



Sart-Tilman - LIEGE



Zwijnaarde - GHENT

Annual Report

2008



CONTENTS

<i>Foreword</i>	2
<i>Companies affiliated to CRM</i>	4
<i>Organization</i>	
Supervisory Board	6
Iron and Steel Committee	7
Departments	9
<i>Income Data</i>	10
<i>Report on Research Activities</i>	
Product Technology	12
Finishing and Coating	16
Sustainable Production	20
Support to Regional and Federal Economy	24
Guidance, Technological Watch	25
<i>Publications</i>	26
<i>Conferences</i>	28

FOREWORD

2

During the year 2008, CRM has managed more than 80 research projects reinforcing its strategic poles of activities: Recycling and Sustainable Production, Products Technology, Surface Engineering, Technology Transfer and Guidance towards SME's.

In the collective steel research programme, under the management of the CRM active members ArcelorMittal and Corus, the developments were mainly focusing on the following installations or processes: sintering, blast furnace, by-products, electric arc furnace, hot and cold rolling, pickling and metallic coating. Other projects were aimed at the development of new generic steels.

Several of these projects have reached the industrial stage and are discussed within the present report.

The contribution of CRM to the European research remains important and has largely contributed to the development of new processes or products. CRM continues to support the RFCS programme, participating to many projects, more than 30 in 2008, and appointing experts to the project evaluation sessions and to the technical committees.

CRM is also participating to the Walloon Marshall Plan and to the different calls for projects, being supported by its industrial members. The success rate has been quite high and new projects have started in the field of construction, energy management and intelligent maintenance.

The project on "steel thixoforming" is progressing, the casting of small ingots having the well suited thixoformable microstructure has been successfully performed at Marichal Ketin. In the Mirage project, co-ordinated by ArcelorMittal, CRM has contributed by manufacturing sandwich panels, containing PCM for energy management in buildings.

The SME's are demanding more and more support from the CRM team in charge of the technology transfer and guidance activities. This activity, supported by the Walloon region, is still increasing with efficient co-ordination between the research centres active in metal and material development, especially with our partners in PiMW (Walloon Pole of Material Engineering).

With the agreement of its members, CRM has pursued its policy for commercial exploitation of some of its inventions. CRM has finalised the development of a surface conversion treatment called "Silicalloy". A first industrial application was successful. The low cost nanocoating "Silicalloy" is applicable in continuous high productive lines on metals and galvanised products. De Leuze S.A. has been licensed for the commercialisation of this Cr-free coating solution.

In other fields of application, the attractiveness of the CRM Tempcore® and MULPIC® cooling processes, for respectively the production of rebars and plates, remains high thanks to the outstanding partnerships with our members.

Priority has been given to the improvement of safety in our laboratories and pilot lines. Thanks to the assistance of ArcelorMittal and Corus, the best safety tools have been implemented. The encouraging result of this policy is one full year without accident. We would like to thank all personnel members for this performance.

In these difficult times, CRM continues to accommodate its management. A high flexibility has been put in place, facing the challenging situation and portfolio evolution, while ensuring high efficiency, cost control and on time delivery. Our main objective remains consisting in the generation of innovative ideas that will be rapidly developed and implemented in industrial plants.

In the year 2008, CRM has participated to the creation of two patrimonial joint ventures with OCAS and AMLR, two research laboratories of ArcelorMittal.

In the “Metal Processing Centre” (MPC joint venture) at Zwijnaarde, the CRM has amalgamated its main pilot assets operating in the field of rolling and thermal treatment with those of OCAS research centre. The new company assets amount to 4.8 MEUR.

The “Surfaces and Advanced Material Coatings” (SAMCoat) JV consolidates in Liège the surface treatment installations of the CRM and AMLR centres. Its assets amount to 6.6 MEUR.

The establishment of these two joint ventures does not change the CRM organization and management, all the new assets in the CRM perimeter are serving our partners.

On October 24, 2008, CRM celebrated its 60th anniversary as well as the establishment of the two joint ventures. This event was an opportunity to review the recent accomplishments and the future prospects.

Jacques PELERIN
ARCELORMITTAL S.A.
President CRM

Kris STEVENS
ARCELORMITTAL FCWE
Vice-President CRM

Rob BOOM
CORUS Research, Development & technology
Vice-President CRM

Jean-Claude HERMAN
CRM
Managing Director

COMPANIES AFFILIATED TO CRM

On May 14, 2008

4

Active Members

ARCELORMITTAL S.A. – G.D. Luxembourg
CORUS GROUP plc – United Kingdom

and every one of their subsidiary companies in the iron and steel industry.

The affiliated companies in the Benelux countries are :

ARCELORMITTAL Belval & Differdange S.A. (ex. ProfilARBED) - G.D. Luxembourg
ARCELORMITTAL Bettembourg S.A. (ex. TrefilARBED) - G.D. Luxembourg
ARCELORMITTAL Dudelange S.A. (ex. GALVALANGE) - G.D. Luxembourg
ARCELORMITTAL France S.A. (ex-USINOR) – G.D. Luxembourg
ARCELORMITTAL Luxembourg (ex-ARBED) - G.D. Luxembourg
ARCELORMITTAL Rodange & Schifflange (ex. ARES) - G.D. Luxembourg
ARCELORMITTAL STAINLESS BELGIUM N.V. (ex-Ugine & ALZ) - Belgium
ARCELORMITTAL STEEL BELGIUM S.A. (ex. SIDMAR) – Belgium
COCKERILL SAMBRE S.A. (ARCELORMITTAL Group) - Belgium
CORUS STAAL B.V - The Netherlands
INDUSTEEL BELGIUM (ARCELORMITTAL Group) - Belgium
SEGAL S.A. (CORUS Group plc) - Belgium

Associated Members

AIR LIQUIDE INDUSTRIES BELGIUM S.A. – Belgium
ÅKERS BELGIUM S.A. – Belgium
AMEPA GmbH – Germany
CARMEUSE S.A. – Belgium
CARRIERES ET FOURS A CHAUX DUMONT-WAUTIER S.A. - Belgium
CARSID – Belgium
CBMM Technology Suisse S.A. – Switzerland
CMI S.A. – Belgium
COMET TRAITEMENTS S.A – Belgium
CONVERTEAM S.A. – France
CUMERIO – Belgium
CYTEC S.A. – Belgium
DE LEUZE S.A. – Belgium
DREVER INTERNATIONAL S.A. – Belgium
DUFERCO CLABECQ S.A. – Belgium
DUFERCO LA LOUVIERE S.A. – Belgium
FONDERIES MARICHAL KETIN & Cie S.A. – Belgium
LE FOUR INDUSTRIEL BELGE S.A. – Belgium
GONTERMANN-PEIPERS GmbH – Germany
HERAEUS ELECTRO-NITE INTERNATIONAL N.V. - Belgium
HERSTAL S.A. – Belgium
INDUCTOTHERM S.A. – Belgium
INSTITUT BELGE DE LA SOUDURE asbl – Belgium
INTERNATIONAL MANGANESE INSTITUTE - France
IRM Group S.A. – Belgium
MAGOTTEAUX INTERNATIONAL S.A. – Belgium
MULTISERV S.A. – Belgique
PAUL WURTH S.A. - G.D. Luxemburg
PRAYON S.A. – Belgium
PRÜFTECHNIK DIETER BUSCH A.G. – Germany
SIEMENS VAI METALS TECHNOLOGIES GmbH - Austria
TECHSPACE AERO S.A. – Belgium
THY-MARCINELLE S.A. – Belgium
TI GROUP AUTOMOTIVE SYSTEMS (BELGIUM) S.A. - Belgium
UMICORE S.A. – Belgium
WHEELABRATOR ALLEVARD – France

ORGANIZATION

on May 14, 2008

Supervisory Board

6

President

Jacques PELERIN, General Manager Country Wallonia, ARCELORMITTAL

Vice-Presidents

Kris STEVENS, Vice-President – Progress Academy, ARCELORMITTAL FCWE

Rob BOOM, Director R&D, Strategy & Competence, CORUS Research, Development & Technology

Administrators

Georges ALLO, Conseiller Scientifique, SPF Economie, PME, Classes Moyennes et Energie

Michel BEGUIN, Managing Director, ARCELORMITTAL Liège Research

André BOCK, Senior Vice-President, ARCELORMITTAL

Jacques CHARLES, Vice-President Research & Development,
ARCELORMITTAL STAINLESS FRANCE

Pinakin CHAUBAL, Process Program Manager, ARCELORMITTAL Research S.A.

