sources and causes of defects, taking into consideration new sensors inclusive soft-sensors, will be developed, tested and implemented. Due to similar problems, plants, and processes the project findings are directly transferable to other rolling processes.

**State of progress:** Research completed; publication EUR N° 21413 EN

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7215-PP/053	T2/T3.6/00	1.800.884	900.442	54 (Mths)		1/07/2000	30/06/2003	31/12/2004

**Title:** Effect of hot and cold rolling technology on the textures & the plastic anisotropy of flat products

**OBJECTIVES AND CONTENTS**

The aim of the project is to realise a continuous hot strip rolling mill for experimnts at practice-oriented rolling speeds of approx. 25 m/s for the European steel industry. This can be achieved by upgrading a continuous rolling mill, which is already installed for the testing of wire and bars at the Institute for Metal Forming of Freiberg University of Mining and Technology, to handle strip widths of 80mm. It will allow to examine in the laboratory the microstructural evolution and, in particular, the development of the texture and properties of deep-drawing steels as a function of the rolling speed under field-proven continuous rolling conditions. The production routes of hot-rolling both in the austenite and a ferrite range will be investigated.

**State of progress:** Research in progress

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7215-PP/050	T3.3/00	1.569.800	627.920	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** High performance cooling system for the production of HSS

**OBJECTIVES AND CONTENTS**

This project is aimed at developing an adequate technical solution to the problem of accelerated cooling in continuous annealing lines. The solution considered is to use non-oxidising pulverised water as quenching medium. Novelities (with regards to existing misting jets) which require further development are: excellent flatness of the product, reduction of the propelling gas quantity, non oxidising effect and important side effects (drying, sealing). All the process and product properties will be analysed.

**State of progress:** Research completed; publication EUR N°

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7210-PR/279	D1.2/01	1.295.100	777.060	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Optimisation of long product rolling through improved understanding of roll wear and lubrication

**OBJECTIVES AND CONTENTS**

The objective of the project is to obtain plant based measurements of work wear on long product mills to be able to realistically optimise the performance of any long product mill. Laboratory tests, including wear and roll gap lubricant tests will be carried out in order to establish the precise conditions occurring on the mills, and to identify the important parameters affecting roll wear. The roll wear information will be used to set up a knowledge database, to be used for optimisation of long product rolling operations.

**State of progress:** Research technically completed; publication in hand

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7210-PR/280	D1.3/01	1.095.255	657.153	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Adaptive mill pacing

**OBJECTIVES AND CONTENTS**

The objective of the project is to develop models for optimal pacing of long product mills to minimise energy consumption while maintaining consistently high quality at reduced costs. The project will study how such a system can be made adaptive to respond to events such as size and material changes, maintenance, breakdowns and cobble delays. The project will identify compare and contrast drivers and constraints in at least three different plants in Europe. Solutions will be shared amongst the partners providing different through process solutions using common methods.

**State of progress:** Research technically completed; publication in hand

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/284	D2.4/01	938.253	562.952	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Optimising the rolling process (pass scheduling) to avoid roll spalling and surface defects

**OBJECTIVES AND CONTENTS**

The objective of the project is to analyse the roll spalling failure theoretically and practically in order to find models to predict roll spalling and to deal with it correctly. Increased knowledge of the mechanisms causing problems is needed to optimise the process. This knowledge will be obtained and introduced into the pass schedule calculation by means of chemical and microscopic analysis and trial plants.

**State of progress:** Research technically completed; publication in hand

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/286	D2.6/01	1.589.500	953.700	42 (Mths)		1/07/2001	30/06/2004	31/12/2004

**Title:** Yield, quality & throughput increase by optimising the transfer bar & finished strip geometry in hot strip mills

**OBJECTIVES AND CONTENTS**

The objective of the project is the development and implementation of a pre-determining algorithm for the transfer bar width of different steel groups. Major rolling parameters will be considered in front of and in the roughing mill. Furthermore, the mechanism of chewing at the strip, in particular thin hot strip, will be investigated and analysed to develop and test an avoidance strategy against tail end chewing.

**State of progress:** Research technically completed; publication in hand

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/066	T2/T3.5/01	2.846.000	1.423.000	42 (Mths)		1/07/2001	30/06/2004	31/12/2004

**Title:** Mastering rolls in high productive finishing mills

**OBJECTIVES AND CONTENTS**

Despite the progress made during the last years, the control of work roll performances remains a major concern for the mill operators. This is due to the complexity of the problem and the shortcoming of real-time information and knowledge at the right production levels. Based on a better understanding of the work-rolls behaviour during hot rolling, the main objective of this proposal is to master the work roll performances in high productive finishing mills. This project seeks to implement an advanced control unit using the latest on-line strip and work roll surface monitoring techniques.

**State of progress:** Research in progress

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7215-PP/064	T3.3/01	1.016.000	508.000	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Further development of the flange-tip straightening process

**OBJECTIVES AND CONTENTS**

Large H-sections are usually straightened in presses. Compared to conventional roller straightening, this process presents disadvantages in terms of throughput and economy. However, conventional roller straightening may produce relatively high residual internal stresses between the flange and web, possibly diminishing quality. By roller straightening via application of the straightening force through the flange tips, it is possible to straighten such sections more economically and with better quality (avoidance of residual internal stress peaks), as was successfully demonstrated in the ECSC project 7215.EA/803. The objective of the proposed pilot project is the further development of this progressive straightening technique in mills producing H-sections of different dimensions. To verify the improved product quality, residual stress measurements will be carried out to allow comparisons between beams straightened conventionally and by the new technique.

**State of progress:** Research technically completed; publication in hand

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**Technical Group TGS4 has 19 Projects and 79 Partners**

**Total Projects: 474 - Total Partners: 1778**

**Technical Group TGS5 : "Finishing and coating"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/187	F7.3/99	1.140.000	684.000	48 (Mths)		1/07/1999	30/06/2002	30/06/2003

**Title:** Jet vapour deposition (JVD): extensive product study and first evaluation of coupling with a processing line

**OBJECTIVES AND CONTENTS**

Jet Vapour Deposition (JVD) is an original PVD method that exhibits outstanding properties: extreme productivity, operation in a moderate vacuum, robust and compact evaporator. It is estimated that JVD represents a technique with a high potential for the future industrial application of new types of coatings. To attain this objective, several steps are still necessary. The JVD performances have been evidenced in rather specific working conditions; its outstanding results must be confirmed in working conditions closer to current industrial ones. This project aims at making the bridge between the current state of JVD and the first implementation in a continuous pilot line. More precisely, the project intends to: study of products widening the range of possible coating elements by developing application oriented formula; to evaluate the compatibility with existing lines and to a first economic evaluation of investment and running costs.

**State of progress:** Research completed; publication EUR N° 21783 EN

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7210-PR/192	F7.8/99	1.007.000	604.200	48 (Mths)		1/07/1999	31/12/2002	30/06/2003

**Title:** Hot dip coating: analysis of the snout area

**OBJECTIVES AND CONTENTS**

Whereas galvanising baths have been the object of intensive research regarding temperature, composition, fluid flow of liquid metal and cross formation, little information is available concerning the snout area. It is widely accepted that the final quality of the coating is strongly related to the first contact of the strip with the liquid metal within the snout. Due to the lack of available information concerning the snout area, it is of major interest to investigate the specific phenomena that are taking place in that location and to relate them to the coating quality of the product and to the process parameters. In order to achieve this main objective, the project intends to achieve a complete characterisation of the snout area. The analysis will concern the zinc surface evolution, the temperature and composition of the bath beneath the snout, the atmosphere composition and the strip behaviour.

**State of progress:** Research technically completed; publication in hand

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7210-PR/218	D2.3/00	714.500	428.700	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Strip stability and speed control on submerged rolls

**OBJECTIVES AND CONTENTS**

The proposed research aims at improving the flatness quality and coating quality at tinning, galvanising and coating lines. Investigations will be made to improve the contact of the strip with submerged roll in order to predict occurrences of strip "aquaplaning" situation and to decrease the strip tension especially with the evolution towards low thickness strips. These investigations will be explored through calculation, measurement campaigns on experimental pilot line and industrial trials. Results are expected to apply to other processes and to improve the reliability and productivity of lines such as cleaning or continuous annealing.

**State of progress:** Research completed; publication EUR N° 21788 EN

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7210-PR/233	E.6/00	862.584	517.550	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Improved quality of steel sheet by better control and reduction of surface contamination

**OBJECTIVES AND CONTENTS**

Steel sheet producers are facing constantly increasing customers demands for surface quality. This leads to a growing interest in surface cleanliness of steel sheet. The aim of this project is to get information about the formation, the transformation, the chemical composition and the technological behaviour of surface contamination on steel sheet. Therefore simulation and pilot tests (rolling, cleaning, annealing, coating) will be carried out under well known conditions and the surface contaminations will be characterised by different analytical methods. The information from these experiments will make it possible to reduce surface contaminations and improve the quality of coated steel sheet.

**State of progress:** Research completed; publication EUR N° 21789 EN

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7210-PR/238	F3.3/00	839.000	503.400	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Improvement of duplex stainless steels pickling efficiency

**OBJECTIVES AND CONTENTS**

Among stainless steels, duplex grades are more and more used for their attractive properties in many applications. From the manufacturing point of view, the main problem that has not been solved until now is their bad pickling behaviour in usual pickling baths, that requires very long duration of immersion and therefore decreases the productivity. The aim of this project is to better understand this poor pickling behaviour of duplex steels, to determine acceptable conditions for their pickling and to reduce the toxicity of the pickling solutions by eliminating the use of nitric acid during the pickling process. In-depth studies of the relationships between the oxide layers formation, related with the conditions of treatments of the productivity and the quality of duplex grades, as well as better environmental pickling conditions are the expected results of the research.

**State of progress:** Research completed; publication EUR N° 21727 EN

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7210-PR/255	F7.1/00	640.530	384.318	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Corrosion properties of coated, formed & joined non-weldable printed steel for automotive application

**OBJECTIVES AND CONTENTS**

There is a great potential for the use of coil coated steel in the automotive sector. Two main types of pre-painted steel can be offered: weldable thin primed and non-weldable thick primed. The first one is now widely used. For the second one, its use is linked with the development of new joining techniques alternative to welding. A better knowledge of the long-term properties of assembled coil coated materials under various climatic conditions is necessary. The objective of the project is to improve the quality and performance of coil coated steel as substitute for electro-deposited coating in the automotive industry by a better understanding of the durability of the assembled parts of these materials.

