Annual Report 2011

CRM GROUP
CRM

Contents

D/2009/0124/1

Foreword

In any circumstances, health and safety remain the top priority at CRM. The way people behave individually and collectively on the shop floor has been continuously improved thanks to training and management presence in the laboratories and pilot facilities. All internal meetings start with a short highlight on safety and a monthly report on incidents, risks, audits and good practices applied in the R&D departments is shared with to all employees.

Despite these good practices, CRM has faced 3 accidents with loss time, recalling to the leadership team the absolute necessity to continue its effort to maintain the zero accident objective achieved between 2008 and 2010 during 970 days.

In 2011 all CRM research activities and general services have been combined with those of AC&CS (formerly AMLR) into CRM Group. In this new group, the CRM non-profit organization maintains its statutes, such as collective centre (equivalent to a so-called De Groote Centre), accredited research centre (Centre "agréé" as recognized by the Walloon Region) and therefore is benefiting from subsidy mechanisms from the European Commission as well as from the Federal and the Regional Authorities.

This new world class R&D organization is managed by a unique leadership team; the CRM Group has a budget of 30 Mio EUR with 225 researchers and employees.

Closing the gap between science and market, turning inventions into products and value creation are the main missions of CRM Group.

To fulfil its mission, the CRM Group is organised in different departments:

- The Energy-efficient & Environment-friendly Metal Production department conducting research activities in energy, iron making, electric arc furnace, recycling, valorisation of by-products and environmental issues.
- The Metallurgical & Thermomechanical Processes active in casting & solidification, hot and cold rolling, thermomechanical treatment & cooling, physical metallurgy and the development of new generic steels.
- The Coating and Surface technology with activities in pickling, metallic and organic coatings, surface conversion and the development of new advanced surface properties.
- The Steel Solutions & Design for Construction department active in new steel solutions for the construction sector.
- The Advanced Materials & Applications department covering the development of new materials for a large field of applications.

These project oriented departments are supported by transversal teams:

- Chemical & Physical Surface treatments with competencies in surface reactivity and properties.
- Metal science & Mechanical testing for chemical, metallurgical, surface and mechanical characterisations
- Operational engineering in charge of design, dimensioning, construction, automatisation and implementation of advanced technical solutions on CRM pilot lines and in plants.
- Measuring techniques and sensors looking for the development and industrial applications of advanced sensors.

In 2011 CRM has continued to invest in competencies and in unique homemade equipment and pilot facilities in order to quickly test and develop new ideas. The present report details some of these investments.

At a European and regional level CRM has continued to invest in partnerships with other research organisations.

The four European steel research institutes CRM, CSM, Swerea MEFOS and VDEh-BFI joined forces in 2011 to found RIES (Research Initiative for European Steel), a network pooling the complementary research areas of these institutes.

The aim of the network is to strengthen the competitiveness of the European steel industry by conducting joint research and development work. In cross-institute working groups, topics for future research are identified and a common approach discussed for obtaining strong industrial supports and public funding for such research projects. Several meetings have already been held on topics such as Recycling and Energy Recovery.

CRM is today active in more than 20 European RFCS projects, in partnership with many European research laboratories and its industrial members.

CRM remains an active member of the PiMW "Poled' Ingénierie des Matériaux de Wallonie", with Liège University and Sirris. The PiMW is launching combined activities in the fields of solar energy and nanotechnology.

Thanks to regional funds, CRM develops activities with industrial partners. In Wallonia, CRM is actively participating to the plan Marshall with different major and challenging contributions, the Mirage Project (advanced surface treatments), the MINT project (intelligent maintenance), the steel thixoforming (easy high temperature steel forming) project together with MK and Liège University and the Phoenix project (recycling) with Comet Traitements.

CRM and four other research centres (ULg – GeMMe, CTP, BCRC and ISSeP) joined their skills to promote valorisation channels for metal bearing solid residues in melting furnaces (RECYMELT project).

The other regional mission devoted to CRM is the technology transfer to SMEs. Day after day, 5 engineers were in contact with the SMEs in Wallonia. The number of demands from SME's, more than 350 in 2011, is growing.

Thanks to the support of the industry and SMEs, CRM continues the development of R&D activities creating new innovative industrial solutions and new technologies, focusing on metallic materials. However, due to the fast changing world economy, CRM is more and more forced to manage the organisation per objective or project. The new organisation must remain flexible and reactive to the fast changing environment and must be very attentive to new opportunities in its core competence, while creating more and more value for the industrial members investing year after year in CRM.

The present annual report highlights the main achievements of the year 2011 obtained in the steel collective programme shared between ArcelorMittal and Tata Steel and in the regional R&D programme in partnership with third Parties.

Paul PERDANG
President CRM

Debashish BHATTACHARJEE
Vice-President CRM

Jacques PELERIN
Vice-President CRM

Jean-Claude HERMAN
General Manager CRM

Company members

On April 18, 2012

Active Members of CRM

ARCELORMITTAL S.A.	G.D. Luxembourg
TATA STEEL EUROPE Ltd	United Kingdom

And each of their subsidiary companies in the iron and steel industry.

The affiliated companies in the Benelux countries are:

ARCELORMITTAL BELVAL & DIFFERDANGE S.A.	G.D. Luxembourg
ARCELORMITTAL BETTEMBOURG S.A.	G.D. Luxembourg
ARCELORMITTAL DUDELANGE S.A.	G.D. Luxembourg
ARCELORMITTAL FRANCE S.A.	France
ARCELORMITTAL LUXEMBOURG S.A.	G.D. Luxembourg
ARCELORMITTAL RODANGE et SCHIFFLANGE S.A.	G.D. Luxembourg
ARCELORMITTAL STEEL BELGIUM N.V.	Belgium
COCKERILL SAMBRE S.A., ARCELORMITTAL Group	Belgium
INDUSTEEL BELGIUM S.A., ARCELORMITTAL Group	Belgium
SEGAL S.A., TATA STEEL EUROPE Ltd	Belgium
TATA STEEL IJMUIDEN B.V., TATA STEEL EUROPE Ltd	The Netherlands

(*) as approved by the General Meeting of April 18, 2012

Associated Members of CRM

AIR LIQUIDE INDUSTRIES BELGIUM S.A.	Belgium
ÅKERS BELGIUM S.A.	Belgium
AMEPA GmbH	Germany
APERAM S.A.	France
AURUBIS N.V.	Belgium
CARMEUSE S.A.	Belgium
CARRIERES ET FOURS A CHAUX DUMONT-WAUTIER S.A.	Belgium
CARSID S.A.	Belgium
CBMM Technology Suisse S.A.	Switzerland
CMI S.A.	Belgium
COMET TRAITEMENTS S.A.	Belgium
DE LEUZE S.A.	Belgium
DREVER INTERNATIONAL S.A.	Belgium
DUFERCO BELGIUM S.A.	Belgium
EMG Automation GmbH	Germany
FONDERIES MARICHAL, KETIN & Cie S.A.	Belgium
LE FOUR INDUSTRIEL BELGE S.A.	Belgium
GONTERMANN-PEIPERS GmbH	Germany
HARSCO BELGIUM SPRL	Belgium
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
NLMK CLABECQ S.A.	Belgium
NLMK LA LOUVIÈRE S.A.	Belgium
PAUL WURTH S.A. G.D.	Luxembourg
PEMCO BVBA	Belgium
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 S.A.	Belgium
TMT (*)	Luxembourg
UMICORE S.A.	Belgium
WINOA S.A.	France
ZincOx Resources plc	United Kingdom