Jean-Pierre COHEUR, Professeur, Université de Liège

Jozef DILEWIJNS, Professor, Universiteit Gent

Chris ELLIOT, Director Technical Construction & Industrial, CORUS RESEARCH

Carlos ESPINA, Vice-President, ARCELORMITTAL Research & Development

Robert JOOS, Directeur Général, Groupement de la Sidérurgie

Herwig JORISSEN, Secretaris-Generaal, Centrale der Metaalbewerkers van België

Vincent LECOMTE, Directeur Général, S.A. des Fonderies Marichal, Ketin & Cie

Paul LIAKOS, Secrétaire Général, ACV-Metaal/CSC-Métal

Greg LUDKOVSKY, Vice-President of Global R&D, ARCELORMITTAL R&D

François MUDRY, GM Scientific Advisor, ARCELORMITTAL R&D

Margriet NIP, Director Product & Market Development, CORUS Strip Products IJmuiden

Sven VANDEPUTTE, General Manager, ARCELORMITTAL R&D Industry Gent

An VAN DE VEL, Scientific Relation Manager, UMICORE RESEARCH

Wim VAN RIJSWIJK, Manager Packaging Steel Programme, CORUS RD&T

José VERDIN, Représentant Centrale de l'Industrie du Métal de Belgique

Observers

Yvon MASYN, Innovatie door Wetenschap en Technologie in Vlaanderen

Pierre VILLERS, Inspecteur Général ff, Direction Générale des Technologies, de la Recherche
et de l'Energie de la Région Wallonne

Jean-Claude HERMAN, Directeur Général, CRM

Auditor

Dominique JACQUET-HERMANS

Iron and Steel Committee

Members

7

ARCELORMITTAL Group

J.P. ALLEMAND, ARCELORMITTAL RESEARCH S.A
M. BABBIT, ARCELORMITTAL RESEARCH S.A
M. BEGUIN, ARCELORMITTAL RESEARCH S.A
J. CHARLES, ARCELORMITTAL STAINLESS FRANCE S.A.
P. CHAUBAL, ARCELORMITTAL RESEARCH S.A.
C. ESPINA, ARCELORMITTAL RESEARCH S.A
J. HOFFMANN, ARCELORMITTAL LUXEMBOURG S.A.
J.-M. STEILER, ARCELORMITTAL RESEARCH S.A.
S. VANDEPUTTE, ARCELORMITTAL R&D INDUSTRY GENT

CORUS Group

R. BOOM, CORUS STAAL B.V.
C. ELLIOT, CORUS CONSTRUCTION AND INDUSTRIAL, UK
M. NIP, CORUS STRIP PRODUCTS NL
W. VAN RIJSWIJK, CORUS RD&T

CRM

J.-C. HERMAN
Ch. MARIQUE

QUALITY MANAGEMENT SYSTEM CERTIFICATE

ISO 9001 : 2000

The BQA, sa hereby declares that the quality management system of CRM (Centre de Recherches Métallurgiques)



located at Avenue du Bois Saint-Jean, 21 – 4000 Liège - Belgium, has been examined on 08-01-2007 and found in conformity with the ISO 9001, edition 2000, standard for the following application field:

Industrial research and associated activities such as testing, calibration and expertise

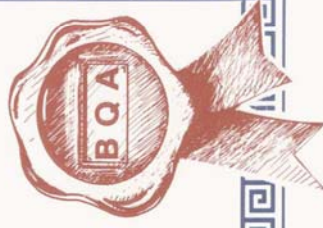
This certificate has been issued by the BQA, sa according to its quality manual concerning the certification of quality systems, and after concluding the contract of certification N° DS/AJ/CER/08-01-2007/336, under which the company accepts a regular control of its quality management system.

Certificate N° C/08-01-2007/336
Valid until 08-01-2010



BQA N° 019-QMS

D. SIMOENS
Director



DS/AJ/C/08-01-2007

Any person aware of misuse of this certificate may address himself to the BQA, sa. This certificate may only be disclosed in its entirety.
BQA, sa - rue Monoyer 24 (89) - 1000 Brussels.

DEPARTMENTS

on March 9, 2009

Managing Director
Jean-Claude HERMAN

Steering Committees
Creativity and Innovation (SIMON P.)
Technology Transfer and Valorisation
Breakthrough projects
Activity Clusters (Dpt Heads)

Management staff
LANNOO G.
MAIRY B.
MARIQUE C.

Product Technology (D1)
LANNOO G. MARIQUE C.
TOLLENEER I. NAVEAUP.

Surface Engineering (D2)
CRAHAY J.
BORDIGNON M.
SCHMITZ A.
SCHMITZ B.

**Sustainable Production
& Upstream Process (D3)**
VANDERHEYDEN B.
NYSSSEN P.
STEYLS D.

**Adv. Materials, Solutions
& Sensors (D4-D7)**
TUSSET V.
FOURNEAUX P. MONFORT G.
WALMAG G. MOREAS G.

Support expertise and technical teams

Metal Science (D6)
VANDEN EYNDE X.

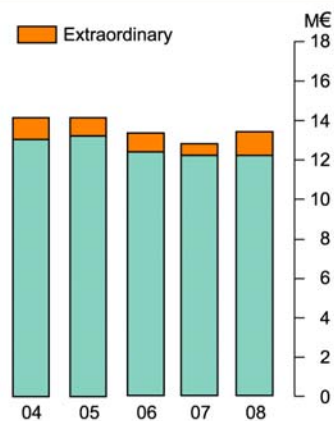
Operational Engineering (D5)
UIJTDEBROEKS H.
FISCHBACH JP. ABREU E.
NOVILLE JF.

**Personnal, Finances & IPR
(D8-D10)**
MAIRY B.
FUDALI S.
GREGOIRE J.

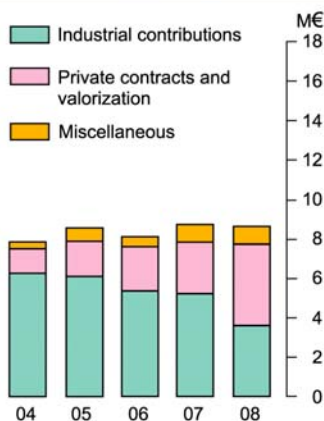
INCOME DATA

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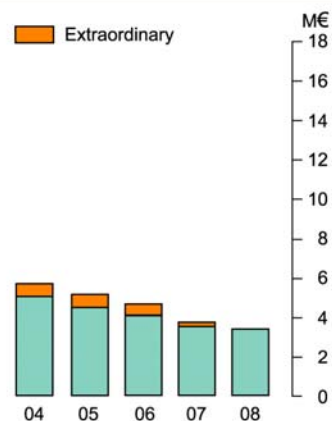
Income