**State of progress:** Research completed; publication EUR N° 21626 EN

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7210-PR/256	F7.2/00	978.000	586.800	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Passive/active transitions in cyclic corrosion tests

**OBJECTIVES AND CONTENTS**

The goal of this project is to study the reactions controlling the behaviour of painted steel products under cyclic exposure conditions. Active/passive transitions under the paint layer will be investigated using a new in-situ Kelvin microprobe, confocal Raman spectroscopy and galvanic coupling. This will help in the interpretation of accelerated test results, which still do not correlate well with the real behaviour of components under service conditions.

**State of progress:** Research technically completed; publication in hand

**Partners**

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7210-PR/257	F7.3/00	795.000	477.000	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Surface conditioning for improved hot-dip coating behaviour of modern high strength steels

**OBJECTIVES AND CONTENTS**

Modern high strength steels contain high contents of alloy elements, which lead to poor wettability during galvanising and reduced alloying formation during galvannealing. Surface conditioning for modern high strength steels is considered as a way to control the coating behaviour by affecting the enrichment of the alloying elements at the steel surface and the presence of oxide layers. The project aims at investigating three different approaches to modify the surface chemistry and to increase the coatability. These methods are pre-coating of the substrate with an electro-deposited metallic layer, modification by gas reactions and surface layer removal by mechanical abrasion or beam technology. It is expected to evaluate different process routes for the processing of modern high strength steels with relatively high alloying contents.

**State of progress:** Research completed; publication EUR N° 21421 EN

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7210-PR/258	F7.4/00	811.500	486.900	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Long-term durability of adhesively bonded sandwich panels

**OBJECTIVES AND CONTENTS**

Today, most European steel manufacturers supply expanded polyurethane core sandwich panels for insulating building applications. However, the use of polyurethane cores will most likely be banned in the future due to the tightening of European fire resistance and environmental regulations: thus it is essential to develop new sandwich panels with mineral wool core. The development of these new products is not easy due to the lack of data and methods related to the forecast of the durability. This methodology will make the development of long-term durable panels possible.

**State of progress:** Research completed; publication EUR N° 21412 EN

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7210-PR/259	F7.5/00	716.000	429.600	48 (Mths)		1/07/2000	30/06/2003	30/06/2004

**Title:** Development of electrically conductive polymer coatings for coil coated steel sheets

**OBJECTIVES AND CONTENTS**

In order to improve the quality and product value of organically coated products it is necessary that further steps in fabrication are introduced by the steel producer. This is also favourable from an environmental aspect. It is challenging to introduce tailored physical properties into coatings (e.g. electronic) to create tailored products for the increasing demands of end-manufacturers. New fields of application for CC (Coil Coated materials) might be opened where the insulating properties of organic coatings hinder customers from using CC e.g. housing of electronic devices. The aim of the project is to characterise and develop electrically conductive primer coatings for coil coating on steel sheets.

**State of progress:** Research technically completed; publication in hand

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7215-PP/049	T3.2/00	1.890.734	945.367	54 (Mths)		1/07/2000	30/06/2003	31/12/2004

**Title:** Enhanced pickling operation

**OBJECTIVES AND CONTENTS**

The first objective of this project is the industrial test of the induction boosted pickling. This original technique has proven to dramatically shorten the pickling operation. It is intended to test it in industrial conditions. Other methods to accelerate the pickling operation will also be tested: scale preparation by cooling the coils after hot-rolling and improved scale breaking. A second objective is the improvement of the homogeneity of the pickled surface. The management of the pickling bath will be undertaken in a very complete approach: development of fast sensors, modelling and definition of feed-forward control system. These methods will be assessed by industrial tests.

**State of progress:** Research in progress

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7215-PP/051	T3.4/00	1.390.500	695.250	48 (Mths)		1/07/2000	30/06/2003	30/06/2004

**Title:** Ultra short annealing of steel strip

**OBJECTIVES AND CONTENTS**

Former studies have shown the high potentialities of compact annealing. However, some critical question are still open : they concern product flatness, cost efficiency, effect on combined fast heating and cooling on mechanical properties and surface effects. The project is aimed at the development of appropriate solutions to these problems. The objective is to build a reduced scale continuous compact line and to evaluate the actual process and product performances in optimised conditions. Several steel grades will be studied. Their bulk and surface properties will be analysed.

**State of progress:** Research technically completed; publication in hand

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7210-PR/281	D2.1/01	938.705	563.223	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Improved quality of galvanised products by controlled wiping

**OBJECTIVES AND CONTENTS**

The objective of the project is to design a new controlled outlet circuit for the wiping gas, with the view to improve the wiping process efficiency. The wiping process presents several drawbacks, such as, high noise levels and vibrations of the strip, the large sensitivity of the knives-strip distance and the excessive oxidation of zinc. Noise reduction is of great importance to workers' health, safety and working attention. Decreasing the zinc oxidation or the splashing on tools and strips will improve the quality of the final product

**State of progress:** Research in progress

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7210-PR/282	D2.2/01	1.159.058	695.435	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Hot dip galvanising: stabilising & cooling the strip in the wiping area

**OBJECTIVES AND CONTENTS**

The objectives of the project are to improve the coating homogeneity and the cooling rate after wiping to guarantee a very homogeneous coating thickness all along the strip in order to ensure uniform sheet properties. The first objective will be realised by two actions, optimised air pad and improved bearings of the bath rolls. The second objective concerns the cooling rate after wiping in respect to higher cooling rates for the processing of HSS steels.

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7210-PR/283	D2.3/01	1.144.110	686.466	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Improved control of mechanical & geometrical properties of steel strips by thermal profile determination all along the annealing line

**OBJECTIVES AND CONTENTS**

The objective of the project is the application of numerical and experimental tools to better control thermal cycles of steel strips in annealing lines. The project aims at reducing the number of trials and broken strips and to adapt the process for new production. The research will result in a reduction of risks of accident during these rather delicate and hazardous operations. The real and complete history of a steel strip all along an industrial annealing line will be described and explained.

**State of progress:** Research technically completed; publication in hand

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7210-PR/285	D2.5/01	1.163.500	698.100	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Improvement in throughput and product quality of continuous annealing lines by extended models and advanced control

**OBJECTIVES AND CONTENTS**

The project aims at developing and testing different techniques to avoid strip wrinkling and improving the guiding of strip processed in the continuous annealing sections of finishing lines. The objectives are to specify the incoming strip flatness for optimal processing concerning wrinkling and strip guidance. Gaining control of thermal roll profile based on on-line measurements inside the furnace and of the roll axis position are further objectives.

**State of progress:** Research technically completed; publication in hand

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7210-PR/319	F7.1/01	1.010.600	606.360	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Enhancement of stainless and pre-painted steel sheets aesthetic performance by means of scratch and fingerprint resistant coatings

**OBJECTIVES AND CONTENTS**

The aim of this project is to improve aesthetic durability of steel sheets surfaces, both in stainless and coil-coated steel, by means of clear coatings resistant to those aesthetic damages, e.g. fingerprints and scratches, that reduce the "value" of steel sheets in applications where appearance is essential. Wide attention will be paid for understanding the nature and processes of aesthetic damage and for defining specific tests of surface resistance/sensitivity to such damages. The influence of various parameters on coating behaviour will be considered, e.g. coating thickness, mechanical properties, disperse of inorganic nanoparticles and curing degree. Different types of coatings will be developed, applied in laboratory and on pilot lines, and carefully characterised, with special attention for UV-curable coatings, that appear to be environmentally and industrially advantageous.

**State of progress:** Research technically completed; publication in hand

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**Title:** Soluble salt contamination on blast cleaned surfaces and the effect on the durability of subsequently applied coatings

**OBJECTIVES AND CONTENTS**

This project will provide a clear understanding of the effects of ionic species present after blast cleaning, on the performance of paint coating systems and the failure mechanism involved. Realistic limits will be established that are not detrimental to the durability of selected paint coatings and, ensure that European products are not discriminated against or suffer cost penalties after export to the world markets. Partners will use a wide range of techniques to ensure that the data generated will be used in support of the European contribution towards the preparation of the standard proposed by the International Standards Organisation (ISO). This will include the development of a standard method of contaminating surfaces, a standard technique for the detection and determination of the levels of contamination, and clear recommendations on how to avoid or reduce the level of contamination, together with coating specifications that can be offered to customers.

**State of progress:** Research technically completed; publication in hand

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**Technical Group TGS5 : "Finishing and coating"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/321	F7.3/01	906.327	543.796	42 (Mths)		1/07/2001	30/06/2004	31/12/2004

**Title:** Prediction of durability performance of coil-coated steel used in the building industry

**OBJECTIVES AND CONTENTS**

Despite several projects financed by ECSC there is still today no well-accepted, reliable and standardised accelerated corrosion test for coil-coated products used in the building industry. Hence, an important challenge is to develop a reliable and standardised accelerated corrosion test for these materials. The overall objective of this project is to gain a greater understanding of the influence of climatic parameters on the degradation of coil-coated steel products used in the building industry. The final aim is to provide guidelines for the development of reliable and repeatable accelerated corrosion tests for coil-coated steel. In order to meet these objectives the influence of a large number of climatic parameters on the degradation of coil-coated steel will be studied by means of factorial design and statistical analyses. The data will also be compared with that of field exposure and that of existing accelerated corrosion tests. In addition the in-situ scanning Kelvin probe will be used in order to follow the mechanisms of degradation as a function of the different climatic parameters.