Organization

On April 18, 2012

Board of Directors of CRM

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Paul PERDANG Global R&D, ARCELORMITTAL

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Jacques PELERIN General Manager Country Wallonia, ARCELORMITTAL
Debashish BHATTACHARJEE Group Director R&D, TATA STEEL GROUP

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Bruno GAY Senior Project Leader Building Products, UMICORE
Jacques HOFFMANN Manager R&D, Long Products, ARCELORMITTAL
Michel HOGGE Professeur, Université de Liège
Sarah JACQUES Attaché, SPF Economie, PME, Classes moyennes et Energie
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Vincent LECOMTE Directeur Général, S.A. des Fonderies Marichal, Ketin & Cie
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Wim VAN DER MEER Director R&D Programmes, TATA STEEL RD&T
Dirk VANDERSCHUEREN Professor, Universiteit Gent
José VERDIN Représentant, Centrale de l'industrie du Métal en Belgique (CMB)

Observers
Jean-Claude HERMAN Directeur Général, CRM
Yvon MASYN Adviseur, Innovatie door Wetenschap en Technologie in Vlaanderen (IWT)
Pierre VILLERS Inspecteur Général, Direction Générale des Technologies, de la Recherche et de l'Energie de la Région Wallonne

Auditor
Dominique JACQUET-HERMANS

Iron and Steel Committee of CRM

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M. BABBIT
P. CHAUBAL
M. DI FANT
J. HOFFMANN
S. VANDEPUTTE

TATA STEEL
M. NIP
J. DALE
W. VAN DER MEER
W. MOONEN

CRM
J.C. HERMAN
Ch. MARIQUE
G. LANNOO

CERTIFICAT DU SYSTEME DE MANAGEMENT DE LA QUALITE

ISO 9001 : 2008

Par la présente, le BQA. sa déclare que le système de management de la qualité de la société

CRM (Centre de Recherches Métallurgiques)

CRM

dont le siège est établi Avenue du Bois Saint-Jean, 21 – 4000 Liège - Belgique, a été examiné le 21-12-2009
et a été jugé conforme à la norme ISO 9001, édition 2008 pour le domaine d'application suivant:

Recherche appliquée et activités associées telles que les essais, l'étalonnage et l'expertise.

Ce certificat est délivré par le BQA. sa conformément à son manuel de qualité relatif à la certification
de systèmes de qualité et après conclusion du contrat de certification N° DS/AJCER/21-12-2009/336
aux termes duquel la firme accepte un contrôle régulier de son système de management de la qualité.

Certificat N° BQA_QMS019_C_2006336
Valable jusqu'au 20-12-2012

BELAC
BQA N° 019-QMS

BQA

D.SIMOENS
Directeur

DS/AJC/21-12-2009

Toute personne ayant connaissance de l'emploi abusif de ce certificat doit en avertir le BQA. sa. Ce certificat ne peut être divulgué que dans son intégralité.
BQA. sa - rue Montoyer 24 (bt) - 1000 Bruxelles.

Jean-Claude HERMAN, CEO

Strategy, General Management, External Relations, PiMW

Joeri NEUTJENS, COO

Business orientation & transformation
Integration Process
Human Resources, Communication,
QSE and performance management,
Health & Safety

Didier DEPARIS, CSO

Exploratory innovation
Chem. & Phys. treatments
R&D support laboratories
Technical assistance & Private trials
Guidance SME's

Bernard MAIRY, CFO

Finance, IP, IT
Administration (Group)
BoD, GA, EC, CC

Christian MARIQUE, CTO

Iron and steel committee
Adherent Members R&D
Energy Efficient & Environment friendly Production,
Advanced Materials
Operational Engineering & Measurements

Philippe HARLET, CTO

Iron and steel committee
Adherent Members R&D
Coating technologies, Metallic & Organic coatings
Construction
DTSL Liège

Griet LANNOO, CTO

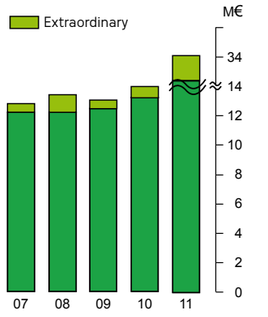
Exploratory Innovation
Metallurgical, thermo mechanical proc.

CEO : Chief Executive Officer - COO : Chief Operational Officer
CFO : Chief Financial Officer - CTO : Chief Technical Officer
CSO : Chief Scientific Officer

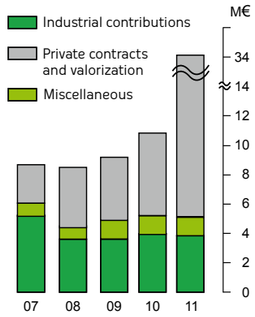
CRM Group management functions
R&D operational functions

Income Data

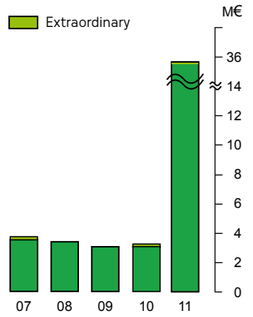
Income



Industrial participations



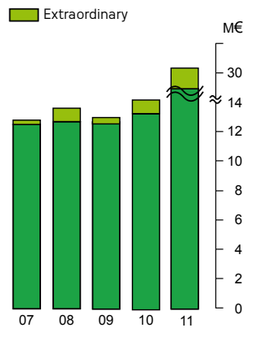
Grants



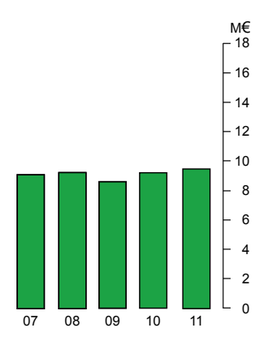
Belgian grants : 1.996 M€

Income by source : 34 M€

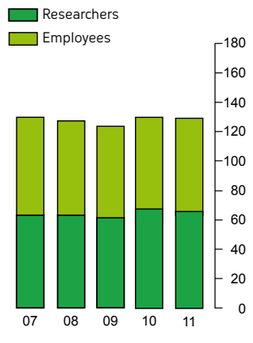
Expenses



Personnel



Number of employees



Report on R&D activities

The competence and activities of CRM focus on metallic materials (steel, non-ferrous metals and associated materials), their manufacturing and processing from raw materials up to finished products.

They cover a broad range of technical expertise shared into four main key fields:

- The energy-efficient and environment-friendly metal production, a field involving the reduction of the energy consumption of various the processing steps, the sustainable and low-cost manufacturing of steel and metals, the recycling and valorization of by-products as well as the related environmental aspects.
- The metallurgical and thermomechanical processing of metals from casting to hot and cold rolling, thermal treatment and cooling with also activities in physical metallurgy and development of new generic steel grades.
- The surface treatments and coating technologies with actions to improve the performances of existing processes or to develop new coating techniques and surface functionalities of various materials.
- The application of advanced metallic materials and integrated solutions, an area of interest for industrial affiliated members, SMEs and the local economy. The development of new sensors and measurement techniques has also to be mentioned in this prospect.