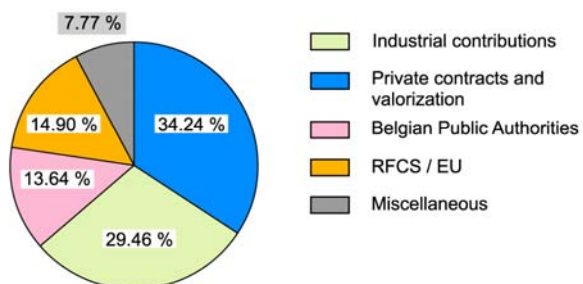
Industrial participations



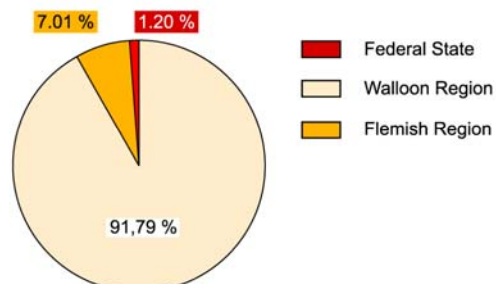
Grants



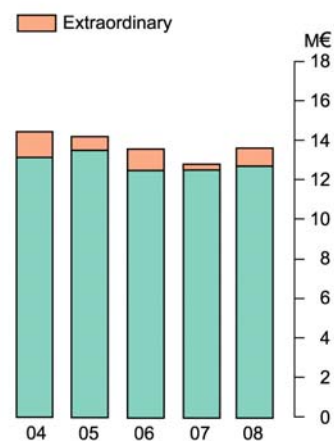
Income by source : 12.235 M€



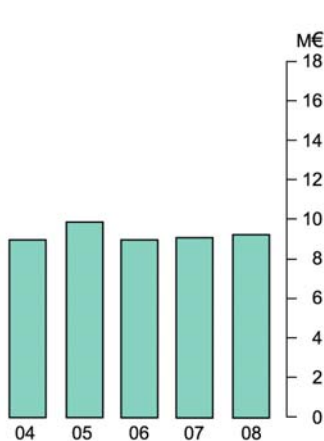
Belgian grants : 1.668 M€



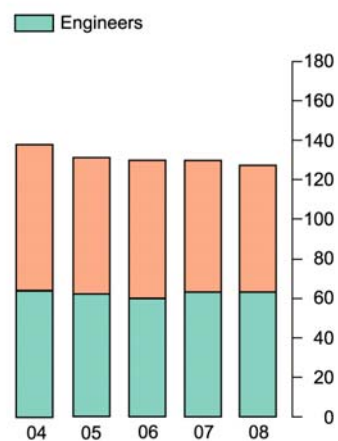
Expenses



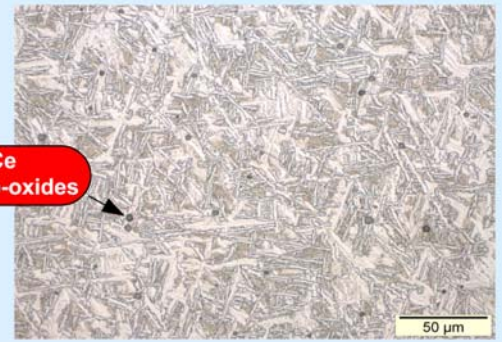
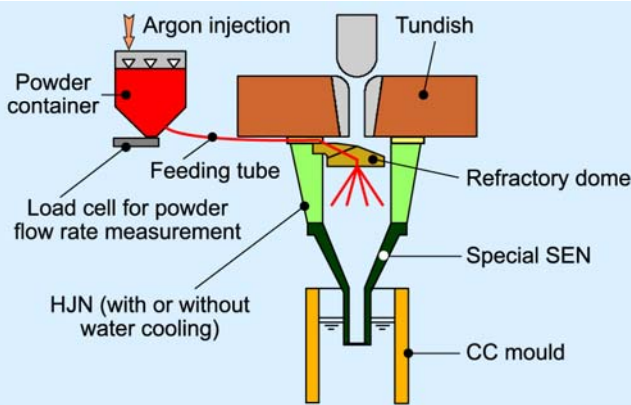
Personnel



Number of employees



Report on Research Activities



Hollow Jet Nozzle technology. (HJN)

Homogeneous distribution of fine particles in hot rolled product.

PRODUCT TECHNOLOGY

12

The interactions between process and product are one of the key aspects that drive the actions and competences of CRM.

Two major axes of development characterize the activities of this department:

- Innovation and optimization in process.
- Basic metallurgy study of new product concepts.

Large scale test facilities at Ghent and Liege allow to cover processing steps from metal solidification and casting to rolling and thermal treatment.

The equipment located in Ghent is managed since end of 2008 inside a joint venture with ArcelorMittal-OCAS called "MPC" (Metal Processing Centre).

Casting

Using the pilot casters available at Liege, a new way to produce high resistance steel is explored in the frame of two RFCS projects with ArcelorMittal (Flat carbon and Stainless steels). The basic concept is to inject in the liquid metal,

just before the casting mould, dispersoid elements acting as inoculants to refine the solidification structure.

Successful trials have been conducted with this Hollow Jet Nozzle technology to add ferro-cerium powder in a resulphurized DP steel grade.

Very fine sulpho-oxides of cerium (average size: 1.4 µm) homogeneously distributed in the as-cast structure have been observed.

During reheating and rolling, these precipitates reduce the growth of the austenite phases and promote the formation of very fine acicular ferrite phase in the final hot rolled product.

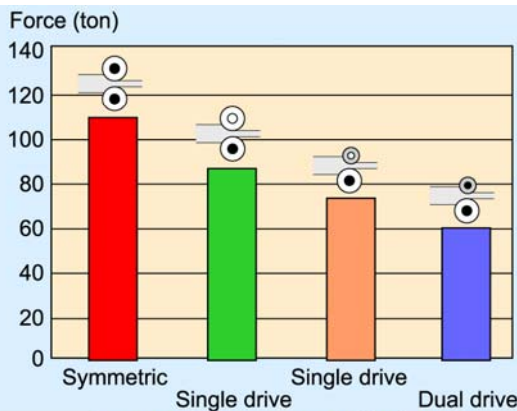
Hot Rolling

Let us recall the availability of a unique continuous hot rolling pilot line located in Ghent and allowing to test and simulate a large variety of operating conditions and industrial lay-outs.

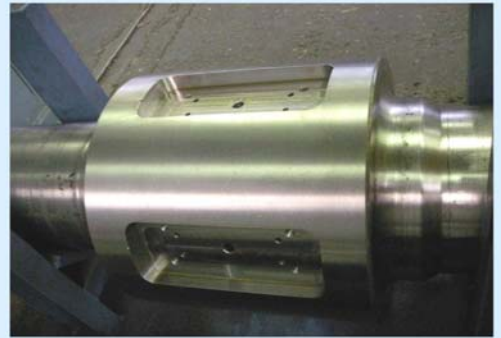
- After an adaptation of the hot rolling pilot line, several continuous trials have been

Continuous hot rolling pilot line.





Impact of the asymmetrical mode on the rolling force.



Pilot working roll machined to include "inserts"

performed with different asymmetrical rolling configurations.

A comparison has been made by changing the roll diameters for both dual- and single-drive layout. For all the tested configurations, a significant reduction of the rolling force has been observed and the model for calculating rolling forces in asymmetric mode has been adapted.

The assessment of the work roll performances during hot rolling is another important field of activity conducted with the support of rollmakers affiliated to CRM (Marichal Ketin and Äkers more particularly). The study of different roll materials on the pilot rolling line is made easier thanks to the use of the "inserts" technique. Several roll qualities can be compared under similar working conditions.

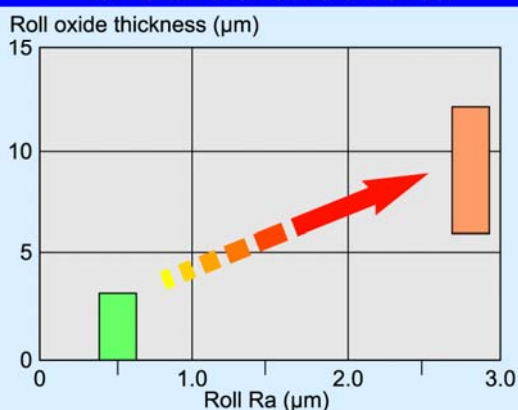
- Long-term test campaigns simulating the first stand of the hot strip finishing mill have allowed to more precisely identify the influence of two important operating parameters:
 - a higher initial roughness of the work roll after grinding positively affects the

formation of an adherent roll oxide layer that reduces the roll degradation,

- the application of a pure oil lubrication is not only beneficial to lower the rolling force but also to significantly decrease the work roll wear.
- A new project has been launched inside the European RFCS programme to investigate the roll degradation in the roughing mill. An adapted version of the on-line measuring unit called "Rollscope" and previously developed for the finishing mill has been implemented by CRM in the roughing mill of ArcelorMittal Dunkirk.
- The prevention of the steel oxidation during reheating and rolling is an essential issue to reduce production cost and improve the product quality. In line with one of the priorities of the Strategic Research Agenda of the European Steel Technology Platform (ESTEP), a new RFCS project aims to select possible protective means able to reduce the scale formation during reheating and rolling.
- In order to reduce the scatter observed in the material properties (mainly the

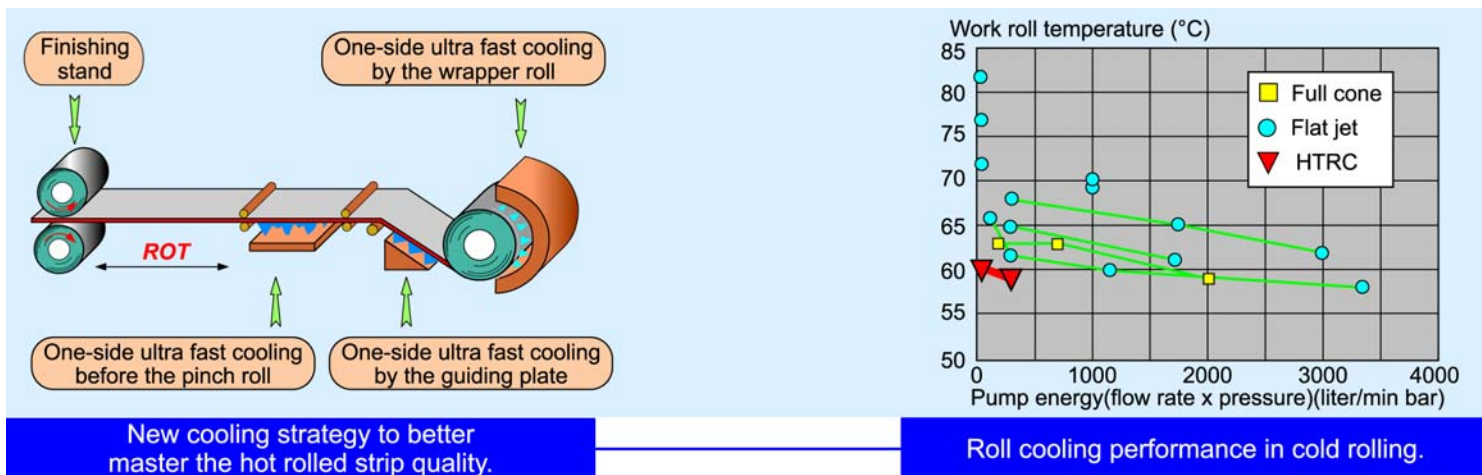
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Influence of initial roll roughness on the formation of an adherent oxide.