**State of progress:** Research technically completed; publication in hand

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**Technical Group TGS5 : "Finishing and coating"**

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7210-PR/322	F7.4/01	1.595.661	957.397	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** A mechanistic study of wetting and dewetting during hot dip galvanizing of high strength steels

**OBJECTIVES AND CONTENTS**

The aim of the project is to gain fundamental understanding by investigating wetting and dewetting of liquid zinc on model surfaces of defined oxide/bare metal structure and to find optimal oxide/bare metal morphologies. It is planned to study the scale formation during oxidation and reduction of substrates in order to learn how to develop a process resulting in a mixed scale similar to these morphologies. Parallel to the model studies the hot dip galvanizing of steels will be analysed after reduction and oxidation of the surface. The project will focus mainly on the interfacial reactions during galvanising, dependence of wettability on surface nature and preparation of optimised surfaces according to the model. Finally, a transfer of the model to the industrial HDG process and verification by industrial trials will be realised in order to optimise the surface preparation for new steels and complex alloys.

**State of progress:** Research technically completed; publication in hand

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/065	T3.4/01	1.056.500	528.250	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Control of the oxidation/reduction process for strip galvanisation

**OBJECTIVES AND CONTENTS**

For obvious economical reasons, high strength steel strip will find in the future more and more applications. For these new applications, high strength sheet is hot-dip galvanised to resist corrosion. These steels are renowned to present wettability and adhesion problems during hot dipping. A previous work has shown that a pre-oxidation, obtained by adjusting the air/gas ratio of the direct fired furnace (DFF), followed by a reduction in the soaking zone of the radiant tube furnace, can improve significantly the zinc wettability. The aim of the project is to develop technical solutions, allowing the industrial application of the oxidation/reduction process for different steel grades. A sensor will be adapted on pilot and industrial lines to control the oxide thickness and the strip temperature after the DFF. The improvement of the zinc wettability and adhesion on conventional and high strength steels will be determined by trials on pilot lines.

**State of progress:** Research technically completed; publication in hand

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7215-PP/068	T4.2/01	1.249.130	624.635	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Extension of on-line automatic surface inspection system (ASIS) to packaging & organic-coated steel lines

**OBJECTIVES AND CONTENTS**

The surface quality of rolled strip is more performed automatically, using "automatic surface inspection systems" or ASIS. Packaging and organic-coated products have however stayed out of this general tendency and quality control of these products is still performed, if we except DWI packaging products, using visual inspection, because the technical requirements of these products are too specific for present ASIS systems. Extending the field of application of ASIS systems to these products will enable the European steel industry to draw an economic benefit estimated at 20M€/year. The objective of the project is to extend the capability of present ASIS systems to these types of product. This will be accomplished by integrating innovative emergent technical solutions for optical sensor and automatic defect detection techniques to present ASIS systems. Two industrial plants will be equipped with a one-channel ASIS test facility that will serve throughout the project.

**State of progress:** Research technically completed; publication in hand

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Technical Group TGS5 has 22 Projects and 80 Partners

Total Projects: 496 - Total Partners: 1858

**Technical Group TGS6 : "Physical metallurgy and design of new generic steel grades"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/223	D3.2/00	1.514.155	908.493	48 (Mths)		1/07/2000	31/12/2003	30/06/2004

**Title:** Steel modelling workbench

**OBJECTIVES AND CONTENTS**

The project will develop a steel-modelling workbench, as an open software environment where models developed by ECSC, in-house, etc. can be linked and run to allow the modular development of integrated models of the various stages of the steel manufacturing process. The use and customisation of this open steel workbench will allow each steel manufacturer to continue their own modelling strategy and developments whilst providing a flexible "standardised" platform for collaborative work. A prototype version of the workbench for demonstrating the feasibility of linking models for selected core steel processing areas will be produced, together with a set of documented protocols and guidelines for incorporating models and data into the computing environment.

**State of progress:** Research technically completed; publication in hand

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7210-PR/224	D3.3/00	881.450	528.870	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** New concepts for understanding & modelling the influence of austenite state on phase transformations in hot rolled steels

**OBJECTIVES AND CONTENTS**

Models for describing phase transformations from work-hardened austenite are classically based on an "homogeneous equivalent austenite" and do not take into account important factors such as: the effect of austenite recovery on subsequent phase transformation, the dislocation substructure in austenite or the effect of partially re-crystallised austenite. The project has two main objectives, to characterise the state of austenite, after deformation and cooling, before transformation based on microstructural features in order to provide adequate data for future phase transformation modelling and to relate the state of austenite to phase transformation kinetics and final microstructure on the basis of a study of nucleation and growth mechanisms and to improve upon the classical hot deformation test results and find a common methodology.

**State of progress:** Research completed; publication EUR N° 21632 EN

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7210-PR/225	D3.4/00	1.005.409	603.246	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Study of ferrite grain growth & transformation mechanisms, at different stages during steel processing, aided by the use of modern OIM techniques

**OBJECTIVES AND CONTENTS**

In process like phase transformation, recrystallisation and grain growth, the conventional observation techniques are insufficient to some extent. In the present work, Orientation Imaging Microscopy (OIM) technique will be used to investigate the effect of the local orientations and mesotexture on the microstructure and texture evolution during transformation, recrystallisation and grain growth. The results will be used to improve the texture in dual phase cold rolled and annealed steels and to get mathematical expressions in order to extend existing models describing ferrite grain growth after transformation and after recrystallisation.

**State of progress:** Research completed; publication EUR N° 21430 EN

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7210-PR/226	D3.5/00	864.195	518.517	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Precipitation engineering

**OBJECTIVES AND CONTENTS**

To develop good deep drawing properties, all the C and N must be precipitated before cold rolling and annealing as they are detrimental for the formation of the (111)-fibre during continuous annealing. Therefore, the precipitation characteristics such as the composition, the distribution and the size and their evolution during steel processing must be controlled. The project will focus on the development of deep drawing qualities. Two types of steel grades will be investigated. For IF-Ti steel grades the precipitation of the C and S with Ti will be studied and the accent will be made on titancarbosulphide precipitation in function of the chemical composition, the casted state, the reheating temperature and the hot rolling parameters. For ELC-Ti steel grades the precipitation of the Ti will be studied and the emphasis will be placed on the influence of the reheating cycle and hot rolling parameters in function of the C.

**State of progress:** Research completed; publication EUR N° 21437 EN

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**Technical Group TGS6 : "Physical metallurgy and design of new generic steel grades"**

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7210-PR/236	F3.1/00	1.007.507	604.504	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Influence of microstructure on SSC and SOHIC in base materials and welded joints of high strength sour service steels

**OBJECTIVES AND CONTENTS**

Objective of this project is to assess the effect of relevant metallurgical parameters such as type and coarseness of local microstructure on the resistance to sulphide stress cracking (SSC) and stress oriented hydrogen induced cracking (SOHIC) of welded spiral pipes and pressure vessels. The project will focus on the behaviour of welded joints obtained by different processes with high grade thermo-mechanical controlled process (TMCP) and quench and tempered (Q&T) steels for sour service pipelines, flow lines and pressure vessels, with the aim of improving the local resistance to SSC and SOHIC, which are known to be especially critical in welds. The properties of base metal will also be investigated.

**State of progress:** Research technically completed; publication in hand

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/240	F3.5/00	1.152.048	691.229	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Critical evaluation of the effect of alloyed nitrogen on the susceptibility of stainless steels to environmentally induced cracking (EiC-Nitrogen)

**OBJECTIVES AND CONTENTS**

The project aims to clarify the effect of nitrogen alloying on the susceptibility of stainless steels to environmentally induced cracking in chloride and hydrogen sulphide environments. Laboratory heats of austenitic and duplex steels will be prepared with systematic variation in nitrogen content, and phase ration for duplex steels. Testing will be performed in concentrated and dilute chloride solutions and sour gas using a combination of constant load, bend and slow strain rate testing. Particular attention will be paid to the relative importance of initiation and propagation of cracks and the interrelation between cracking and other corrosion forms.

**State of progress:** Research technically completed; publication in hand

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/245	F5.1/00	1.173.000	703.800	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** The prediction of HAZ microstructures and properties in structural steel

**OBJECTIVES AND CONTENTS**

The modelling of microstructural development in parent steel has advanced rapidly in recent years although the majority of these advances have been applicable to a restricted range of steel compositions or product types. The objective of the current proposal is to extend this methodology to modelling of HAZ Microstructures. The aim being to derive and use quantitative thermodynamic and kinetic algorithms to develop a PC based program which can predict microstructural development as a series of contours around the weld bead of both single and multi-pass conventional welded joints and for high energy density welding.

**State of progress:** Research completed; publication EUR N° 21338 EN

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7210-PR/246	F5.2/00	1.143.578	686.147	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Performance criteria for cold formed structural steels

**OBJECTIVES AND CONTENTS**

Cold forming and hole punching are two processes that offer flexibility to the designer and fabricator. However, guidance on cold forming is currently limited to qualitative information related to the suitability of the material while hole punching is subject to severe restrictions in many design codes. The aim of the project is to derive guidance on the effects of cold bending and hole punching on material properties and to quantify the effect of this on subsequent structural integrity. The project will utilise a range of experimental methods of varying scale, coupled with modelling of the two processes.

**State of progress:** Research technically completed; publication in hand

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7210-PR/247	F5.3/00	877.163	526.297	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Quantitative structure - property relationships for complex bainitic microstructures

**OBJECTIVES AND CONTENTS**

A methodology for the automatic characterisation of microstructures using an Image Classifier will be developed for multiphase and mixed grain size microstructures. Isothermal and continuous heat treatments will be performed to generate specific microstructures, for detailed metallographic analysis of the key parameters contributing to the properties. This will be followed by mechanical testing for improved understanding of the quantitative structure-property relationships. The output from the project will include improved structure-property relationships for bainitic steels and a software module for the automatic quantification of complex microstructures.

**State of progress:** Research completed; publication EUR N° 21245 EN

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7210-PR/248	F5.4/00	1.558.588	935.152	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Non-destructive evaluation (NDE) of quality characteristics of heavy plates

**OBJECTIVES AND CONTENTS**

The aim of the project is the improvement of the quality and the reduction of production costs of heavy plates by the development of non-destructive testing (ndt) techniques, fit for on-line closed loop process control in a heavy plate mill. The project targets to a qualified processing of diverse and redundant information for characterisation and documentation of steel quality. The inspection parameters, which will be used, are based on electromagnetic ndt-techniques, ultrasonic techniques by electromagnetic acoustic transducers, design and build-up of a prototype inspection equipment and capability and reliability test of the developed ndt-techniques and systems under field conditions in heavy plate mills.