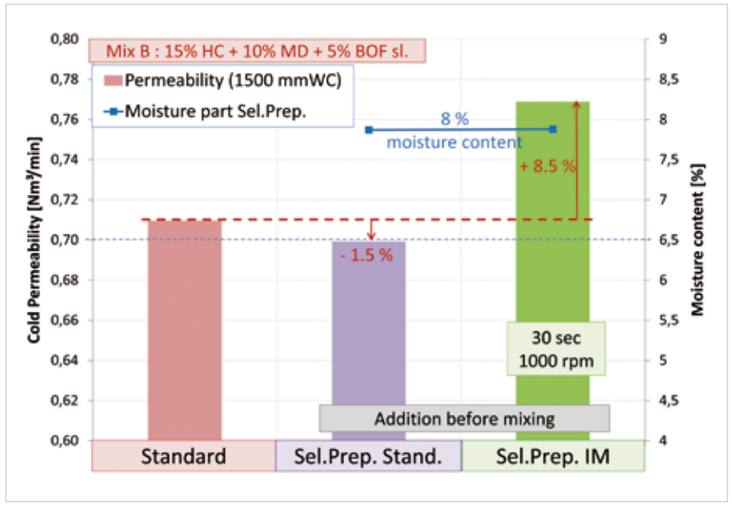
Energy-efficient and environment-friendly metal production

A first important topic managed by CRM in the upstream processes is the support given to its affiliated companies (Arcelor-Mittal and Tata Steel) operating world-wide to increase the internal recycling of plant reverts and to deal with the chal-lenging use of fluctuating and low grade raw materials.

This issue is particularly critical for the sintering process where lower quality iron ores have to be more extensively used whilst keeping high sintering per-formances in terms of productivity, solid fuel consumption and sinter quality, while minimizing environmental impact.

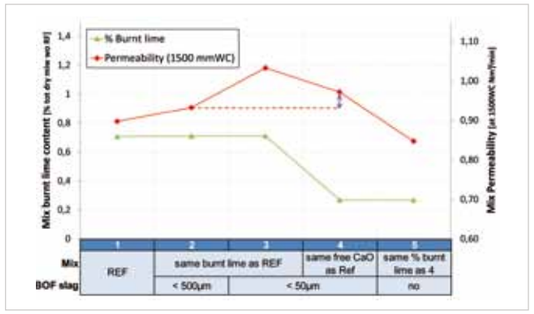
A specific effort is put on the preparation and preconditioning of fine raw materials and notably on the selective granula-tion of a part of the sinter mix (fine ores, dust and sludge) as a way to counteract the negative characteristics of this finer input. Among the pre-processing tech-niques available at CRM(roll-compaction, intensive mixing and pelletizing), the intensive mixing appears very promis-ing with the possibility to prepare mixes showing an improved cold permeability.

Another topic of interest for the steel industry is the recycling of the BOF slag at the sinter plant. It has been shown that the slag crushed under 500 µm can be substituted to a part of the lime-stone without significant effect on sin-ter productivity and solid fuel consump-tion, at constant burnt lime content. If the BOF slag is further crushed (< 50 µm), the granulation of the mix is improved by liberation of the free lime present in the slag and allows a reduc-tion of the burnt lime consumption.

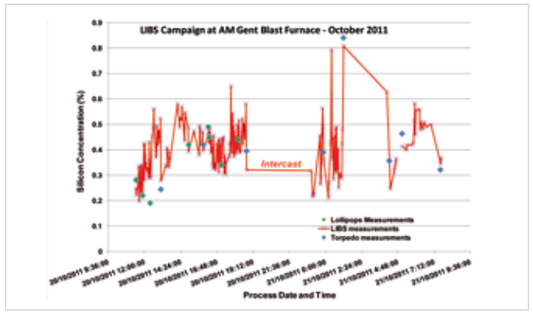


■ Improving the permeability of fine grain size sinter mix by intensive mixing

■ Preconditioning units for recycled and raw materials equipped with a flexible dust and fumes collection



■ A fine crushing of the BOF slag improves its recycling to the sinter plant



■ Continuous measurement of the hot metal Si content with the LIBS technology

To sustain these activities and to improve the fundamental knowledge about mecha-nisms governing the granulation, a First DoCa (PhD) financially supported by the Wal-loon Region is running in close collaboration with the University of Liège and the Institute of Chemical Technology (ICT) of Prague.

For what concerns the Blast Furnace (BF) operations, an innovative development based on the LIBS (Laser Induced Break-down Spectroscopy) technology is posi-tively progressing with the aim to measure, in a continuous way, the hot metal compo-sition and temperature directly in the blast furnace runners. Let us recall that the first equipment based on the LIBS technology has been introduced at CRM several years ago thanks to the financial support of the Walloon Region and the European Fund for Regional Development (EFRD) (Program 2004-2008). To carry out the measure-ments in the BF environment, a LIBS sen-sor has been designed and built by CRM. This compact prototype has been tested at ArcelorMittal Ghent during a whole week demonstrating its ability to withstand the BF casting floor harsh environment and to obtain accurate and consistent measure-ments of the hot metal composition. To be mentioned that, for the first time, meas-urements were also carried out in the slag runner during several hours.

After its implementation in different Electric Arc Furnace (EAF) steel plants in Europe and North America, the CRM model is under test to control the pro-cess in a furnace located in Mexico and working with a continuous feeding of DRI (Direct Reduced Iron).

■ Installation of the LIBS unit in the Blast Furnace hot metal runner

■ Continuous measurement of hot metal composition with the LIBS unit at ArcelorMittal Ghent

Main objectives are the dynamic process monitoring and tracking of the DRI melting, the evolution of the molten steel volume, its temperature and carbon content as well as to fix the end point before tapping. Gains are expected in terms of energy savings and shorter tap-to-tap time. The first results are really encouraging showing a very good appraisal of the industrial situation with the model simulations.
The performances of the CRM model implemented at the ArcelorMittal Dofasco plant (Canada) have been further enhanced by integrating new modules to better predict the carbon evolution and to more accurately assess the heat losses during the process. Since the implementation of the model, the tapping temperature has been continuously reduced with a gain of more than 15°C leading to significant cost cutting in energy consumption.
In the recycling field, two projects must be particularly pointed out.

- With the support of the Walloon Region, CRM and four other research centres (ULg – GeMMe, CTP, BCRC and ISSeP) joined their skills to promote valorisation channels for metal bearing solid residues in melting furnaces (RECYMELT project). The recyclability of these metal bearing solid residues are assessed in terms of yield (recovered metal fraction) and environmental impact using a new 350 kg melting unit. More than 20 by-products collected from various industrial sectors (foundries, cement industry, industrial recyclers, stainless steel…) will be processed in this installation.

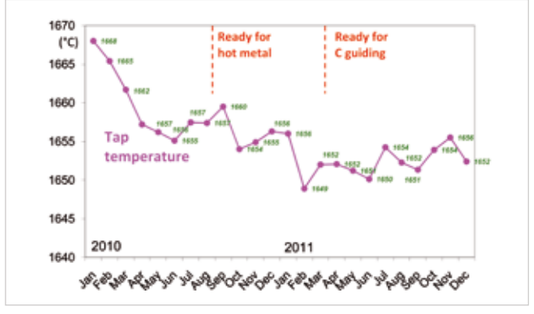
- Within the frame of the Walloon Marshall Plan, CRM contributes to the Phoenix project, coordinated by COMET TRAITEMENTS. The objective is to valorise, through a direct reduction process, agglomerates made of a mix of Fe-rich ferrous shredding residues and C-rich powder extracted from organic shredder residues after a catalytic cracking.