Rollscope unit in R5 Dunkirk.





14

mechanical strength) of hot coiled strip as well over the strip length as over the width, it is aimed to develop a new flexible and width-adaptable cooling device located before or at the coiler level. It will allow to adjust the cooling strategy based on the results of on-line iterative simulations and measurements of strip tensile properties. This development is conducted in the frame of a European RFCS project.

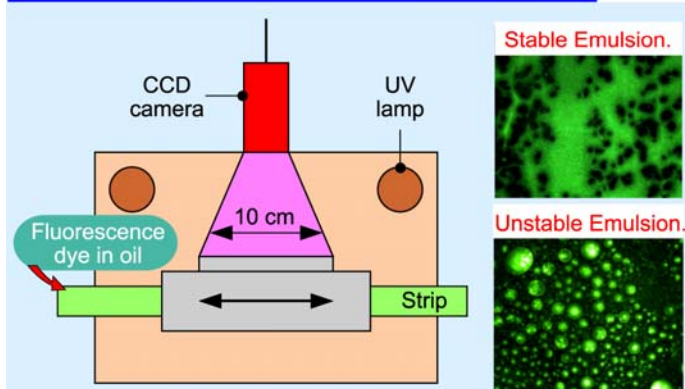
Cold rolling

- New cooling techniques for enhancing the processing performances during cold rolling are investigated in a RFCS project conducted in collaboration with ArcelorMittal. Pilot trials realized on the ARSA cold rolling mill at Maizières with the HTRC technology (High Turbulence Roll Cooling) have confirmed a high cooling performance of HTRC even with a very low water pressure of 0.5 bar. The energy consumption can be reduced by more than 90% compared to conventional nozzle cooling systems.

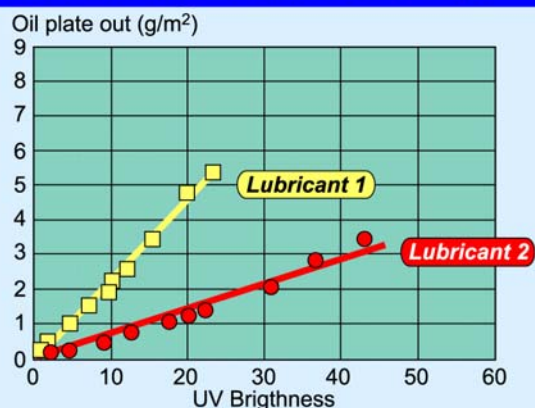
- Surface cleanliness in cold rolling is an important issue for final product quality aspects. Simulations on the formation and adherence of wear debris in relation with the lubricant parameters are conducted on the dedicated plate out / wash-off simulator built by CRM. In the frame of this RFCS project coordinated by Corus, the application of the remote LIBS technology for measuring on-line the sheet surface contamination is also realized. This LIBS unit has been acquired thanks to the support of EFRD (European Fund for Regional Development) and the Walloon Region.

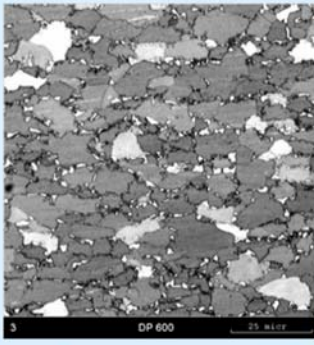
- The original method recently developed to determine the quantity and homogeneity of an oil film, plated out on a metal surface, has proven its efficiency and reliability. Stable or unstable emulsions can be quickly measured in a range between 0.02 g/m^2 and 5 g/m^2 . The technique is based on the use of fluorescence, UV lighting and a CCD camera.

Measurement of oil plate out by fluorescence.

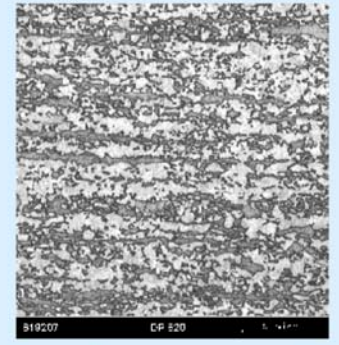
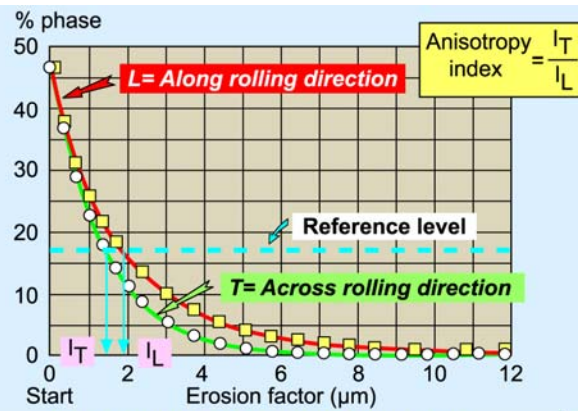


Quantification of the oil plate out on strip.





Low Anisotropy index: 1,05



Higher Anisotropy index: 1,30

Quantitative assessment of banding in multi-phase microstructure.

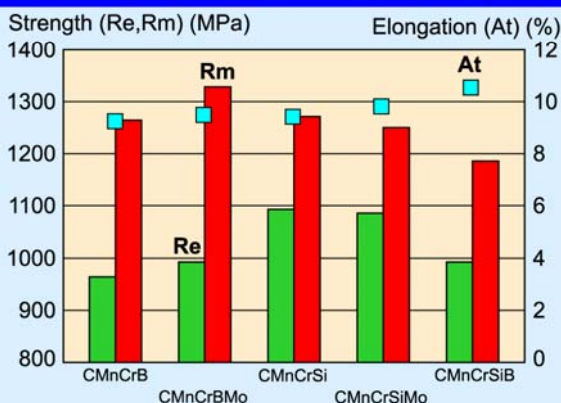
Thermal treatment and annealing

- The controlled production of advanced high strength steels implies a detailed quantification of the complex multi-phase microstructures, an objective pursued in the frame of a RFCS project involving also Corus and ArcelorMittal. CRM developed a quantitative assessment of banding due to macro-segregation for steels like DP or TRIP grades. The metallographic procedure relies on a mathematical treatment of the electronic image. The surface occupied by one representative phase is progressively eroded. This progressive erosion is made along and across the rolling direction and shows a faster evolution across the rolling direction when banding is present. It leads to define an anisotropy index, helpful to better classify the different steel grades.
- Other RFCS research conducted with ArcelorMittal and Corus aim at developing new high resistance steel grades by:

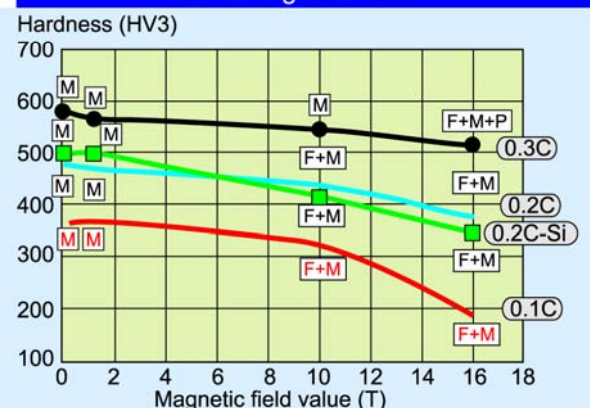
 - exploiting the formation of a hot rolled tempered martensite through the application of a quench & tempering cycle in existing hot rolling lines (quench before coiling and tempering in the coil). High tensile strength can be reached while keeping a good elongation level.
 - favouring the formation of ultra-fine bainitic structure while limiting the consumption of alloying elements such as niobium. Gaining more basic knowledge in this field is necessary, as the influence of alloying elements on the bainitic hardenability has not been studied yet as extensively as the martensitic hardenability.
 - applying a high magnetic field to influence the recrystallisation and phase transformation of steel during annealing (a collaboration with the University of Liège - Supras laboratory). Depending on the steel grade, it has been shown that an increasing magnetic field alters the martensitic structures, promotes the presence of a higher ferrite fraction after quenching and softens the microstructure.

15

Mechanical properties of martensitic grades.



Softening a martensitic structure with a magnetic field.





SAMCoat
Surfaces & Advanced Material Coatings



Galvanizing pilot line.

Small scale pickling simulator.