**State of progress:** Research completed; publication EUR N° 21436 EN

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7210-PR/287	D3.1/01	1.214.000	728.400	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Grain refinement of cold rolled microalloyed steels by rapid transformation annealing

**OBJECTIVES AND CONTENTS**

Refinement of grain size is the standard way to improve both strength and ductility. Recent work has indicated that fine grain structures of around 4 µm could be achievable in commercial production with appropriate development of the production of cold rolled microalloyed steels with a homogeneous grain refined structure by rapid transformation annealing. Its benefits on the materials properties will also be assessed. This annealing process offers the prospect of producing high yield strength steels with minimal alloying costs, which in turn results in a more easily recyclable product for environmental benefits.

**State of progress:** Research technically completed; publication in hand

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7210-PR/288	D3.2/01	1.017.000	610.200	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Ultra fine grained steel by innovative deformation cycles

**OBJECTIVES AND CONTENTS**

The project will assess the benefits that can be achieved in terms of strength, ductility and toughness by the formation of ultra-fine (UF) microstructures either in the bulk or the external layers of strips/plates and rods of low and medium/high carbon steels. A wide range of steels will be considered, concerning carbon content from 0,04% to 1,6% as well as the use of microalloying additions. Recommendations with emphasis on the fundamental metallurgy and process conditions, concentrating on approaches which would involve minimum changes to process technology, will be given to the new thin-slab and strip casting facilities.

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7210-PR/289	D3.3/01	1.256.807	754.084	54 (Mths)		1/07/2001	31/12/2004	31/12/2005

**Title:** Grain refinement by intragranular ferrite nucleation on precipitates in microalloyed steels

**OBJECTIVES AND CONTENTS**

Grain refinement is the only strengthening mechanism that adds both strength and toughness to the steel. The thermo-mechanical control process (TMPC) which control grain size by a controlled rolling and an accelerated cooling is, however, not always applicable for heavy products. To overcome this problem an intragranular ferrite nucleation potential of microalloy carbonitrides can be utilised. In this work the enhancement of ferrite nucleation on carbonitride particles, predominantly VN, precipitated in austenite during finishing rolling or slow cooling after rolling, will be examined as the method for improvement of both strength and toughness for thicker plates and heavy beams. Isothermal and continuous thermo-mechanical treatments will be performed to elucidate the kinetics of M(C,N) precipitation in austenite. The output from this project will include new hot rolling practises for thick plates and heavy long products for achieving maximum grain refinement by enhanced intragranular ferrite nucleation.

**State of progress:** Research in progress

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/291	D3.5/01	1.513.577	908.146	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Constitutive modelling for complex loading in metal forming processes

**OBJECTIVES AND CONTENTS**

Constitutive data for metal forming processes are generally measured in laboratory tests at constant strain rate and temperature and require interpretation for situations involving more complex thermomechanical conditions, including strains reversal. The project investigates experimentally the constitutive behaviour for complex loading, in order to identify the nature of controlling mechanisms, and develop constitutive models suitable for incorporation into finite element (FE) models of deformation in hot rolling. The FE models will allow prediction of loads, microstructural evolution and defect formation for low alloy, medium carbon and stainless steels and will be validated against data from both laboratory and industrial scale mills.

**State of progress:** Research technically completed; publication in hand

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/292	D3.6/01	1.467.281	880.368	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** On-line prediction of the mechanical properties of hot rolled strips

**OBJECTIVES AND CONTENTS**

The project aims at validating a metallurgical model in different hot rolling conditions and to implement it on-line. The model will allow the prediction of the final mechanical properties and the microstructural characteristics of hot rolled steel strips immediately after production. The model will be validated on the selected hot strip mills, improved in order to reduce the observed deviations and extended in order to satisfy new elements not taken into account yet. The metallurgical modelling approach will also be compared with statistical models and neural networks.

**State of progress:** Research technically completed; publication in hand

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/293	D3.7/01	919.503	551.702	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Heavy warm rolling for the production of thin hot strips

**OBJECTIVES AND CONTENTS**

The project aims at defining guidelines for the production of thin gauge hot rolled strips in an economically accepted way. Laboratory trials will be carried out to simulate the transfer of hot rolled materials for an additional rolling stand where a heavy warm rolling reduction will be performed. The feasibility and possibilities of this novel approach will be investigated. Research work will be concentrated on ferritic rolling of ELC-, ULC- and IF-steels, warm rolling of plain CMn steels and pearlitic rolling of eutectoidic and proeutectoidic steels. The influence of the processing parameters on the mechanical properties and the surface quality will be investigated. Guidelines will be defined for the design of the equipment and the obtained results will be evaluated regarding the properties and the estimated cost.

**State of progress:** Research technically completed; publication in hand

**Partners**

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**Technical Group TGS6 : "Physical metallurgy and design of new generic steel grades"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/295	D3.9/01	1.367.400	820.440	42 (Mths)		1/07/2001	30/06/2004	31/12/2004

**Title:** New metallurgy for microalloyed TRIP steels

**OBJECTIVES AND CONTENTS**

The projected market in Europe for high strength TRIP (Transformation Induced Plasticity) steels for automobile applications is estimated to be between 50.000 and 100.000 tonnes per year, starting from 2004. Their properties make them first choice for stretch formed structural components with high-energy absorbing capacity, particularly important for safety considerations. Current production TRIP steels with 0.2%wt carbon are limited to around 800MPa. The development of higher strength grades (>1000MPa) is necessary to meet current vehicle weight reduction targets. The project will investigate the possibility of applying precipitation hardening techniques to the TRIP metallurgy.

**State of progress:** Research in progress

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7210-PR/304	F3.2/01	1.034.500	620.700	42 (Mths)		1/07/2001	30/06/2004	31/12/2004

**Title:** Methods of improving the deep drawing properties of austenitic stainless steels

**OBJECTIVES AND CONTENTS**

The aim of this project is to improve the deep drawability by controlling of the austenite stability, the strain hardening behaviour, the texture and the surface topography in order to enable new applications for austenitic steels, e.g. in the automotive industry.

**State of progress:** Research technically completed; publication in hand

**Partners**

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/308	F3.6/01	1.040.500	624.300	48 (Mths)		1/07/2001	31/12/2004	30/06/2005

**Title:** Development of a cost effective low Ni austenitic steel with superior high temperature properties up to 950°C (CELNIS)

**OBJECTIVES AND CONTENTS**

The objective of the project is to develop a material with a reduced Ni content (< 20 versus 32%), a 50% higher creep rupture strength and a comparable oxidation resistance than the Alloy 800H. Besides, postweld heat treatments should not be necessary. For the development the European material 1.4910 will be used as benchmark criterion.

**State of progress:** Research in progress

**Partners**

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**Technical Group TGS6 : "Physical metallurgy and design of new generic steel grades"**

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7210-PR/312	F5.1/01	895.252	537.151	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Quantitative correlation of fracture toughness and microstructure for high strength steels and their welds

**OBJECTIVES AND CONTENTS**

Fracture mechanics methods take account of the quantified toughness and hence allow for safe and economical design. Especially, fracture toughness values are often missing and are expensive to obtain. The aim of this project is to apply a newly developed method of correlation between microstructural parameters and fracture toughness allowing for an economical alternative of obtaining fracture toughness values directly after steel has been produced. This offers steel producers an additional opportunity of characterisation of the steels during production and development of new grades respectively. Within the project the four steel grades S 355, S 460, S 690 and S 890, among them different heat treatments and different toughness levels, will be investigated. Welds of these steels will be included. Special attention will be given to quantitative examination. Crack initiation and growth will be analysed.

**State of progress:** Research technically completed; publication in hand

**Partners**

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***Technical Group TGS6 : "Physical metallurgy and design of new generic steel grades"***

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Technical Group TGS6 has 20 Projects and 103 Partners

Total Projects: 516 - Total Partners: 1961

**Technical Group TGS7 : "Steel products and applications for automobiles, packaging and home appliances"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/179	F4.2/99	1.282.000	769.200	48 (Mths)		1/07/1999	30/06/2003	30/06/2003

**Title:** Manufacturing guidelines when using ultra high strength steels in automotive applications

**OBJECTIVES AND CONTENTS**

In recent years, the drive for weight reduction in the automotive industry, resulting from pressures for improved fuel economy and performance is reflected by the increased utilisation of high strength steels (HSS). There is also potential for the utilisation of ultra high strength steels (UHSS) to improve performance. However, the UHSS do not present the same properties as the materials they are replacing and certain applications need to be addressed in order to effect their use within the automotive industry. The project will focus on steels with a tensile strength of between 600 and 1200N/MPa. A number of issues relating to the manufacturability and design of UHSS will be investigated including formability and springback, weldability, fatigue life and crash performance. The research aims at the generation of a comprehensive set of manufacturing guidelines for the use of UHSS in automotive components.

**State of progress:** Research completed; publication EUR N° 21909 EN

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**Technical Group TGS7 : "Steel products and applications for automobiles, packaging and home appliances"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/032	T3.3/99	1.999.000	999.500	48 (Mths)		1/07/1999	30/06/2002	30/06/2003

**Title:** Transition joints steel-aluminium for car parts of Al weldable to the steel body

**OBJECTIVES AND CONTENTS**

Tailored blanks in steel sheets of various thickness or strength are current examples of innovative body-in-white engineering. The partial use of specifically lighter metallic materials provides further opportunities for weight saving. At present aluminium plays a prime role in this regard. Using a combination of laser energy and cold forming overlap shaped transition joints of steel and aluminium can be produced. Steel/aluminium tailored blanks could also be manufactured with the same technique. To produce parts in real tailored blank format, the project intends to combine low alloyed deep drawing qualities and stainless steels with aluminium alloys for external and internal application in the automotive car bodies. Steel blanks will be used in sheet thickness of 0.8 to 1.2 mm in deep drawing qualities and high strength steels uncoated or galvanised and stainless steels mainly 304-types joint to aluminium blanks in sheet thickness of 1.0 to 1.4 mm in aluminium grades of AA6000 and 5000 series.