- The new 350 kg induction furnace

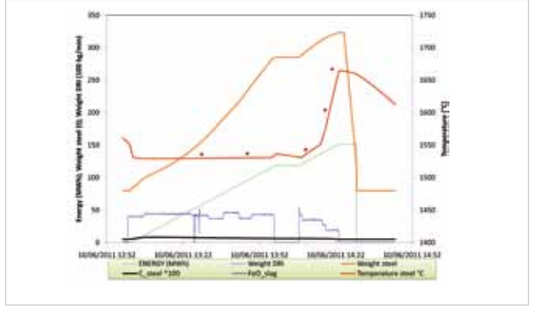
A high metallization rate (> 92%) is obtained in all cases, indicating that the whole carbon amount present in the C-rich powder is used for the reduction of the oxides.

COMET TRAITEMENTS has decided to build a semi-industrial catalytic cracking pilot with a capacity of 100 kg/hr. This pilot plant will be commissioned during the 2nd semester of 2012. This pilot plant will provide higher amounts of C-rich powder needed to perform larger scale trials on the RHF (Rotary Hearth Furnace) pilot unit of CRM. Trials with steelmaking residues like oily mill scales and sludges or BF/BOF dust are also planned, anticipating a potential synergy for the recycling and valorisation of residues from different industrial sources.

- The first melting operation



- Progressive reduction of the EAF tapping temperature thanks the implementation of the CRM model



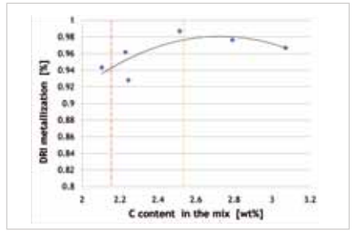
- EAF model : Dynamic monitoring of the process with a continuous feeding of DRI

A thematic day dealing with the "Recycling and Valorization of By-Products" has been organized by CRM on November 4, 2011 with the participation of 30 members coming from 7 countries (Belgium, Luxemburg, France, Italy, The Netherlands, Spain and United Kingdom).

Stricter control on the environment and the need to comply with more severe air quality standards impose to propose new technological solutions especially in terms of particulate matter (PM) emissions. With the support of the Walloon Region, CRM has developed with the collaboration of two other collective research centres (CERTECH & CENAERO) an acoustic agglomeration system to improve the efficiency of existing dedusting systems (PARAGGLO project). Based on fluid and acoustic simulations realized by CENAERO, an optimized acoustic chamber with four ultrasound generators has been constructed by CRM. It is able to operate at gas flow rates up to 200 Nm^3/h.

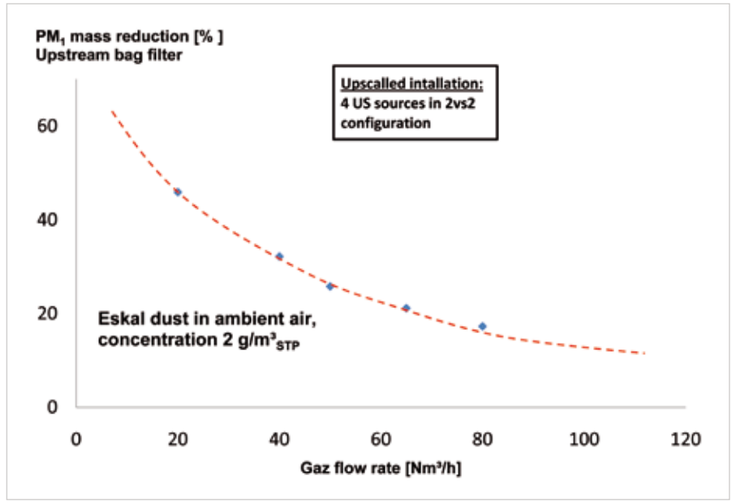
Depending on the nature of the dust and the operational conditions (flow rate, dust concentration, T°) abatement ranges between 40 and 50 % are observed for the finest particles which is a very positive result.

It has finally to be highlighted that the upgrading of the equipments managed by this department has been pursued in 2011 with the commissioning of a new gas collection and de-dusting system (notably a large scale bag filter) to allow safe and clean working conditions inside and outside the building.



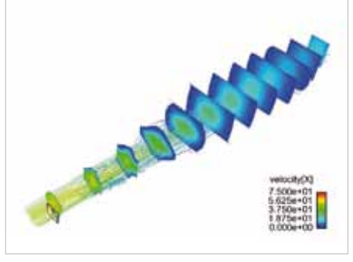
- The DRI metallization rate as a function of the mix C content

- The DRI residual C content as a function of the mix C content



- Abatement of fine particulate matters by applying ultrasounds

- A common gas and dust collector for several units



- Modelling the gas velocity fields for a maximal acoustic effect of ultrasounds

- Building of the acoustic chamber equipped with four ultrasonic generators

- A new bag filter to treat the fumes of several reactors

Metallurgical and thermomechanical processing

A large variety of topics are dealt within this department notably in the domain of rolling, cooling and process-product assessment.

In the field of hot rolling, three main axes of development have to be more especially pointed out: the mastering of the work roll degradation, the application of advanced cooling technologies and the search for new lubrication solutions.

The improvement of the work roll performance is covered by different projects supported by the European Research Fund for Coal and Steel (RFCS) and concerns the flat as well as the long product rolling.

- In the case of the roughing mill (Project WINROLLS), where ArcelorMittal Dunkirk (France) is the reference plant, simulations have been performed in the pilot line of CRM to compare the exit roll cooling performance of a classical nozzle and a High Turbulent Roll Cooling (HTRC). The results indicated that the HTRC technology has a higher cooling efficiency than the classical nozzle but that the application of an entry cooling, whatever the solution is exerts a major positive influence. Another aspect studied in this project is the influence of the initial roll temperature at the beginning of a new rolling campaign. Before performing real tests, simulations by finite element modeling have been realized to characterize the internal behaviour and thermal pattern inside the roll.

- For the rolling of long products (Project LPROLLCOAT), with ArcelorMittal and Tata Steel as industrial partners, the aim is to extend the life time of the rolls by applying available and new generation of wear resistant and thermal barrier coatings. CRM is more particularly evaluating metallic coatings deposited by high velocity oxy-fuel or cold gas spraying process. These coatings applied on small disks containing work roll inserts are tested at high temperature on a rotating disk machine for a first screening of thier performance.

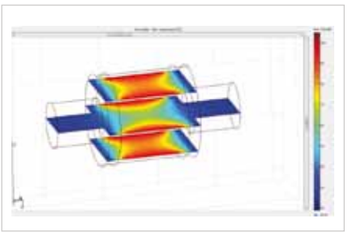
- Another activity concerns the (continuous) on-line evaluation of the roll degradation with the Rollscope unit of CRM. In 2011, two complete industrial campaigns have been realized in a medium section mill of Tata Steel at Scunthorpe (UK) allowing to accurately characterize the surface state of the rolls from the beginning until the end of several rolling sequences.