FINISHING AND COATING

16

The activities of this department are clustered around some major fields covering the surface preparation of metallic products (pickling, degreasing), the annealing, the metallic coating and the post-conditioning treatments.

The development of new coatings concepts and advanced materials are also part of the activities as well as the detailed characterization and analysis of the produced materials.

Unique pilot installations and characterization equipment are available to support these actions.

It has to be especially pointed out that the continuous annealing and galvanizing pilot line of CRM is integrated since the end of 2008 in a joint venture with ArcelorMittal Research Liege, nicknamed "SAMCOAT" (Surfaces Advanced Metallic Coatings).

Pickling

To support the projects conducted in this area aiming to optimize strip surface quality and to partially or totally replace the use of acid species for removing oxides layer from

steel strip, a small simulator has been built that complements the large scale equipment available on the CASTL line. Let us recall that the CASTL line has been erected with the financial support of EFRD and the Walloon Region.

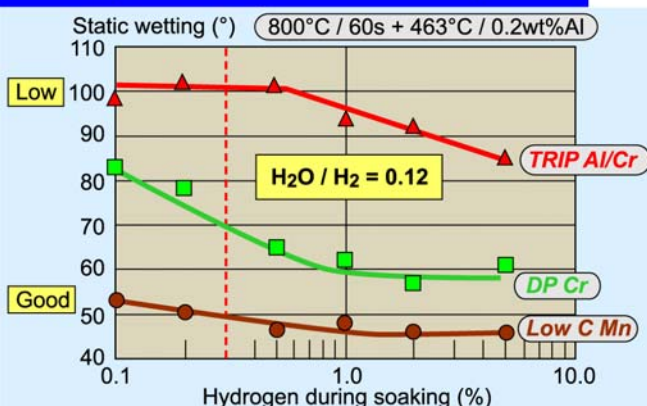
Hot dip galvanization

- For an efficient galvanizing of high strength steels, an appropriate control of the annealing furnace atmosphere has to be carried out combining a high dew point in a first section and a sufficiently high level of hydrogen in a second one.

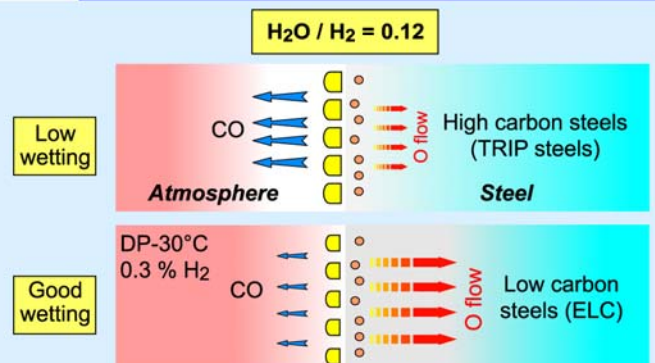
A new process window has been searched for aiming to replace the injection of water vapor by a partial reduction of the hydrogen amount. It has been shown that the benefit of a higher oxidation potential is only kept when the hydrogen level in the furnace is higher than 1%. It is due to the action of the steel carbon that rapidly diffuses to the free surface and reduces the amount of active water vapor.

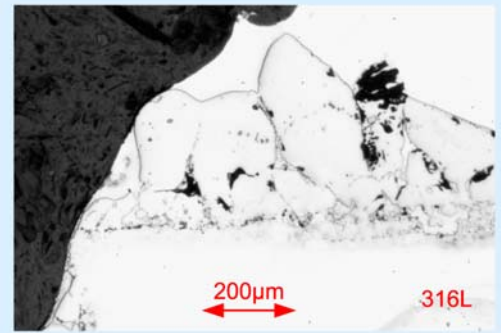
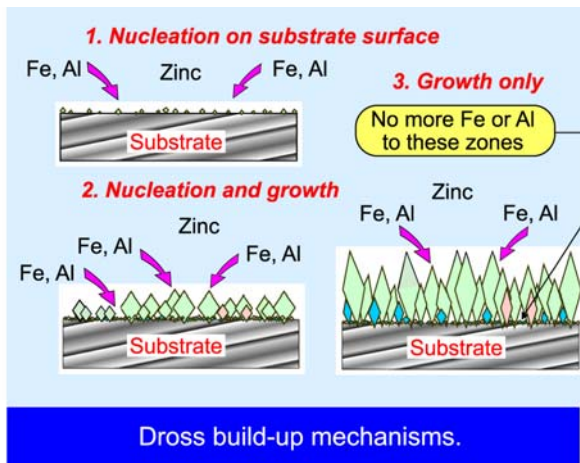
- Dross growth on rolls and hardware immersed in zinc bath is associated with the

Wetting performance of different steel grades.



Oxidation-reduction mechanisms during soaking.





Cross section view of dross.

occurrence of stringent defects on galvanized strip.

To identify the build-up mechanisms, pilot line tests at CRM and industrial campaigns have been performed. Samples of various materials have been placed on roll flanges and supports for the duration of a full galvanizing campaign (GI or GA). At the same time, samples have been placed in static situation and removed from time to time in order to gather some kinetic data.

Dross build-up has appeared depending on the hydrodynamic situation in the bath (higher is the local zinc velocity, bigger is the build-up).

Most probable evolution is, firstly, the nucleation of Fe_2Al_5 small germs on the rolls, then followed by a continuous Fe and Al feeding of those crystals supplied by the saturated flow of zinc along the roll. When the bigger crystals have reached a sufficient size, the transport of Al and Fe towards the substrate surface is blocked, preventing underneath crystals growth.

As shown during several test campaigns, this dross build-up is quite independent of the base

material. Even non-wetting materials (like graphite or WC layers) are sensitive but the formed dross layer is easier to be removed from these materials.

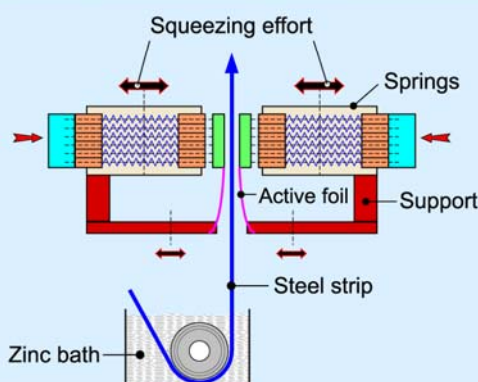
- A new wiping concept has been experimented on the continuous pilot line at a speed of 70m/min.

Based on a pair of thin metallic foils supported by mechanical actuators and located at the exit of the zinc bath, it aims to progressively squeeze the liquid coating down to a few microns. The objective is to find an alternative to conventional gas wiping limited by splashing at high line speed.

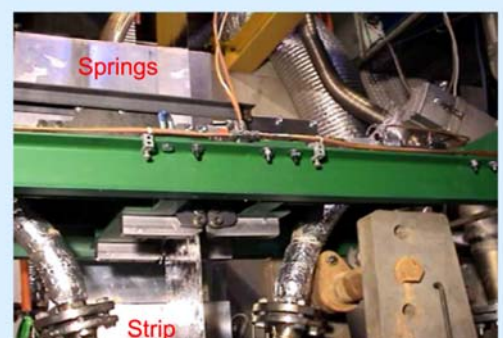
The wiping efficiency has not reached the expected level (~90/93% compared to the aimed 97%) due to very small dross particles rather rapidly entrapped between the foil and the strip. It has also failed to reach the expected few microns thin coating. This problem of dross will require to develop a specific solution to allow the further development of this new foil concept.

17

Advanced wiping with an active foil.

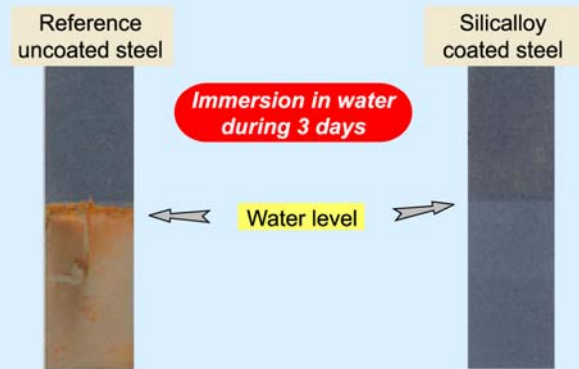


View of the foil wiping device.





Roll coating of Silicalloy.



Corrosion test.

18

Surface conversion treatment

- Aiming a full chromium- and VOC-free coating, a new system called “Silicalloy” has been developed by CRM thanks to the financial support of the Walloon Region and the collaboration with CoRi (Belgian Coating Research Institute).