**State of progress:** Research technically completed; publication in hand

**Partners**

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7215-PP/035	T3.6/99	1.390.000	695.000	48 (Mths)		1/07/1999	30/06/2002	30/06/2003

**Title:** Laser hybrid welding of tailored tubes with integrated quality analysis and closed loop process control

**OBJECTIVES AND CONTENTS**

Tailored blanks and tubes are increasingly being used in automotive lightweight construction. Hybrid welding techniques are more and more applied to improve the laser welding speed when producing tailored blanks and tubes. Cost-effective methods, e.g. MIG, TIG or plasma welding in combination with laser welding, allow a comparatively high joining speed with insignificantly higher investment costs. The benefits expected from the research are the following: a better understanding of the laser/MIG hybrid welding process and of the integrated quality assurance and process control at hybrid welding; a deeper knowledge about the mechanical seam properties and forming properties of hybrid welded steels and, finally, their corrosion and painting behaviour.

**State of progress:** Research completed; publication EUR N° 21418 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/222	D3.1/00	1.052.129	631.277	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Development of hot rolled high strength steels with inherent corrosion resistance

**OBJECTIVES AND CONTENTS**

Hot rolled high strength steels possessing improved resistance to perforation corrosion are available in Japan for supply to subframe / underbody parts. However some work indicates that they may be prone to pitting corrosion with subsequent detrimental to fatigue life. The objectives of the proposed project are to investigate the effect of steel compositions e.g low CMn Nb or dual phase steel with additions of Cu+P, and microstructures on the rate of perforation corrosion and fatigue performance of steels in order to design a range of steels to enable weight reduction and possible elimination of protective coatings.

**State of progress:** Research completed; publication EUR N° 21434 EN

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7210-PR/227	D3.6/00	1.361.000	816.600	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Development of new DDQ grade combining low ageing sensitivity, BH and higher n-value

**OBJECTIVES AND CONTENTS**

In the production process of exposed car panels, cold rolled sheets are deformed and submitted to a paint baking process. To obtain the required final stamped steel sheet, several steel properties must be developed and controlled for deep-drawing such as high n-value, low ageing sensitivity and Bake hardening. In order to obtain a better understanding of the involved mechanisms, correlation will be searched between these three properties, the process parameters (coiling temperature, annealing temperature) and metallurgical characteristics such as precipitation density and distribution, solute carbon distribution and dislocation density. Two types of steel grades will be investigated, Nb and/or Ti sub-stoichiometric ULC steel grades and

**State of progress:** Research completed; publication EUR N° 21438 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/242	F4.1/00	1.179.803	707.882	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** The relative impact performance of (...) and tailor welded blank techniques for optimum mass efficiency

**OBJECTIVES AND CONTENTS**

The automotive "body-in-white" structure has been traditionally fabricated by using press formed components. The demand for increased crash safety and greater mass efficiency has led to the extensive substitution of traditional mild steel with higher strength products. This project examine the different forming processes now at the disposal of the automotive designer, which may be exploited to fabricate crash-sensitive body structures. The relative performance of a number of design solutions will be evaluated both practically and analytically.

The forming processes will include press-forming, hydroforming and roll-forming, and the work will also evaluate the potential of tailor welded blanks and patchpiece technologies to further enhance structural performanc and mass efficiency.

**State of progress:** Research completed; publication EUR N° 21631 EN

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7210-PR/243	F4.2/00	1.065.500	639.300	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Investigation of the formability (including hydroforming capability), springback & crash resistance of modern high strength steels under development

**OBJECTIVES AND CONTENTS**

This project will assess the effect of the hardening mechanism and microstructure on tensile and formability properties. Therefore a wide range of high strength steels (HSLA, DP, Multiphase, TRIP, etc.) will be generated. Tensile and formability properties will be determined, including the possibility for hydroforming. In addition the crash resistance and springback will be investigated. For each forming type the most suitable hardening mechanism and microstructure will be assessed, which will allow to define a production strategy that guarantees strength, formability and safety requirements.

**State of progress:** Research completed; publication EUR N° 21414 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/306	F3.4/01	1.602.500	961.500	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Technically and commercially viable alternatives to lead as machinability enhancers in steels used for automotive components manufacture

**OBJECTIVES AND CONTENTS**

The purpose of this project is to investigate in depth the most promising alternatives to lead as machinability enhancers in free cutting engineering steel grades and to evaluate their performance in component manufacturing tests. Economic models will be used to determine their commercial viability of various alternative additions.

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7210-PR/307	F3.5/01	973.000	583.800	30 (Mths)		1/07/2001	31/12/2003	31/12/2003

**Title:** High volume forming of stainless steel with easy to clean lubricants

**OBJECTIVES AND CONTENTS**

In this proposal a unique approach is chosen by the optimisation and adaptation of the stainless steel forming system as a whole with environmental and social benefits. Careful development steps are proposed in producing sheet finish, lubricant formulation and tool steel selection. The result of the programme will be a clean and proven technology needed for increasing the use of stainless steel.

**State of progress:** Research technically completed; publication in hand

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/309	F4.1/01	1.383.545	830.127	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Improved fatigue strength of HSS tailored blanks

**OBJECTIVES AND CONTENTS**

The project involves the fatigue examination of high strength steels related to laser welds oriented in the main stress direction (longitudinal weld seams). Based on a 5 zones model for the weld seam, the fatigue resistance will be evaluated by local approaches. The influence of tailored blanking effect will be considered with different material and/or thickness combinations. Extensive fatigue tests including base metal and laser welds will be performed. The influence of biaxial loading, forming (uniaxial stretching, plain strain) as well as artificially generated weld defects will be considered. A data bank for steel sheets will be established for the transfer of the results.

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/310	F4.2/01	1.257.000	754.200	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title: Improvement of formability of continuously organic coated coils by controlling ageing behaviour of low carbon steel substrates**

**OBJECTIVES AND CONTENTS**

The aim of this project is to define low C steels and process conditions to manufacture continuous "COIL COATED" coils free from coil breaks (fluting) and stretcher strains after cold forming. The objective is to be achieved by exploring the possibility of using hot coils rolled in the austenitic and ferritic field with different chemical compositions. The effect of the chemical composition, hot rolling conditions both in the austenitic and in the ferritic phase, total thickness reduction during cold rolling, annealing cycle in the hot-dip zinc coating and continuous annealing lines, the repartition of pre-deformation between skinpass and stretch leveling in the galvanising or continuous annealing line on recrystallised ferrite grain size, yield point elongation and strain ageing index will be investigated. Also the response to pickling and the sensitivity of strip edges to crack appearance will be assessed.

**State of progress:** Research technically completed; publication in hand

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7210-PR/311	F4.3/01	1.025.700	615.420	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Evaluation of dynamic fracture resistance of LASER & resistance spot welds for automotive applications

**OBJECTIVES AND CONTENTS**

Concerning the cost reductions and increased safety, crash-tests are the most appropriate for appreciating global improvement. Steelmakers need simpler dynamic testing for the evaluation of the steels characteristics, particularly of welds (spot or LASER joints). Furthermore, mechanically effective tests, which are sensitive to microstructural gradients, should be preferred. Constitutive laws should be derived from these tests for incorporation to Finite Element codes for predicting car behaviour during crash situations. The proposed research intends to use a newly developed test (Impact Tensile test) for assessing the influence of welding conditions, steel compositions and microstructures on the dynamic behaviour of welds. The objective of this research is to offer a new tool for the selection and development of new high strength steel grades for automotive applications together with optimal joining conditions.

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**Technical Group TGS7 : "Steel products and applications for automobiles, packaging and home appliances"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/062	T3.1/01	3.905.600	1.562.240	48 (Mths)		1/07/2001	30/06/2004	30/06/2005

**Title:** New production method for steel and steel compound sections

**OBJECTIVES AND CONTENTS**

The objective of the project is to develop a thorough understanding of the relationship between engineering conditions, the manipulation of process variables and product quality. Product quality indicators will be developed, the processes will be modelled and the actual condition of the plant will be assessed. The project will identify the physical parameters, which are critical to the production of shape free coils and will establish a tolerance window. Verification of the results will be made by means of extensive process trials.

**State of progress:** Research in progress

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Technical Group TGS7 has 13 Projects and 55 Partners

Total Projects: 529 - Total Partners: 2016

**Technical Group TGS8 : "Steel products and applications for building, construction and industry"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/184	F6.2/99	817.500	490.500	42 (Mths)		1/07/1999	30/06/2002	31/12/2002

**Title: Natural fire safety concept - the development and validation of a cfd-based engineering methodology for evaluating thermal action on steel and composite structures**

**OBJECTIVES AND CONTENTS**

The project, complementary to the European projects on the "Natural Fire Safety Concept", is aimed at the development and validation of advanced CFD-based engineering methodology for evaluating thermal action on steel/composite structures and its impact on the fire-related EuroCodes (EC1 and EC3). The validated methodology will provide detailed information about the local thermal exposures and temperatures throughout the structure when exposed to 'natural fires'. This would allow a designer to optimise the structure with associated cost savings. It will offer a potential alternative to fire-resistance tests and a cost-effective means for assessing the calibration and sensitivity of the traditional calculation methods used in the design guides.

**State of progress:** Research completed; publication EUR N° 21444 EN

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**Technical Group TGS8 : "Steel products and applications for building, construction and industry"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/237	F3.2/00	1.209.500	725.700	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Improving the machinability of stainless steels

**OBJECTIVES AND CONTENTS**

Stainless steels are indispensable for various applications, although machining properties have characterised as difficult. Recent trends in the metal working industries target to increase the metal removing rates in production processes. The project will focus on the improvement of the machinability of stainless steels and, on the possibilities of improved machining. Environmental friendly stainless steels adapted for particular applications will be evaluated against high speed cutting dry/low amount lubrication machining.