- Industrial application of the Rollscope at Tata Steel Scunthorpe

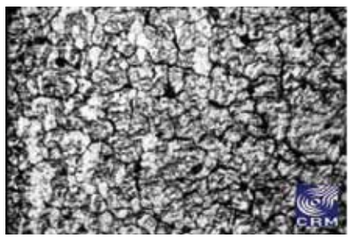
- Cooling with classical nozzle

- Cooling with an HTRC unit

- High temperature rotating disk machine



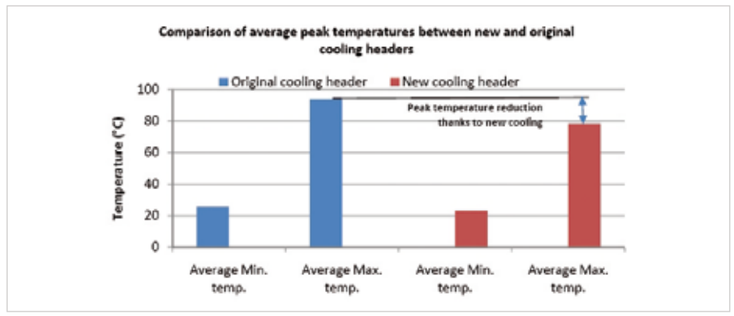
- Finite element modelling of work roll pre-heating



- Image of the roll delivered by the Rollscope (end of campaign)

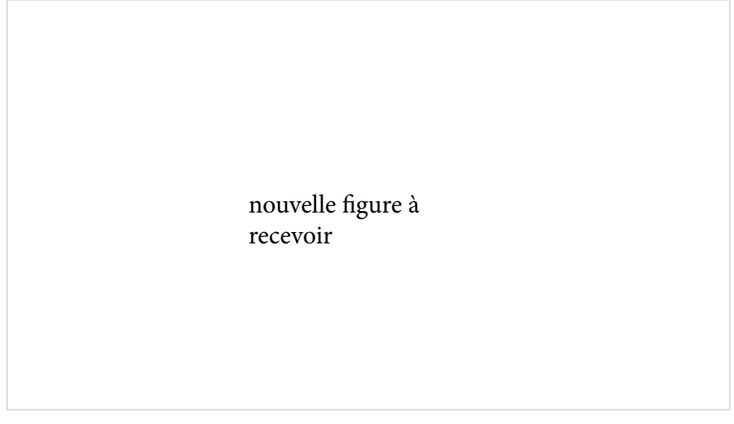
■ In order to reduce the thermal fatigue of big grooved rolls used in the ArcelorMittal sheet pile mill at Belval (Luxemburg), a new roll cooling device designed by CRM has been industrially tested (Project “Selective Cooling”). It has been shown that this fully automatic cooling unit allows to decrease the average peak temperature of the roll by more than 15 °C and to reduce accordingly the thermal stresses exerted on the roll.

■ Industrial trial with the selective cooling system at ArcelorMittal Belval



■ Reduction of the roll peak temperature by applying selective cooling

■ The recycling of waste oils in the hot strip mill for assuming the roll **lubrication** is another challenging issue offering several interesting perspectives: saving of natural resources, lower lubricant cost, reduced energy consumption. The waste oils to be reused can be obtained from other processing steps like cold rolling. Feasibility trials realized in the pilot hot rolling mill of CRM have confirmed that the lubrication efficiency reached with waste oils, adequately pre-conditioned, is very similar to that of conventional fresh hot rolling oils.



■ High efficiency of recycled waste oil as lubricant in hot rolling

■ Continuous hot rolling trial at CRM Ghent (10 mm thick strip)

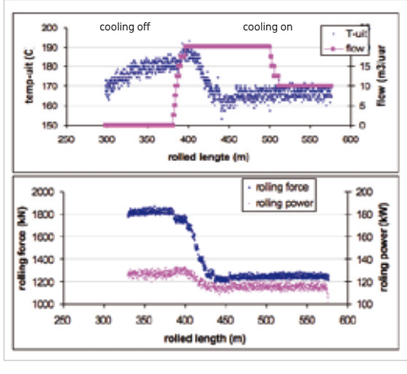
■ Coiling of the thick strip

This development will be pursued, considering all the positive potential benefits of this approach.

A particular achievement to be pointed out is the continuous hot rolling of a thick strip coil (10 mm of thickness) successfully realized in the CRM pilot mill, enlarging the simulation capabilities of this unique equipment.

■ In the domain of cold rolling, a pilot and demonstration RFCS project INCOOL has been launched to industrially implement an intense and turbulent cooling concept called “Water Pillow Cushion” (WPC) aiming to cool down the work roll or the strip. A better control of the strip temperature would help to reduce temperature related surface defects, to enhance the lubrication efficiency and to favour an increase of the rolling speed. Applications are forecast in cold rolling plants of ArcelorMittal Liège and Tata Steel IJmuiden (The Netherlands). First trials realized in the pilot cold rolling mill of Tata Steel with a prototype designed and built by CRM have confirmed a better lubrication efficiency due to a lower temperature in the roll gap leading to a significant drop of the applied rolling force and a decrease in the number of heat scratches.

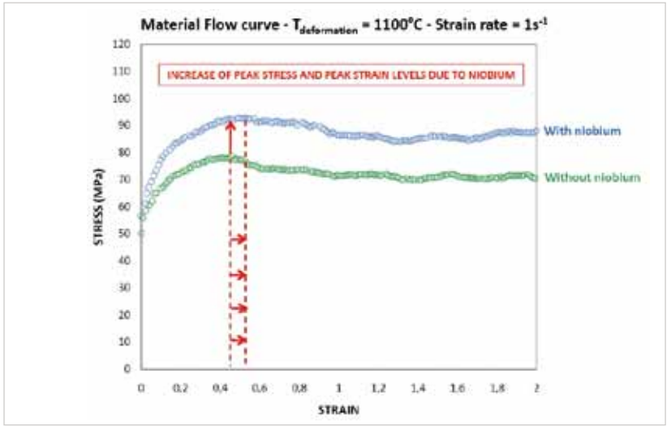
■ The cold rolling pilot line at Tata Steel IJmuiden



■ Drastic reduction of the rolling force and strip temperature when applying an intense and turbulent cooling in cold rolling

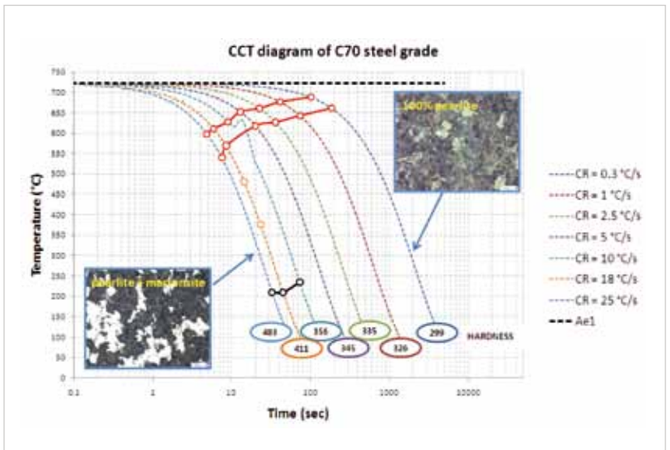
The acquisition of new basic knowledge in the field of physical metallurgy is a permanent objective particularly to develop new concepts of advanced high strength steels. It is illustrated through two specific examples:

- The investigation of the metallurgical phenomena occurring during the hot deformation of silicon and niobium alloyed grades. This information will enable to improve the "StripCam" hot rolling model for AHSS (Advanced High Strength Steels), a powerful tool to simulate the process, to tune the operating conditions (mill setting) and to predict the product properties. Hot deformation trials were performed to determine the dynamic recrystallization kinetic (DRX) for several conditions of temperature, strain rate and deformation level. The effects of niobium and silicon, of the deformation temperature and strain rate on the peak stress level have been identified and quantified.



- Effect of Niobium and Silicon on the dynamic recrystallisation of steel

- The optimization of the thermomechanical treatment of high carbon flat products is another item to be mentioned. The idea is to promote the globularization of the pearlitic phase by a strain induced sphewroization phenomenon. Dilatometry trials were helpful in that prospect to determine the pearlite transformation kinetics and to build the CCT diagram of an industrial steel grade.