This efficient, fast, green and low cost treatment, can be applied with a roll coater on steel or metallic strip. The formed layer is a very thin (100nm) hybrid coating made of silica and polymers. The combined structures provide hardness and flexibility. The other advantages of the coating are its transparency and hydrophobicity, that are key aspects for specific applications of finished products. As far as corrosion is concerned, this coating offers performances similar to those of the best conventional passivation products. The commercial valorisation and application of this new concept will be performed by Deleuze S.A., a company affiliated to CRM, through a development project of the “Marshall plan” supported by the Walloon Region and in partnership with CMI, CoRI and FUNDP.

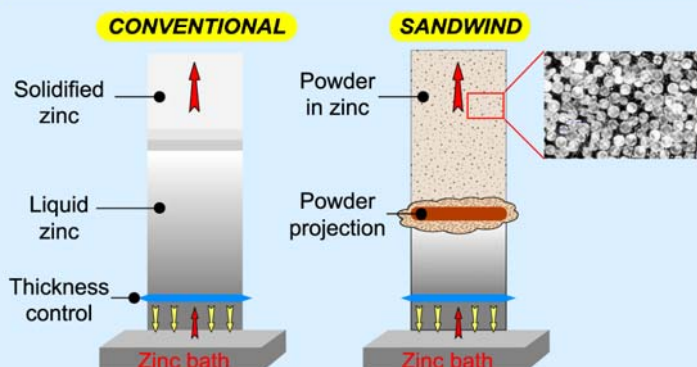
- The development of another post-treatment of the galvanized sheet aiming the incorporation of particles in the zinc coating layer before it gets solidified has been pursued with the support of the Walloon Region (“Sandwind” project).

Once the strip emerges from liquid zinc bath, the zinc excess is removed by gas wipers and then the strip is covered with a thin zinc film that solidifies at some distance upwards. The process takes profit of the section where the coating is still liquid to incorporate particles by jet sprays. By this method, significant improvements can be obtained in terms of reflectivity, surface aspect, friction, wear and resistance,

Tests have successfully been carried out on the galvanizing pilot line of CRM and evidenced the possibility to operate continuously while managing the powder flow and the coating adherence.

- A new project (“nicknamed “Clearzinc”) and dealing with the development of new protective coating concepts, possibly free of

Basic concept of the “Sandwind” process.

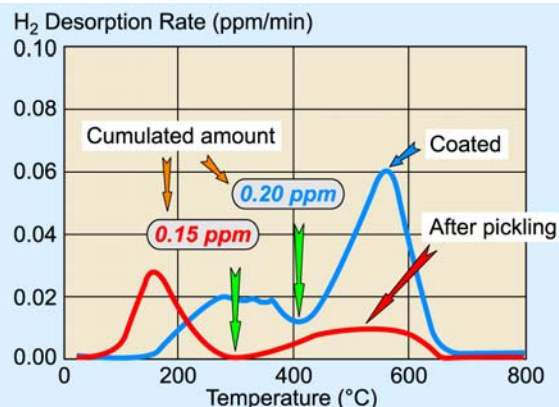


Sandwind pilot injection unit.





H2 measurement unit.



Hydrogen desorption curve on a coated sample before and after Zinc removal.

zinc, has been launched at the end of 2008 in the frame of the EFRD programme 2007-2013, supported by the Walloon Region.

Product characterization

- In the frame of a RFCS project, consisting to set up methodologies of hydrogen measurements in coated steels, CRM is dealing with sample preparation before hydrogen analysis.

Different issues are treated: the impact of the coating removal and machining of samples, the possible hydrogen runaway resulting from storage, the incidence of the storage cryogenic medium or of other chemical species used in the sample preparation, ...

The results are quantified in terms of desorption curves obtained on a sophisticated home-made measurement unit, allowing to clearly identify the impact of the different processing parameters.

- In order to comply with more and more stringent specifications of the customers on

final products and to reach a fast and early determination of these properties, sensors allowing an on-line monitoring and characterization of the product surface morphology are proposed by the "Advanced Techniques" department of CRM.

Waviness is one of the properties, especially important for the automotive sector. It requires a dedicated development as mostly not eye-naked visible before painting of coated or uncoated products.

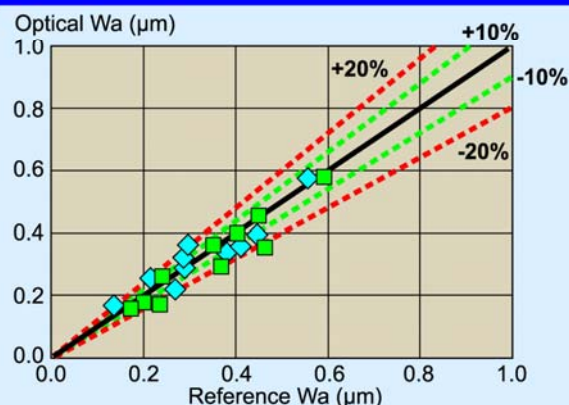
Based on the on-line microscopy concept developed by CRM for the determination of the roughness profile on moving products, an adapted equipment has been designed in the frame of a RFCS project. It combines a high speed camera, an adapted lighting unit, synchronization techniques and a new image processing approach. Correlation with static laboratory measurements is encouraging and opens the way for industrial tests in Corus-Segal and ArcelorMittal Avilès.

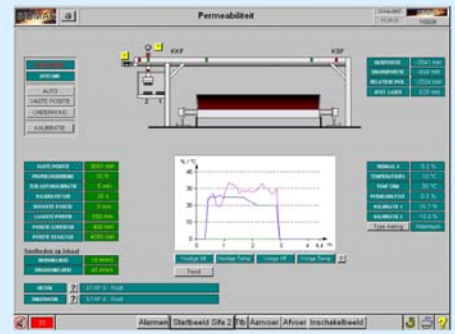
19

Wavimeter prototype unit.



Waviness measurement.





Overview of SuPerMagnaG system.

Display in control room at Sifa2 ArcelorMittal Gent.

SUSTAINABLE PRODUCTION

20

In the upstream processes (sintering, blast furnace, steelmaking), the expertise of CRM covers a large range of activities from the development and implementation of metallurgical models and sensors to the optimization of existing processes or the introduction of new concepts.

It is completed by a high competence in environmental questions and by-products recycling and valorisation.

Sintering of iron ores

- An important programme deals with the control of the sintering process.

The “SuPerMagnaG” sensor, implemented at ArcelorMittal Gent to continuously provide a mapping of the upper layer sinter quality has been intensively exploited to assess its diagnosis and process control ability. A new sensor support has been designed, aiming at an optimised robustness and reliability. It is currently in its final implementation phase. This configuration will allow, through continuous long-term campaigns, to enhance the control on

the process and to reduce sinter heterogeneities and production costs.

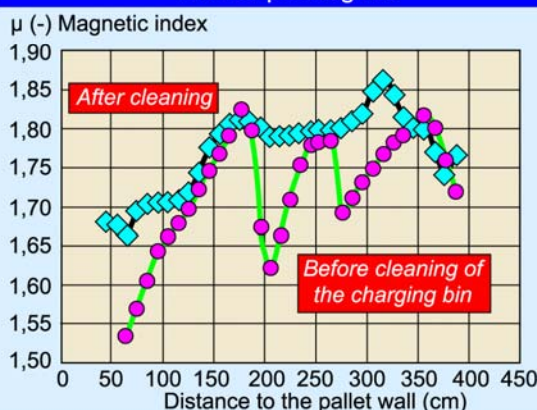
In combination with this sensor application, CRM has pursued the development and the industrial implementation of its sinter model as a complementary process control tool.

Blast furnace operations

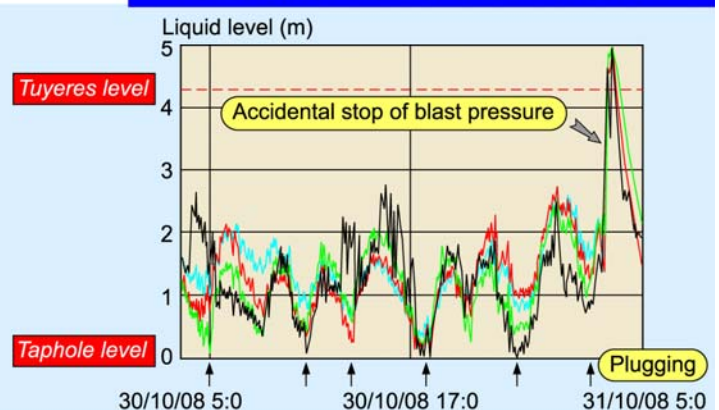
CRM has successfully developed a robust technique to determine the liquid level evolution inside the blast furnace hearth, measuring the deformation of the hearth shell. The sensor can be placed onto the hearth shell in less than three hours.