**State of progress:** Research completed; publication EUR N° 21801 EN

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**Technical Group TGS8 : "Steel products and applications for building, construction and industry"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/239	F3.4/00	1.263.785	758.270	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Development of Cr-Mo-V ferritic steels for high temperature hydroprocessing reactors with enhanced behaviour

**OBJECTIVES AND CONTENTS**

The operating temperatures of hydro-processing reactors are at present in the range from 400-480 °C with a corresponding hydrogen partial pressure of 10 to 35 MPa. Currently thick-walled reactors are made of 2.25Cr1Mo or 3Cr1Mo steels. The need for high stress intensity values in order to reduce the reactor wall thickness has been the continuous driving force for the development of alternative higher strength materials such as the addition of V. The aim of the project is the development of a new version of Cr-Mo-V steel with tailored addition of elements to increase the mechanical properties, to maintain the hardness in the welded zone below 250 HV and to reduce the internal protective coating disbonding and the wall thickness.

**State of progress:** Research completed; publication EUR N° 21419 EN

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**Technical Group TGS8 : "Steel products and applications for building, construction and industry"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/241	F3.6/00	967.682	580.609	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Development of machinability enhanced tool steels for improved product economy in hard milling

**OBJECTIVES AND CONTENTS**

Direct milling of tool steels in the hardened state has considerable economic and positive environmental potential. To incorporate this feature in the next generation of tool steels without the loss of critical properties, it is proposed to investigate both hot (type H13) and cold working (type D2) steels using innovative methods in steel modification and hard milling. Limits to steel modification through different approaches on hard machinability and application properties will be highlighted. The results will be used to develop the next generation of tool steels designed for economic machining even in the hardened state.

**State of progress:** Research completed; publication EUR N° 21726 EN

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7210-PR/249	F6.1/00	724.000	434.400	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Probabilistic quantification of safety of a steel structure

**OBJECTIVES AND CONTENTS**

Modern design rules are based on limit state design which considers ultimate limit states and limit states of serviceability. For these different limit states, the designer ensures a sufficient safety by using factors YM on the material properties and YF on the loads. The determination of these safety factors has been based on expert judgement, experience and a probabilistic approach. It is the aim of this project to perform complete reliability analysis of steel, composite and concrete buildings in order to highlight the advantage of the steel construction and to quantify in a scientific and mathematical way the safety level of the different construction types.

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**Technical Group TGS8 : "Steel products and applications for building, construction and industry"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/250	F6.2/00	1.228.374	737.025	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Applicability of composite structures to sway frames

**OBJECTIVES AND CONTENTS**

The missing knowledge on the behaviour of composite structures designed as sway frames i.e frames capable to resist to horizontal forces without being supported by other structures, leads to the common design practice to use concrete cores or concrete buildings as main structures which give lateral support to composite structures. The proposed research project has the following two objectives; to demonstrate the reliability of stand alone composite frames and to give design guidance to structural engineers by providing design and detailing rules for composite frames as stand alone structures. The result of this project would significantly help to promote the use of composite structures as main frame solutions and to avoid concrete core or other solutions where concrete structures are considered as main frames.

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7210-PR/251	F6.3/00	642.500	385.500	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Risk-based fire resistance requirements

**OBJECTIVES AND CONTENTS**

The current fire resistance requirements in national have been found to vary significantly. In this project, a fire risk assessment method will be developed to provide a rational basis for implementing fire resistance requirements in national regulations in such a way that fire resistance requirements will not have a bigger role than justified by their role in reduction of risks. The benefits of the method to steel construction industry and the whole society will be demonstrated in different types of occupancies.

**State of progress:** Research completed; publication EUR N° 21443 EN

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7210-PR/252	F6.4/00	1.342.000	805.200	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Novel jointing systems for the automated production of light gauge steel elements

**OBJECTIVES AND CONTENTS**

The broad objective is to develop novel jointing systems (clinching, linear mechanical jointing, combination of mechanical fasteners and gluing, etc.) including quality control for automated production of light gauge steel elements (like wall, floor, roof and truss elements) in order to improve the competitiveness of light gauge steel structures. The work includes mild steel and stainless steel. Additional sub-objectives of the project are : to determine performance criteria and detailed guidance for the choice of various jointing technologies and formulate design rules for the composite action between mechanically fasteners and glued boards.

**State of progress:** Research completed; publication EUR N° 21439 EN

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7210-PR/253	F6.5/00	955.954	573.573	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Design rules for cold-formed structural hollow section

**OBJECTIVES AND CONTENTS**

The objective of this project is to develop more reliable design rules for hollow section structures, because some of the present rules of Eurocode 3 seem to be unsafe and to extend the design rules of connections over high b/t ratios. Rules and practical guidelines for following technical design aspects will be developed: models for stress-strain properties, rotation capacity and limits for cross-section classification, reliable design rules and requirements for reliable welding of hollow sections connections, extension of the design rules in Eurocode 3 for welded connections for b/t>35. As a final result unified and practical guidelines will be developed. Hot-formed hollow sections will be used as a reference material.

**State of progress:** Research technically completed; publication in hand

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7210-PR/254	F6.6/00	1.215.000	729.000	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Calculation rules of lightweight steel section in fire situation

**OBJECTIVES AND CONTENTS**

The development of steel frame modular buildings is gaining increased interest throughout Europe. Lightweight steel frame structures are used in partitions and suspended ceilings and for load-bearing structures of rack-storage buildings or domestic houses. Currently there are no operational rules to assess the fire behaviour of these lightweight steel frames. The aim of the project is to develop simple calculation models to be incorporated in Eurocode 3-1.2 and in standards for extended application of fire resistance test results. Performing fire tests will check the validity of these calculation methods.

**State of progress:** Research completed; publication EUR N° 21426 EN

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/048	T3.1/00	2.438.500	1.219.250	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Ultra-high strength pipeline prototyping for natural gas transmission

**OBJECTIVES AND CONTENTS**

Steel and gas companies are showing an increasing interest in ultra high steel plates and pipes in the conceptual design of long distance gas pipelines. The project will examine problems of building a new pipeline with special emphasis on the issues of girth weld defect tolerance and the fracture propagation behaviour in high-pressure natural gas. The primary objective of the project is to define the realistic in-service behaviour of API X100 pipelines through the construction and testing of experimental pipelines. The obtained results could be used by gas companies to better define the suitable technical solutions with respect to safety/environmental and cost/effectiveness aspects for the assessment for more economic pipelines.

**State of progress:** Research completed; publication EUR N° 21440 EN

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7215-PP/058	TF6.3/00	2.000.000	1.000.000	42 (Mths)		1/07/2000	30/06/2002	31/12/2003

**Title:** Steel in residential buildings for adaptable and sustainable construction

**OBJECTIVES AND CONTENTS**

This proposal concerns the demonstration of steel in residential buildings in which the methods of achieving maximum use of adaptable space, and the wider environmental benefits of steel are realised. The adaptable use of space will be demonstrated by relocatable walls; extensions vertically and horizontally, and large modular units which can be moved and added to. The buildings will take the form of family houses and small and large apartment. The performance of the buildings will be monitored in service, before and after adaptation. The cost efficiency of the buildings will be monitored and incorporated into a global economic and environmental assessment of steel in residential buildings.

**State of progress:** Research completed; publication EUR N° 21420 EN

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7210-PR/290	D3.4/01	668.000	400.800	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Bainitic steels for new rail materials

**OBJECTIVES AND CONTENTS**

Rail steel are designed to resist wear and rolling contact fatigue caused by forces transmitted through the wheel/rail contact zone. The aims of the project are twofold: to investigate morphology, transformation characteristics and properties of bainite mixed with a low amount of lath martensite, as compared to conventional pearlite structure, and to define chemical compositions, for given hot rolling and in line/off line cooling conditions to achieve the optimum bainitic structure able to develop hardness values higher than 400 HB minimum tensile strength of 1400 MPa, good wear resistance and elongation = 10%. The welding behaviour will also be studied.

**State of progress:** Research technically completed; publication in hand

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7210-PR/303	F3.1/01	1.423.000	853.800	42 (Mths)		1/07/2001	30/06/2004	31/12/2004

**Title:** Improving the fatigue performance of welded stainless steels

**OBJECTIVES AND CONTENTS**

This project focuses on methods for improving the basic fatigue strength welded austenitic and duplex steels by choice of welding process or the use of post-weld improvement techniques.

**State of progress:** Research in progress

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7210-PR/305	F3.3/01	1.020.150	612.090	42 (Mths)		1/07/2001	30/06/2004	31/12/2004

**Title:** Stainless steels for wet conditions in municipal incineration and combustion plants

**OBJECTIVES AND CONTENTS**

This project aims at the characterisation of the corrosive environment in different parts of the wet cleaning systems in waste incineration and in fossil fuel plants. Application ranges of stainless steel in these environments will be defined. Through quantification of factors influencing the corrosion behaviour, knowledge will be added to the field of sew point corrosion. This will enable the use of stainless steels in different parts of the cleaning systems in question.

**State of progress:** Research in progress

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7210-PR/313	F5.2/01	1.230.000	738.000	48 (Mths)		1/07/2001	30/06/2004	30/06/2005

**Title:** Application of high strength steel plates to welded deck components for ships and bridges subjected to medium/high loads

**OBJECTIVES AND CONTENTS**

The project aims at finding new markets for high strength steel (HSS) plates which are weldable on field without any additional heat treatment and manufacturing very high stressed deck components to be used in marine and road structures. The project will focus on the definition of procedures for welding field components, made of HSS plates (Yield Stress up to 1100 MPa) and up to 16 mm thick, welded by conventional and laser technologies, in order to avoid any post heat treatment. The project will also focus on the design of high performance welded decks of both traditional and sandwich shapes, in terms of stiffness, fatigue and impact fatigue resistance. The expected overall benefits concern the significant new market outlets of the HSS plates, safer and lighter components for ships and bridges and more accurate fatigue design of the existing European codes.

**State of progress:** Research in progress

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**Technical Group TGS8 : "Steel products and applications for building, construction and industry"**

DE-64289 DARMSTADT

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/314	F6.1/01	700.500	420.300	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title: Generalisation of criteria for floor vibrations for industrial, office, residential and public buildings and gymnastic halls**

**OBJECTIVES AND CONTENTS**

General design criteria for floor vibration checks do currently not exist and the present recommendations are neither satisfactory nor applicable to the prediction of the vibration behaviour of floor. Therefore design criteria are needed in order to have general specification of vibration excitations. Currently the design criteria depend on the individual demands of the specifier (e.g. owner). Also simplified vibration checks for floors to ensure the specific criteria are fulfilled, are required. The preparation of the design recommendations should be performed by the following steps: the evaluation of all existing materials, performance of measurements, dynamic numerical simulations and preparation of simplified methods.