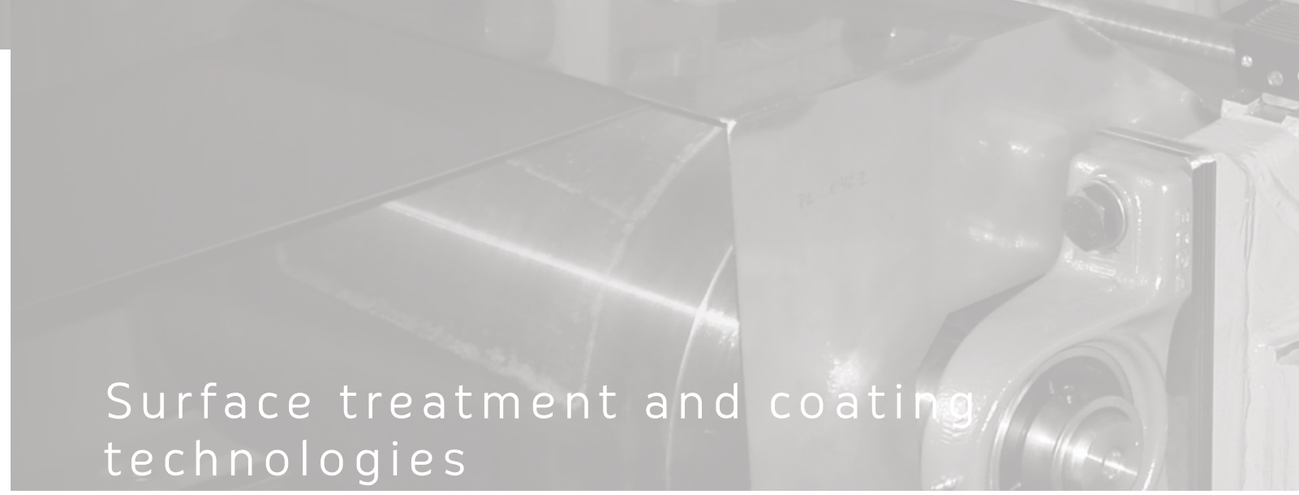
- CCT diagram of pearlitic steels

MATERIALS RESEARCH CLUSTER GENT

The partners of the **Materials Research Cluster**

On September 20, 2011 the inauguration of the Materials Research Cluster Gent took place. The Materials Research Cluster Gent is an organically grown collaboration between seven partners located in Zwijnaarde among which the CRM. It is an example of open innovation, of bringing together staff and resources of the complementary mix of competencies of the different partners (OCAS, Ghent University, Sirris, BIL, Clusta, CRM, SIM and its division Flamac) to represent a pool of expertise in materials research, with a focus on metals, active and competitive in Flanders and far beyond.

- Visit of the MRC installations

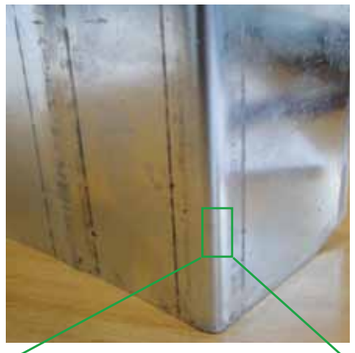


Surface treatment and coating technologies

The metallic coating of advanced high strength steels remains an important issue for the steel industry in order to offer attractive finished products to the market. An adequate preparation or conditioning of the steel surface before hot dip galvanizing is a critical step in the coating process.

In the frame of a RFCS project called FERRIGAL, a novel concept has been successfully tested in collaboration with other partners (OCAS, Tata Steel, MPIE). It is based on the application of a sol-gel solution on the steel strip before treatment. Iron oxide solutions, homogeneously deposited on the strip, react during annealing to create a very thin iron coating. This last layer favors a high reactivity of the steel during its dipping in the liquid zinc despite the presence in the steel of alloying elements like Si, Mn or Al.
A very good behavior of the coated products and especially their aptitude to a severe bending has confirmed a high adherence of the zinc layer on the strip.

This concept will be further developed through continuous pilot trials in the CRM facilities.
With the support of the Walloon Region, associating other research centres (CRIBC, Materia Nova) an innovative coating process has been designed by CRM.
It aims to incorporate very fine particles in the zinc layer just after the wipers before the zinc gets fully solidified. Successful trials have been conducted in the continuous hot dip galvanizing line of CRM by spraying fine glass beads in the freshly galvanized strip.
An adherent and covering glass bead layer has been formed on the whole width of the strip giving it very attractive reflective properties.

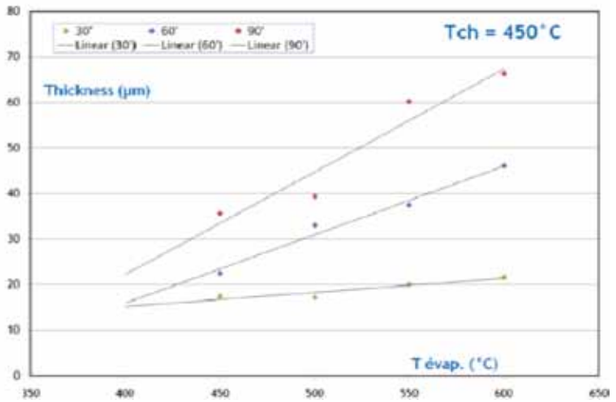


- Very good bending behaviour of a "Ferrigal" processed TRIP steel

- Pilot test with glass beads spraying – start of the process

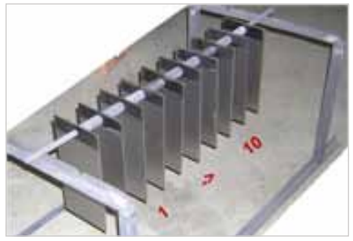
- Full covering of the strip

A new batch galvanizing process ("EVAPLEX"), proposed by UMICORE and associating also DREVER as equipment builder, is under intensive testing on the pilot prototype implemented by CRM at PiMW ("Pôle d'Ingénierie des Matériaux de Wallonie")
Let us recall that the Evaplex process consists of the deposition on the finished products of a zinc vapor created under a moderate vacuum level. The design of the vessel allows to test in one set packs of 10 samples and to assess the influence of several operating parameters (treatment time, zinc evaporation temperature, chamber temperature) on the quality of the coating and more precisely the thickness of the formed zinc layer.



■ Control of the zinc coating thickness during the EVAPLEX process

■ Bi-layers zinc-free coating after an outdoor exposure of 28 days



■ Samples pack used in the EVAPLEX prototype

For what concerns the surface conversion of metallic products, the full chromium-free solution named "Silicalloy", that has been designed by CRM and licensed to DELEUZE SA, has been confirmed by industrial members as the reference product for the passivation and temporary protection of galvanized products. It has to be recalled that this development has been realized with the support of the Walloon Region (DGO6 and Marshall Plan programmes).

Anticorrosion performance:

Salt spray		24h	48h	72h	96h
Silicalloy coating weight (mgSi/m²)	25	< 5 %			
	50		< 5 %		
	75			< 5 %	
	100				< 5 %

Silicalloy coated hot-dip galvanised steel: % of white rust usely measured during salt spray exposure as a function of silicalloy coating weight (In green, the target for this kind of product)

■ Very high anti-corrosion performances of "Silicalloy" coated hot-dip galvanised steel, with a % of white rust below the allowed limit.

The development of new protective coating free of zinc (CLEARZINC project) is studied in the frame of the 2008-2012 programme associating the Walloon Region and the European Fund for Regional Development (EFRD). Bi-layer coatings produced by cathodic electro-deposition show a very good resistance to weathering conditions during more than 28 days when compared to uncoated steel.