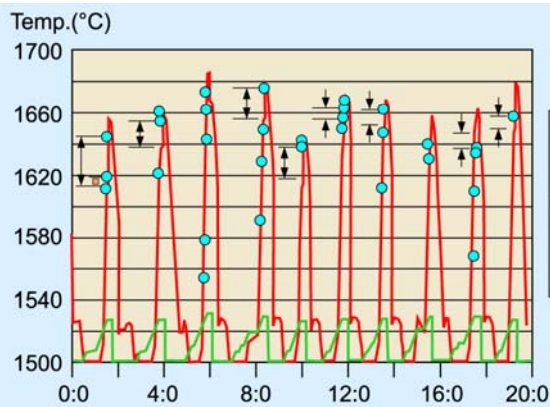
It was demonstrated on several blast furnaces that the evolution of the new level indicator gives a reliable information consistent with the tapping sequences. It can be used for improved scheduling of the tapping operation and to prevent incidents like slag level reaching the tuyeres.

Control of the sintering process with SupermagnaG

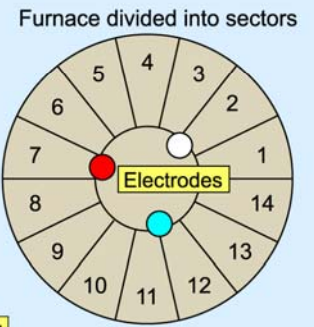
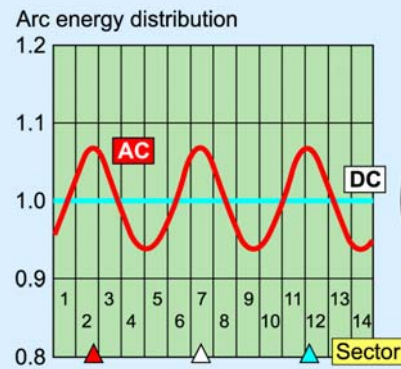


Follow-up of the filling level in BF hearth.





Thermal follow-up of the EAF process.



Distribution of the arc energy in EAFmodel.

- The European project “ULCOS” aiming to drastically reduce the CO₂ emissions has reached the second phase of development aiming to validate and demonstrate, at a larger industrial scale, the concept of the blast furnace operating with an important recycling of the top gas.

EAF Steelmaking

- The development of a dynamic model of the EAF operations is progressing.

Contrarily to a statistical approach, the CRM model is based on a fundamental set of computations integrating thermodynamics and kinetics aspects and taking into account the cyclic furnace data in real time. The main purpose of the on-line application is to provide the operator with a better estimation of the charge melting state and of the liquid steel temperature. This, in turn, will enable lower tap temperature and reduced energy consumption. The model has already been successfully used for off-line simulations of different furnaces and scenarios (e.g. various operating patterns).

Its first on-line application was carried out in ArcelorMittal Esch-Belval. The deployment of the model is being pursued in other ArcelorMittal plants.

The accuracy of the model predictions is constantly improved, taking into account the uneven arc distribution in AC furnace or by developing in close collaboration with ArcelorMittal Esch-Belval and Differdange (DC furnaces) improved monitoring systems for an enhanced post-combustion rate (Off-gas measurements), for a tighter control on the burners or for a better appraisal of the scrap characteristics. Several of these actions are conducted in the frame of RFCS projects.

Environmental aspects

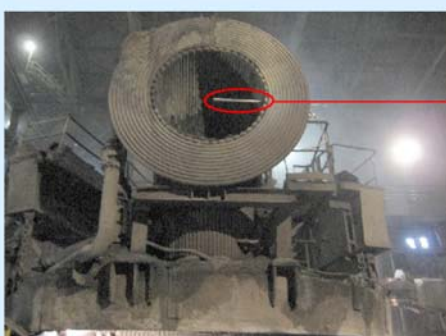
By-product recycling and valorization

- CRM is notably equipped with a pilot rotary hearth furnace (capacity : up to 100 kg/h).

In the frame of a project supported by the “Poles of Competitivity” of the Walloon region (Marshall Plan)

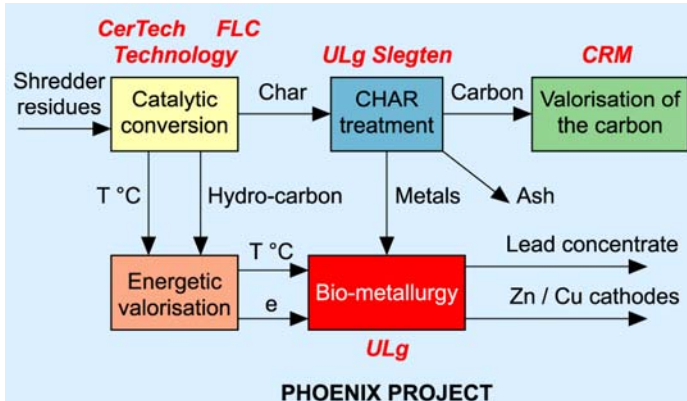
21

Post combustion measurement at ArcelorMittal Differdange.



Rotary hearth furnace.





PHOENIX PROJECT

Shredding residues processing.



Versatile briquetting unit for conditioning residues and byproducts.

22

nicknamed Phoenix and coordinated by COMET Traitements, the treatment of organic matters contained in the shredding residues of metallic components is aimed at through a novel low temperature and emission processing. CRM is charged to study the valorisation in the steel industry of the carbon compounds issued from this new process. The equipment available at CRM will be complemented by a new mixer and a briquetting unit suited to condition these carboneous by-products together with iron-bearing products for feeding the RHF with self-reducing briquettes.

Improved air quality

During the 4 last years CRM has successfully coordinated the Interreg III Euregio "Meuse-Rhin" programme on advanced techniques for fine dust abatement supported by the Walloon Region. The other partners were RWTH Aachen, Hogeschool Zuyd Heerlen and CMK Hasselt.

The project consortium has in particular studied the possibility to comply with stricter environmental regulations by improving the

collection efficiency of dedusting systems already in place, without the need of expensive additional abatement means.

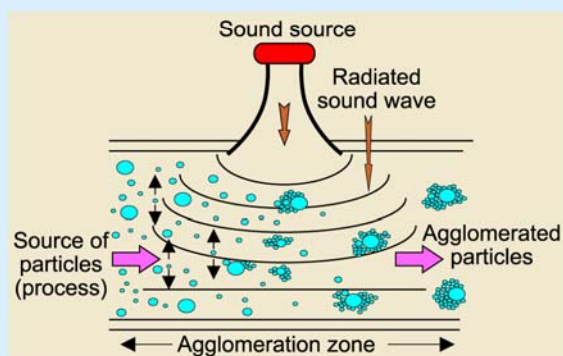
The concept tested at CRM is to agglomerate fine dust particles by applying powerful ultrasounds to the dust laden fumes in order to facilitate the subsequent capture of the so generated clusters.

The bench-scale test results obtained at CRM with dusts from different origins show the applicability of this concept to a wide range of industrial processes (up to 50% improvement for PM_{2.5} collection by bag filters).

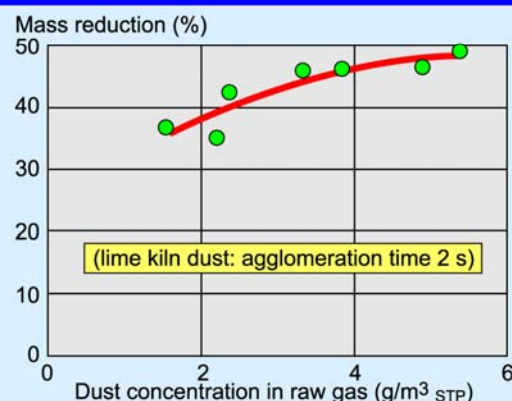
Tests with fuel engine fumes have shown that the technique can also be efficient on nanoparticles.

A market study realized by CIDE-SOCRAN has shown a real potentiality for this concept with possible applications in medium-sized boilers for collective heating systems or electricity generation.

Particles agglomeration by ultrasound.

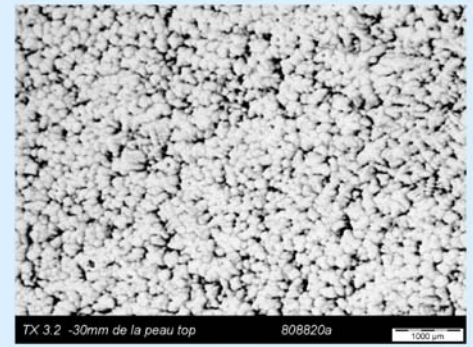


Effect of ultrasounds on PM_{2.5} abatement.





Thixo casting trial at Marichal Ketin.



Thixocast globular structure.

SUPPORT TO REGIONAL AND FEDERAL ECONOMY

CRM is actively contributing to the research programmes launched by the Federal and Regional Belgian Authorities in partnership with other research centres, universities and industrial research laboratories.

Beside dedicated and thematic RD projects, these actions aim to promote the innovation towards the industry and support the development of new competences.