**State of progress:** Research technically completed; publication in hand

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**Technical Group TGS8 : "Steel products and applications for building, construction and industry"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/315	F6.2/01	1.112.179	667.307	30 (Mths)		1/07/2001	31/12/2003	31/12/2003

**Title:** Large web openings for service integration in composite floors

**OBJECTIVES AND CONTENTS**

Steel or composite beams with large openings through the webs of the steel sections are commonly used and large service ducts are passed through the openings. The integration of services within the beam depth is important in order to minimise the floor zone in long span construction. The research will include test on composite beams with large rectangular and circular openings in regions of high shear. The tests will evaluate the local bending resistance, and issues such as control of local buckling and the effectiveness of web stiffeners. Design recommendations as well as simplified design tables will be presented for scheme design. Practical issues of fire resistance and service integration of this design guidance will lead to the greater use of long span construction with facility for service integration.

**State of progress:** Research completed; publication EUR N° 21345 EN

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**Technical Group TGS8 : "Steel products and applications for building, construction and industry"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/316	F6.3/01	968.500	581.100	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Earthquake resistant design. The "INERD" project

**OBJECTIVES AND CONTENTS**

Part one this research project intends to define design rules and is presented in two parts. Part one consists in a strengthening measure for lower storeys of reinforced concrete structures, by which steel profiles encased in the columns provides ductility and a basic reliable shear and compression resistance. This obviates the "soft storey" mechanism, frequent failure mode of R.C. buildings. Part two consists in using connections of diagonals of frames with bracing's as dissipate zones. This design, applicable to braced frames, which by nature are stiff, can accommodate without problem a local increase of flexibility and results in significant cost reductions of the structure.

**State of progress:** Research in progress

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7210-PR/317	F6.4/01	847.450	508.470	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Design method for steel structures in marine environments including the corrosion behaviour

**OBJECTIVES AND CONTENTS**

Design Codes for steel structures are based on a semi-probabilistic approach, taking into account the statistical distribution of the parameters that govern the design. The aim of the project is to introduce corrosion phenomena in design rules compatible with the semi-probabilistic philosophy. Corrosion parameters will be reviewed as regards their ability to represent corrosion behaviour. The consistency and simplicity of measurement techniques will be examined, leading to measurement procedures, and safety factors will be proposed. At last, design examples will demonstrate the relevance of the design concept proposed in this research. Therefore, the rational use of steel in structures will be reinforced, avoiding excessive safety rules that penalise steel related costs against competitive materials.

**State of progress:** Research in progress

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**Technical Group TGS8 : "Steel products and applications for building, construction and industry"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/318	F6.5/01	915.500	549.300	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Structural design of cold worked austenitic stainless steel

**OBJECTIVES AND CONTENTS**

The objective of the project is to develop comprehensive design rules suitable for structural elements made from cold worked stainless steel. The overall objective will be achieved by generating test results on commonly used materials grades at a range of cold worked strength levels, developing numerical models based on standardised methods and validated against the test results, developing a methodology in the form of design rules suitable for incorporation into standards which enable cold worked stainless steels to be used cost effectively and safely in structures, ensuring that the deliverables of the project are in a format that is readily disseminated and used in the EU.

**State of progress:** Research technically completed; publication in hand

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7215-PP/070	TF6.1/01	1.199.500	599.750	42 (Mths)		1/07/2001	30/06/2004	31/12/2004

**Title:** Steel in low-rise building, a symbiosis of cold formed sections and light rolled profiles

**OBJECTIVES AND CONTENTS**

Steel starts to be used in housing and low-rise buildings and this new way of building seems to have quite interesting future prospects. Several concepts for steel housing have been developed involving flat and long products. This project aims at selecting relevant economical solutions from existing building concepts and hence developing a symbiosis of cold-formed sections and hot rolled profiles. These developments will be done in different-fields of the building as well as in the load bearing structure and the roof structure. The project should also deal with the installation of the electric equipment, heating equipment, the water supply and all required technical services as well as certain system of insulation. This demonstration project will show that a suitable combination of all building components leads to logical, aesthetic and hence optimised and economical solutions.

**State of progress:** Research in progress

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***Technical Group TGS8 : "Steel products and applications for building, construction and industry"***

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**Technical Group TGS8 has 22 Projects and 119 Partners**

**Total Projects: 551 - Total Partners: 2135**



**Technical Group TGS9 : "Factory-wide control, social and environmental issues"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/169	E.2/99	1.003.500	602.100	48 (Mths)		1/07/1999	31/12/2002	30/06/2003

**Title:** Improved detection of radioactivity in scrap

**OBJECTIVES AND CONTENTS**

Over the last decade, the problem of possible meltdown of radioactive material inadvertently getting into the scrap supply chain has been recognised worldwide. Many steel companies and other non-ferrous metal producers have installed proprietary radiation detection equipment at the point of entry, usually on a road weighbridge and/or on rail line. The work programme of this research will involve: an evaluation of scrap supply routes to the furnace in order to determine the best locations for detection systems; improvements in detection algorithms; the development of a new detector for operation on magnet/spider cranes; the mathematical modelling of radiation propagation through scrap and experimental trials on novel and existing systems. The results of this research will improve the degree of prevention of radioactive contamination risks for the workers and the surrounding plant environment.

**State of progress:** Research completed; publication EUR N° 21629 EN

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**Technical Group TGS9 : "Factory-wide control, social and environmental issues"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/195	B.2/00	860.500	516.300	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Characterization, modelling & validation of the impact of iron and steelmaking slags used in road construction on groundwater

**OBJECTIVES AND CONTENTS**

The main goal of this research is to develop a method for the elaboration of a technical guide for using slags in road construction with a view to preserve the quality of groundwater. The following areas will be addressed: characterisation of iron and steel making slags and slag mixtures with tests of their behaviour to water, application of pollution transfer models taking into account the preceding characteristics and hydro-geological and weather conditions of the site used. Finally a technical guide for the use of slags in various contexts will be elaborated.

**State of progress:** Research completed; publication EUR N°

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7210-PR/228	E.1/00	1.307.179	784.308	48 (Mths)		1/07/2000	31/12/2003	30/06/2004

**Title:** On-line measurement of magnetic properties of electrical steel strip

**OBJECTIVES AND CONTENTS**

The objective of this projects is the development, testing and optimisation of an electric device for measuring standardised magnetic properties of a non-oriented electrical steel strip moving inside a processing line. This will be the first equipment in the world which enables the manufacturers of this kind of materials to determine accurately the magnetic properties of their products (including magnetic anisotropy without the necessity of cutting samples from each coil and performing measurements on them off-line).

**State of progress:** Research technically completed; publication in hand

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7210-PR/229	E.2/00	851.500	510.900	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Assessment of steel inclusions cleanliness by mixed NDT methods

**OBJECTIVES AND CONTENTS**

Inclusions cleanliness remains an important factor of steel quality. Present non destructive techniques (NDT) are not sufficient to assess it. Lack of inclusions cleanliness in steels for packaging applications is also a large source of class lowering and disputes with customers. This project aims at improving, on one hand ultrasound and micro-radiography combined with data fusion techniques and numerical signal processing for the inspection of as-cast samples and on the other hand magnetic stray flux method using giant magneto resistive heads for the on-line inspection of cold rolled strips. Validation and comparison trials will be performed on as-cast and rolled samples. The main impacts will be the reduction of off-cut, scarfing and class lowering and an increase of the trade acceptance of steel.

**State of progress:** Research completed; publication EUR N° 21729 EN

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7210-PR/230	E.3/00	929.650	557.790	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** New developments for the quantification of non conductive materials (slags, inclusions) in steel industry by optical emission spectrometries (laser, spark)

**OBJECTIVES AND CONTENTS**

In modern steel making, process control has become a top priority, with a special emphasis on slag and steel chemistry. Steel cleanliness assessment must be performed ever faster and more accurately, making optical emission spectroscopy a tool of choice for analytical laboratories. The aim of this project is to develop fast and robust models for the slag composition control during steel making and the quantification of inclusions in the final product using laser and spark sources.

**State of progress:** Research completed; publication EUR N° 21415 EN

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7210-PR/231	E.4/00	1.609.875	965.925	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** Fast analysis of production control samples without preparation

**OBJECTIVES AND CONTENTS**

The focus of the project is to develop new strategies for fast process control, resulting in drastically reduced control delays in parallel with reduced investment and maintenance costs at all stages where process needs fast analytical control. The global analytical productivity improvement will result in adapting new types of liquid steel, pig iron and slag samplings to innovative preparation methods that can be introduced in parallel with the laser-OES spectrometry application.

**State of progress:** Research completed; publication EUR N° 21694 EN

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7210-PR/232	E.5/00	1.072.562	643.537	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title:** GDOES expert system for at-the-line-control of coated steel products

**OBJECTIVES AND CONTENTS**

The aim of the project is the generation of a data-base and expert system for a systematic collection and evaluation of glow discharge optical emission spectrometry (GDOES) analysis results. A consequent long-term evaluation of the analysis data and their junction to short-term quality parameters (like T-test, thickness, and homogeneity of the coating) could supply important information about the quality of different process stages and the material quality. The long-term data collection in production control requires some fundamental improvements in analysis and calibration techniques, statistical description of the analysis data like repeatability and reproducibility, etc. to evaluate the reliability of information.

**State of progress:** Research completed; publication EUR N° 21341 EN

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7210-PR/234	E.7/00	1.281.675	769.005	36 (Mths)		1/07/2000	30/06/2003	30/06/2003

**Title: Implementation of a knowledge based system for control of steelworks waste water treatment plant (Knowater-II)**

**OBJECTIVES AND CONTENTS**

The project's aim is to improve the treatment of effluents arising from steelwork processes concerning environmental performance and legal compliance by development and application of Knowledge-based System (KBS) to waste water treatment plants. Furthermore, a significant beneficial effect on the environment by reducing the flow of untreated effluents and by maintaining wastewater within the levels specified by the local authorities is expected. A former ECSC RTD contract work on the feasibility of developing such KBS has proved this technology to be economic and effective. KBS shall now be applied to industrial plants to verify its robustness and to confirm the benefits that can be achieved in practice. The system shall be easily transferable to any production site in order to be used by plant operators to maximum beneficial effect.