Several equipments have been acquired and implemented in the frame of this EFRD programme:

■ A roll-coater, an air-dryer and a strip guiding unit that complete the technical capabilities of the pilot CASTL line

■ The new roll-coater in the CASTL line

■ The new strip air-dryer in the CASTL line

■ The new strip guider in the CASTL line

■ A SEM-FEG microscope with multiple analytical functionalities allowing sophisticated and advanced characterization of a large range of metallic and non-metallic materials.

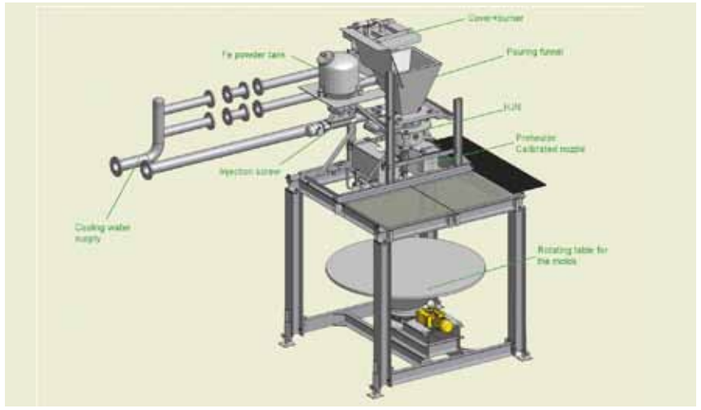
■ The new SEM-FEG microscope

Advanced metallic materials, integrated applications and new sensors

As previously mentioned, this area covers a very broad range of activities and expertise aiming to support the industrial members, the R&D policy of the Federal or Regional Public Authorities as well as the local economy and the SME's.

Advanced metallic materials

- A first example of new materials development relates to the project THIXOWAL. Coordinated by MARICHAL KETIN and managed with the support of the "Pôle Mecatech" and the Walloon Region inside the so-called "Plan Marshall". It aims at implementing a new processing route able to cast and shape in a very compact and direct way advanced steel components exhibiting a very fine thixotropic



- Sketch of the ingot casting unit to produce thixotropic microstructure

- The low superheat ingot casting unit

- Example of thixo-forged product

structure and excellent mechanical properties. CRM contributes to the design, testing and building of the dedicated ingot casting unit where the key point is to cast at low temperature to achieve a globular solidification structure and supports the optimization of the one step forging operation.

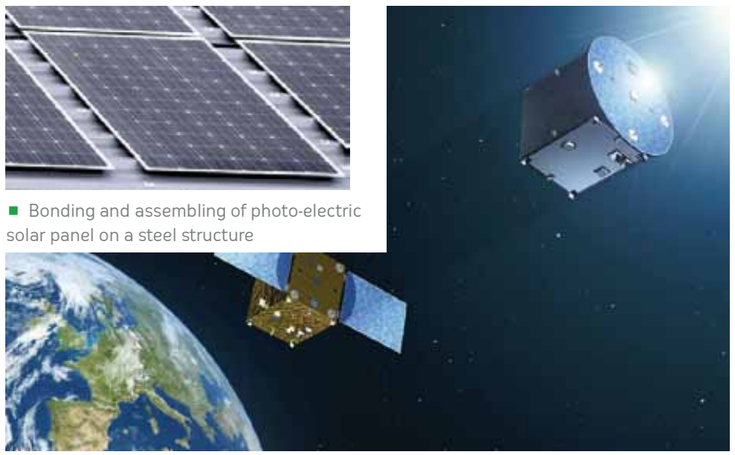
- A second example concerns the rapid manufacturing by laser cladding or laser melting of Titanium parts (TipTopLam), a project coordinated by SIRRIS with the financial support of the Walloon Region and the European Fund for Regional Development. CRM contributes to the detailed characterization and evaluation of the obtained materials, notably the performances of the products in term of mechanical resistance and deformation capacity.

- Ti-samples used for tensile test manufactured by additive manufacturing

Integrated solutions and applications

- Selecting and testing new bonding solutions for the durable junction of multi-materials are the main objectives of a collaborative project between several Walloon research partners (SIRRIS, CRM, CEWAC, CoRI, University of Liege). Focused on applications in building, joining methodologies associating low cost of processing and limited environmental impact, will be searched for specific applications such as the bonding of a frameless photoelectric solar panel on a steel structure
- Following the development undertaken by CRM to use PCM (Phase Change Material) to improve the thermal comfort in housing and home furniture (floor, panel, air conditioning), a fully new application has been launched. This new project is carried out in partnership with the company WALOPT, in answer to a call from the ESA (European Space Agency). The project aims to design a specific heat storage device dedicated to small satellites. The main problem of small satellites (less than 100 kg) is their low thermal inertia, leading during orbital cycle to important temperature fluctuations. This is detrimental for the embarked equipment and subsystems and the realization of experiments where the ambient temperature must be kept within narrow limits. The use of PCM to store excess heat and to release it when needed represents an attractive solution to increase the thermal inertia of small satellite without increasing their weight.

- Bonding and assembling of photo-electric solar panel on a steel structure

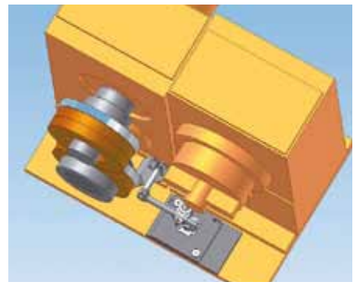


- Control of the thermal inertia of small satellites by PCM

New sensors and measurement techniques

Several examples of new developments in this field have already been presented in the previous chapters.

- Let us illustrate some additional cases. Coordinated by CMI and supported by the Marshall Plan of the Walloon Region, the project "MINT" aims to propose an innovative and integrated approach for the intelligent maintenance of industrial installations. Inside this project, CRM has designed and implemented, with the support of ARCELORMITTAL Ferblatil, a 2D profilometer to continuously monitor the blade wear of an edge shear machine.

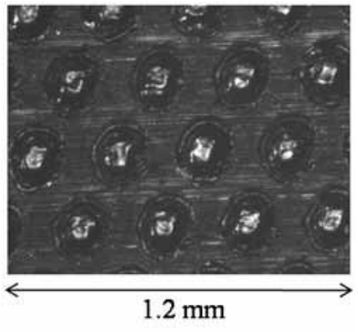


- Positioning of the profilometer in an edge shear blade machine

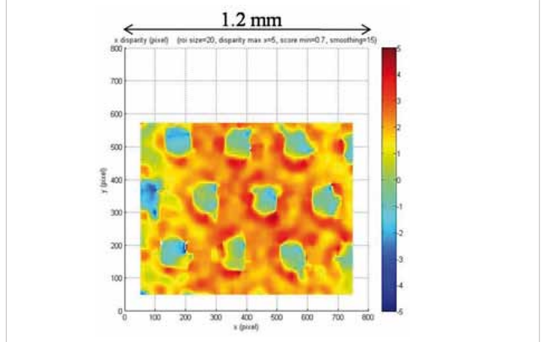
- View of the profilometer installed by CRM at ARCELORMITTAL Ferblatil

Long test campaigns during several months have confirmed the ability of this sensor to assess the blade wear dynamics and to help for finely tuning the shear machine set-up.

Another technique under investigation deals with a non-contact method for a 3D micro-topography of moving products. A stereomicroscopy technique has been applied on EBT (Electro- Beam Texturing) roll material, allowing a very accurate detection and characterization of these textured surfaces.