- In line with the “Poles of Competitivity” of the Walloon Region (nicknamed “Marshall Plan”), CRM contributes to several projects :

- The thixo-casting/forming of steel grades (“THIXOACIER”) to manufacture components through a “near net shape” approach is coordinated by Marichal Ketin.

Casting trials, both in the CRM pilot installation and in the foundry of Marichal Ketin, have shown that a fully globular microstructure on dedicated steel grades can be achieved by using the water cooled Hollow Jet Nozzle with iron powder injection.

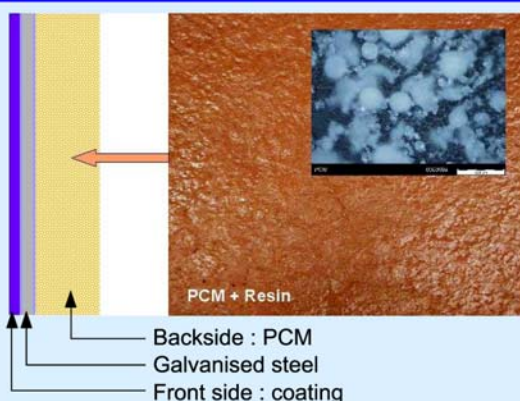
Forming tests have confirmed that this type of globular structure, when sufficiently reheated to obtain 20% of liquid fraction inside the structure, exhibits a thixotropic behaviour, i.e. it requires a very low forming force to be shaped at the final dimensions.

- The project “MIRAGE”, coordinated by ArcelorMittal, aims at developing innovative steel products notably for the construction.

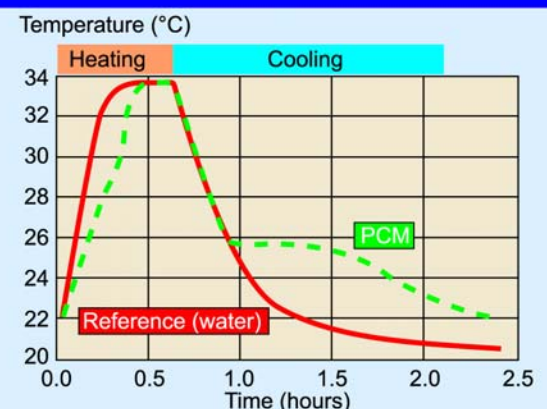
The CRM contribution is focused on the design of novel steel panels characterized by an “intelligent thermal behaviour” in order to better meet the daily heating-cooling cycles of a building. The basic concept is to use “Phase Change Materials” (PCM) that are fixed inside a resin on the backside of the steel panels. When the temperature is high, PCM accumulate heat and so prevent uncomfortable overheating. The accumulated heat is released during the night time. Prototype steel panels have been prepared (in collaboration with CoRI) and the characterisation of their thermal behaviour is performed by a dedicated test called T-History.

23

Steel panel with PCM.

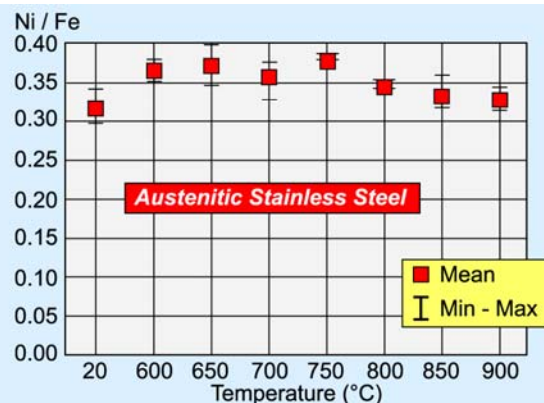


Thermal behaviour of PCM.





Telelis equipment.



Distance analysis with LIBS on hot material .

24

- A similar concept is applied to develop new house furniture and finishing products. It is investigated in a collaborative project “RETERMAT” supported by the Walloon Region and associating several Belgian research centres CRM, CSTC (Construction), CENTEXBEL (Textile) and CERTECH (Chemical).

- Another application of PCM is searched for in the project “EverFire”, launched in the frame of the Walloon programme “EnergyWall”, and aiming to develop renewable energy sources and high energy efficiency. Conducted in collaboration with the Belgian research centre for Ceramic (BCRC), the objective is to develop a heat accumulator for medium temperature levels (400 to 800°C) to be installed in domestic hearth.

- CRM is also active in the development of sensors and analytical measurement techniques for process control.

Using the LIBS technology, acquired thanks to the support of EFRD and Walloon region, different industrial applications are explored.

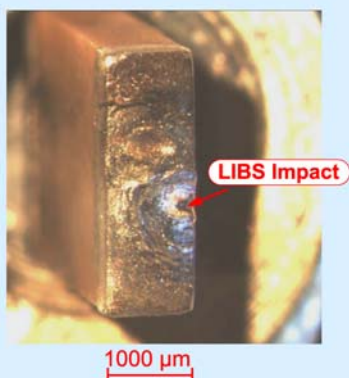
- With the financial support of IWT, a study is carried out for the remote analysis of semis in steelmaking and foundries.

Laboratory test, at 3 meter distance, on hot samples from different steel grades, have shown that the LIBS method can successfully analyse their chemical composition without the need for a specific calibration at high temperature.

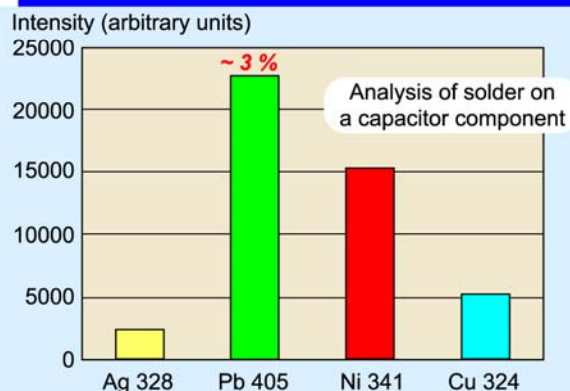
Similar results prove the feasibility of the technology with cast iron, even containing a high level of alloying elements, up to a temperature of 300°C, requested by the foundry process.

A second example of application concerns the measurement of lead in solder for the electronic industry. No fast analytical method applicable on very thin components is today available, the existing methods need very long specific calibration procedures. Tests carried out at CRM show that the LIBS method is a powerful alternative way allowing a quasi non-destructive analysis on very small components, without specific preparation.

Analysis of solder with LIBS.



Results of LIBS measurements.





Cross-section of a welded metallic frame.

Mould for wheel rim

GUIDANCE, TECHNOLOGICAL WATCH

The CRM's activity in providing a technical support to small and medium companies is continuing thanks to the support of the Walloon Region. It takes profit of the expertise and equipments available at CRM in wear, tribology, metal forming, fracture mechanics, fatigue, corrosion, surface and structure analysis,... The ISO 9001 certification covering all the CRM activities and the ISO 17025 accreditation for a great number of tests and calibration help to reinforce the CRM actions

As an example of the activities realised in 2008, let us mention :

- The analysis of the breakage of a welded metallic frame in galvanized steel. Detailed metallographic examinations have revealed that the main causes were attributed to excessive fatigue sollicitations amplified by corrosion problems and unadapted welding conditions. A new welding mode has been defined to solve the problem.
- The setting of a quality control approach for the manufacturing of aluminum wheel rim. The on-site application of hardness

measurements allows to regularly control the internal quality of the moulds used to cast the wheel rim.

The support to an expertise study on the fracture origin of a springing bar used in private car. Detailed examinations have confirmed that the rupture was due to a shock resulting from a crash and not to fatigue problems caused by eventual pre-existing internal defects.

The identification of the breakage of a roll supporting shaft placed in a continuous annealing furnace. Rotary bending has led to a fatigue fracture initiated on surface defects caused by a bad machining of the shaft.

The multi-partners guidance "Surface and Material" involving Materia Nova, CoRI and CRM has organized on June 6, 2008 a thematic day on "Corrosion resistance – Investigation means and protective coatings". More than 40 people have joined the meeting held at CRM Liege. All the information is available on the internet site: <http://www.gis-surfaces.be>

25

Car suspension bar.



Roll for continuous annealing furnace.



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26

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Centre de Recherches Métallurgiques asbl

Centrum voor Research in de Metallurgie vzw

Avenue du Bois Saint-Jean, 21
Domaine Universitaire du Sart Tilman (P59)
B-4000 LIEGE
TEL. : +32-(0)4-2546 211
FAX +32-(0)4-2546 464
E-mail : crm@rdmetal.ulg.ac.be

Technologipark 903c
B-9042 ZWIJNAARDE (GENT)
TEL. : +32-(0)9-2645 764
FAX +32-(0)9-2645 834
E-mail : crm@agt0.ugent.ac.be

<http://www.crm-eur.com>