**State of progress:** Research technically completed; publication in hand

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7210-PR/235	E.8/00	1.013.422	608.054	42 (Mths)		1/07/2000	31/12/2003	31/12/2003

**Title:** Advanced process control for biological water treatment plants in steel works

**OBJECTIVES AND CONTENTS**

Steel production gets more flexible causing varying influents to process integrated water treatment. Operational demands on these treatment plants increase continuously and biological treatment can help to meet these requirements satisfactorily. An innovative approach to this is to apply advanced, model based control for intelligent biological water treatment. This methodology will lead to lessen the energy consumption, the treatment agents input and the sludge dumping. Process water supply by biological treatment gains stability and flexibility by quick, predictive control. This new application (biological treatment, to introduce model based control) for the iron and steel industry a process-control model shall be developed, tested and optimised in laboratory, half technical scale and operational trials.

**State of progress:** Research technically completed; publication in hand

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**Technical Group TGS9 : "Factory-wide control, social and environmental issues"**

Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7215-PP/055	T4.2/00	1.625.000	812.500	42 (Mths)		1/07/2000	30/06/2003	31/12/2003

**Title:** Combined measuring system for an improved nondestructive determination of the mechanical/technological material properties of steel sheet

**OBJECTIVES AND CONTENTS**

The aim of the project is to develop and to test a pilot measuring facility based on a combined non-destructive multi-parameter testing method for rapid determination of direction-dependent mechanical/technological properties of steel sheet. The technology to be developed within this project shall meet operative requirements e.g. to be insensitive to operating disturbances, to reduce measurement uncertainty to be almost independent from influences by different steel grades, and to reach high reproducibility and easy calibration for different processing lines. Pilot tests on production units will be carried out and laboratory trials and suitable models shall help to determine the correlation between the material properties and the electro-magnetically measured variables.

**State of progress:** Research completed; publication EUR N° 21339 EN

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7210-PR/267	C1.2/01	1.037.770	622.662	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Sustainable agriculture using blast furnace and steel slags as liming agents

**OBJECTIVES AND CONTENTS**

Steel industry develops fertilisers from BOF steel slag, which could be used to provide agriculture with excellent liming agents to protect soil to acidify. These new fertilisers are in competition to natural liming materials. This research should show that steel slags are good fertilising materials with no harmful effects on the soil and to the groundwater. Test fields, which have been treated with fertilisers from iron and steel slag on long-term experiments, will be investigated to draft clear statements on the sustainable effects of the use of iron and steel slags in agriculture.

**State of progress:** Research technically completed; publication in hand

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/296	E.1/01	1.450.300	802.380	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** Development of techniques for the production of glassy standard materials for the analysis of slags by spectroscopic method

**OBJECTIVES AND CONTENTS**

The aim of the project is the development of new techniques for the production of pure glassy reference material for slag analysis without sample preparation. The availability of pure glassy reference and testing material will improve productivity by the fast analysis of slags without preparation for the whole iron and steel production.

**State of progress:** Research technically completed; publication in hand

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7210-PR/297	E.2/01	1.040.500	503.100	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** High spatial resolution analysis of steel samples using laser ablation ICP-MS

**OBJECTIVES AND CONTENTS**

There is a general need for improved as well as more cost-effective, methods for spatially resolved elemental analysis of materials. The aim of this project therefore is to develop practical methods for laterally resolved microanalysis using state-of-the art Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) equipment, tailored to the needs of the steel industry. A successful outcome of the project will be beneficial for the competitiveness of European metallurgical industry, and it will also contribute to e.g. the safety of cars and the reduction of hazardous waste from steel plants.

**State of progress:** Research technically completed; publication in hand

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Contract N°	Reference N°	Budget (€)	Funding (€)	Duration	Dates:	Starting	Ending	Actual
7210-PR/298	E.3/01	1.529.500	917.700	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Fast characterisation of steel cleanness by advanced mathematical analysis of spark and laser source optical emission data

**OBJECTIVES AND CONTENTS**

In modern steelmaking the rapid availability of information concerning steel cleanness is essential. To provide this it is necessary to determine the size and type of inclusions. This project will focus on using mathematical techniques for the evaluation of data from spark and laser optical emission spectrometers to predict and certify steel cleanness rapidly. The objective is to devise data processing algorithms and test procedures to provide a five-minute indicative test for process samples and a fifteen-minute definitive test for products. These will be validated against present time consuming procedures.

**State of progress:** Research technically completed; publication in hand

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7210-PR/299	E.4/01	1.051.200	630.720	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Tracing of airborne dust

**OBJECTIVES AND CONTENTS**

The fine particulate matter (PM10), which pollutes the atmosphere, is derived from a range of sources, including the steel industry, other industrial processes, road traffic, and domestic fuel use. It is necessary to identify which sources are the most important, so that control measures can be targeted effectively. The aim of this project is to test a range of analytical methods and mathematical techniques, which can identify the PM10 originating from the steel industry. The work will identify which of the methods are the most cost-effective.

**State of progress:** Research in progress

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7210-PR/300	E.5/01	1.055.000	633.000	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title:** In-line assessment of steel cleanness during the secondary steel making process

**OBJECTIVES AND CONTENTS**

The aim of this project is to work out an appropriate steel cleanness index, to be used for in-line quality assessment during secondary steel making process. Another objective is to complete the information obtained in this way with a more precise knowledge of the inclusion size and distribution using statistical/stereological tools and distribution models. This ladle treatment in-line control will be based on the fast and simultaneous determination of the steel and slag chemistry.

**State of progress:** Research technically completed; publication in hand

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7210-PR/301	E.6/01	1.052.301	631.381	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** Eco-efficient technology for recovering acids and metals from rinse water in stainless steel pickling

**OBJECTIVES AND CONTENTS**

The objective for this project is to take a major step towards the close loop circulation of water in steel plant. This will be done by developing a method for removing also nitrates from rinse water in such a way that clean water can be fed to pickling acid regeneration plant, where acids can be separated and recycled back to the pickling use.

**State of progress:** Research technically completed; publication in hand

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7210-PR/302	E.7/01	787.677	472.606	42 (Mths)		1/07/2001	31/12/2004	31/12/2004

**Title:** On-line slag analysis utilizing contact free microwave technology

**OBJECTIVES AND CONTENTS**

Introducing on-line technology for slag analysis can radically reduce the delay time for slag analysis as well as simplify the analysis procedure. The objective of this project is to test, evaluate and introduce microwave technology as an on-line slag analysis tool on laboratory/pilot as well as production scale with the aim to reduce and to simplify the slag analysis procedure.

**State of progress:** Research technically completed; publication in hand

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**Technical Group TGS9 : "Factory-wide control, social and environmental issues"**

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7215-PP/063	T3.2/01	1.124.500	562.250	24 (Mths)		1/07/2001	30/06/2003	30/06/2003

**Title: Demonstration at full industrial scale of innovative ecological pickling process for cold rolled stainless steel strip able to improve on-line monitored surface appearance**

**OBJECTIVES AND CONTENTS**

The final stage in the production cycle of cold rolled stainless steel strips generally consists of a sequence of electrolytic and chemical pickling treatments. Their purpose is to produce a base metal free of scale and with an aesthetically good surface appearance. The objective of the project is to demonstrate, at full industrial scale, the technical feasibility of improved pickling cycles for cold rolled stainless strip, using a low-energy electrolytic descaling section, coupled with chemical pickling section. Both sections are operated with environmentally friendly pickling liquors, totally free from noxious emissions. A surface monitoring system is installed in order to guarantee consistently improved surface quality and surface aspect.

**State of progress:** Research completed; publication EUR N° 21690 EN

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7215-PP/067	T4.1/01	1.134.000	567.000	36 (Mths)		1/07/2001	30/06/2004	30/06/2004

**Title: On-line determination of laser weld quality for optimisation and real time control of welding**

**OBJECTIVES AND CONTENTS**

The overall aim of the project is to develop and to test in industrial conditions a pilot system based on advanced optical and non-contact ultrasonic techniques able to characterise on-line the weld quality as well as to improve the control of laser welding. The techniques will be applied in two cases: coil joining at the entry section of a rolling mill and tailored blank production. Moreover, it is intended to develop a model allowing to set criteria in order to decide whether the weld quality is sufficient or not with regard to the service requirements of a rolling mill.

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7215-PP/069	T4.3/01	1.622.108	811.054	45 (Mths)		1/07/2001	30/06/2004	31/03/2005

**Title:** Application of data-based technologies to demonstrate on-line quality control of mini mills

**OBJECTIVES AND CONTENTS**

To improve the hot strip quality of mini mills a concept for an on-line quality control system will be developed, implemented and some aspects will be demonstrated. The consideration of the interrelations between the different process steps concerning quality control is of main interest. To solve this problem and to investigate the relationships between process, plant and quality variables databases technologies will be applied. Because of the importance of surface quality the improvement of this feature is selected as demonstration example to show the suitability of the on-line quality control concept.

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7210-PR/294	T4/D3.8/01	1.142.350	685.410	39 (Mths)		1/07/2001	30/06/2004	30/09/2004

**Title:** New approaches to non-destructive characterisation of microstructure & applications to on-line control of steel quality (NANDACS)

**OBJECTIVES AND CONTENTS**

Increasing the productivity while maintaining a consistent quality is considered as one of the most important technical goals in the steel industry. As the process may require closed loop control management, real-time knowledge of the microstructure becomes essential. Existing evaluation systems have shown a number of limitations in their use, which could be overcome with recent developments such as laser ultrasonic or new X-ray diffraction inspection devices. This project aims at capitalising these recent developments and evaluating the respective potential of these developments for on-line determination of microstructures in different environmental conditions.

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Technical Group TGS9 has 22 Projects and 94 Partners

Total Projects: 573 - Total Partners: 2229