■ Stereo image of EBT roll



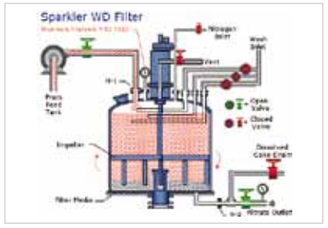
■ Stereo micro-topographical map of EBT roll

Guidance & technological watch

Thanks to the financial support of the Walloon Region, a team of almost 5 guiders is directly supporting the technical requests of SMEs with more than 350 actions in 2011. The possibility for these companies to take profit of the initiative “Chèques Technologies”, a service offered by the Walloon Region under the management of AST (Agency for Technological Stimulation) has to be pointed out.

To illustrate the actions realized in this field, let us mention the solving of a perforation problem observed in the filtration grid of a nutsche-type reactor.

Detailed metallographic examinations have indicated the occurrence of a crevice corrosion resulting from the presence of large amount of sodium chloride in the treated solution and a low resistance under these conditions of the selected alloyed steel. Thanks to appropriate electrochemical simulations tests performed at CRM, a more adapted alloy has been selected that has proven to withstand these very corrosive conditions during long term immersion tests.



■ Scheme of a nutsche-type reactor

■ Filtration grid showing local perforations

During 2011, CRM has participated to different exhibitions, fairs and conferences.

Let us more particularly mention:
“Metamorphoses” organized by Spi + on October 26 & 27, 2011 at Val St Lambert (Seraing) and aiming to promote innovative materials in different application fields. More than 1000 visitors and 50 exhibitors have attended this event.

“Eurofinish” organized on September 27 to 29, 2011 at Flanders Expo (Gent and aiming to promote new surface treatment technologies. A total of 115 exhibitors and more than 1500 visitors have attended this event.

Publications & Conferences

Energy-efficient and environment-friendly metal production

P. Nyssen, C. Ojeda, J.-C. Baumert, M. Picco, J. Thibaut, S. Sun, S. Waterfall, M. Ranger, M. Lowry
Implementation and on-line use of a dynamic process model at the Arcelor-Mittal-Dofasco Electric Arc Furnace
4th International Conference on Modelling and Simulation of Metallurgical Processes in Steelmaking, 28-30 June 2011, Düsseldorf

C. Mathy, B. Vanderheyden, J.-C. Pierret, F. Stas, W. Holbrecht, W. Lumen
SuPerMagnag : a new magnetic sensor for an on-line monitoring of the sintering process
6th European Coke and Ironmaking Congress, 28-30 June 2011, Düsseldorf

J. van der Stel, M. Hattink, D. Sert, J. Borlée, A. Hirsch, M. Zagaria, N. Eklund, M. Pettersson, L. Sundqvist, B.-E .Sköld, C. Feilmayr, R. Lin, A. Feiterna, M. Grant, O. Ansseau, J. Adam, K. Kinnunen, J. P. Simoes, W. Küttner
Developments of the ULCOS low CO_2 blast furnace process at LKAB experimental BF in Luleå
1st International Conference on Energy Efficiency and CO2 Reduction in the Steel Industry, 28-30 June 2011, Düsseldorf

B. Bergmans, M. Dormann, F. Idczak, S. Petitjean, D. Steyls, B. Vanderheyden
Advanced technique to reduce emissions of fine particulate matter using ultrasounds
First International Conference on Sustainable Chemistry, 6-8 July 2011, Antwerp

B. Vanderheyden, F. Van Loo, M. Dormann
Overview on the CRM activities in Recycling of Steelmaking By-Products
Thematic day on Recycling and Valorization of By-Products, CRM Liege – November 4, 2011

B. Vanderheyden, D. Steyls, P-F. Bareel, C. Bodson
Innovative techniques for the valorization of shredder residues as secondary raw materials in the steel industry
Second International Conference on Clean Technologies in the Steel Industry, 26-28 Sept. 2011, Budapest

C. Mathy, B. Vanderheyden, J.-C. Pierret, F. Stas, W. Holbrecht, W. Lumen
SuPerMagnag : a new magnetic sensor for an on-line monitoring of the sintering process
8th International Workshop CETAS 2011, 17-19 May 2011, Luxemburg

G. Monfort, L. Bellavia, B. Vanderheyden, V. Tusset
Development of an on-line LIBS-based sensor for monitoring the hot metal composition in the blast furnace runners
8th International Workshop CETAS 2011, 17-19 May 2011, Luxemburg

P. Nyssen, C. Ojeda, D. Borenstein
Production of Low Nitrogen High Quality Steel through EAF Route
Journées Annuelles de la Société Française de Métallurgie et de Matériaux, 4-6 July 2011, Nancy

Metallurgical and thermo-mechanical processing

G. Lannoo, J. Malbrancke, I. Tolleneer
Effect of asymmetric rolling on process & product properties
Journées Annuelles de la Société Française de Métallurgie et de Matériaux, 4-6 July 2011, Nancy

C. Marique
The water cooling to optimize and control the metallurgical properties of steel
Journées Annuelles de la Société Française de Métallurgie et de Matériaux, 4-6 July 2011, Nancy

Publications & Conferences

Surface treatment and coating technologies

C. Georges, X.Vanden Eynden
Determination and study of diffusible hydrogen content in electro-galvanized steels by use of thermal desorption analysis
Proceedings of the 2011 Galvatech conference, 2011, Genova

C. Georges, T. Machado, P. Drillet, T. Sturel and T. Vietoris
Measurement and modeling of hydrogen desorption at room temperature in Al-Si coated boron steel
Proceedings of the international SteelHydrogen Conference, 2011, Gent

Advanced metallic materials, integrated applications and new sensors

X.Vanden Eynden
In situ XPS for Surface Speciation during Annealing of Steels
CETAS 8th International Workshop "Chemistry & Materials Characterisation in the Steel and Metals Industry", 17-19 May 2011, Luxemburg

A. Farinha
Speciation of Fe, Ni and Co for Recycling Purposes
CETAS 8th International Workshop "Chemistry & Materials Characterisation in the Steel and Metals Industry", 17-19 May 2011, Luxemburg

G. Monfort
Development of an on-line LIBS-based Sensor for Monitoring the hot Metal Composition in the blast furnace runners
CETAS 8th International Workshop "Chemistry & Materials Characterisation in the Steel and Metals Industry", 17-19 May 2011, Luxemburg

G. Moreas
Wavimeter: on-line Measurement of Waviness
CETAS 8th International Workshop "Chemistry & Materials Characterisation in the Steel and Metals Industry", 17-19 May 2011, Luxemburg

O. Lemaire, X. Vanden Eynden, S. Flament, V. Tusset
On-site direct microscopy and composition analysis in metal industry
CETAS 8th International Workshop "Chemistry & Materials Characterisation in the Steel and Metals Industry", 17-19 May 2011, Luxemburg

V. Tusset
Choix technologiques et conseils techniques
Journée Guidance ACCORD-Wallonie, 8 Novembre 2011

G. Moreas, W. Bilstein
Industrial on-line micro-topography measurements
Galvatech 2011, 21-24 June 2011, Genova

S. Flament, G. Walmag, J. Malbrancke, G. Moreas, M. Sinnaeve
Work roll surface degradation in hot rolling: on-site laboratory evaluation methods
Abrasion 2011, 21-24 Août 2011, Liège

F. Novello
PREDICOR: Mesure en temps réel de la vitesse de corrosion
Journée Thématique « Matériaux durables : de leur conception à la mesure de leurs performances », 3 Mai 2011, Liège

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