# Annual Report

2009

CRM

*Sart-Tilman ▌ LIÈGE*

*Zwijnaarde ▌ GHENT*

CRM

Annual Report 2009

Editor: Centre de Recherches Métallurgiques ❙ Avenue Ariane, 5 ❙ B-1200 Bruxelles
Centrum voor Research in de Metallurgie ❙ Avenue Ariane, 5 ❙ B-1200 Bruxelles



*D/2009/0124/1*

# Contents



CRM

# Foreword



During the year 2009, marked by a bad economic situation, the research activity performed at CRM was strongly encouraged by our industrial members, outlining that value creation needs innovation.

Closing the gap between science and market, turning inventions into products & value creation remain the main missions of CRM. The innovation at CRM is based on ideas and exploratory work generated internally under control of a steering committee called ***"Creativity and Innovation"***.

To fulfil its mission, the CRM is organised **in 4 departments with 13 key activity clusters**:

- The **Sustainable production & upstream** processes department conducting research activities in ironmaking, electric arc furnace, recycling, valorisation of by-products and environmental issues.

- The **Surface engineering** department with activities in pickling, metallic coating, surface conversion and development of new surfaces and coatings.

- The **Product development** department active in casting & solidification, hot and cold rolling, thermomechanical treatment & cooling, physical metallurgy and the development of new generic steels.

- The **Advanced materials**, Solutions & Sensors department covering the development of new materials for a large field of applications, novel measurement technologies and the guidance for SME's. This team is operating in the PiMW in partnership with four other research centres and Liege university.



These project oriented departments are supported by two transversal teams:

- **Metal science** for chemical, metallurgical and surface characterisations

- **Operational engineering** in charge of design, dimensioning, construction, automatisation and implementation of advanced technical solutions on CRM pilot lines and in plants.

A high flexible organisation allows CRM to accommodate to the portfolio evolution, ensuring a high efficiency while controlling the time to market.

As an independent collective research centre, CRM has continued to benefit from financial support from the Belgian and Regional authorities, as well as from the European Commission. Within the Plan Marshall of the Walloon Region, CRM has launched strategic partnerships with other research centres and universities for the benefit of the industrial CRM members. CRM is participating to numerous projects in the field of steel thixoforming, intelligent maintenance, recycling and valorisation of by-products, thermal energy recovery, new highly performing coatings, ...

CRM has also been involved in numerous pilot projects conducting new processes until an industrial stage.

This annual report gives an overview of the major achievements obtained during the past year. Despite the world financial crisis, and thanks to the active support and great motivation of the CRM members, a significant progress has been made in all activities.

**Jacques PELERIN**
ARCELORMITTAL S.A.
*President CRM*

**Rob BOOM**
CORUS Research, Development & Technology,
*Vice-President CRM*

**Kris STEVENS**
ARCELORMITTAL FCWE
*Vice-President CRM*

**Jean-Claude HERMAN**
CRM
*Managing Director*

# Companies affiliated to CRM

On April 15, 2009

## 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*
- AURUBIS - *Belgium*
- CARMEUSE S.A. - *Belgium*
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- CARSID - *Belgium*
- CBMM Technology Suisse S.A. - *Switzerland*
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- COMET TRAITEMENTS S.A - *Belgium*
- CONVERTEAM S.A. - *France*
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- DREVER INTERNATIONAL S.A. - *Belgium*
- DUFERCO CLABECQ S.A. - *Belgium*
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- 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*
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- TECHSPACE AERO S.A. - *Belgium*
- THY-MARCINELLE S.A. - *Belgium*
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- UMICORE S.A. - *Belgium*
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CRM

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On April 15, 2009



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- Paul PERDANG, Manager, Finance, ARCELORMITTAL
- Peter SMITH, Director Technical Processes, CORUS Research
- 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

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- Jean-Claude HERMAN, Directeur Général, CRM
- 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

### Auditor

- Dominique JACQUET-HERMANS



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- M. BABBIT, ArcelorMittal Research S.A
- M. BEGUIN, ArcelorMittal Research S.A
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- M. DI FANT, ArcelorMittal Research S.A
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- J.-C. HERMAN
- Ch. MARIQUE

CRM

# 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)***

*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/AJ/CER/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*

*BQA N° 019-QMS*

*D.SIMOENS*
*Directeur*

BQA

*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 (b9) - 1000 Bruxelles.*

*DS/AJ/C/21-12-2009*



# Departments

**Managing Director**
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MAIRY B.
MARIQUE C.

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*Technology Transfer and Valorisation* (JC HERMAN
*Breakthrough projects* (C. MARIQUE)
*Activity Clusters* (Dpt Heads)
*Programme coordination* (C. MARIQUE)
A.Q. (V. TUSSET)

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MARIQUE C.
TOLLENEER I.
NAVEAU P.

**Surface Engineering (D2)**
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BORDIGNON M.
SCHMITZ A.
SCHMITZ B.

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NYSSEN P.
STEYLS D.

**Adv. Materials, Solutions & Sensors (D4-D7)**
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WALMAG G.
MOREAS G.

**Metal Science (D6)**
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**Operational Engineering (D5)**
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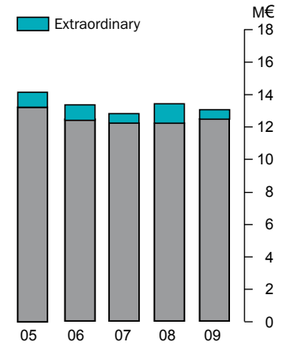
FISCHBACH JP.
ABREU E.
NOVILLE JF.

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

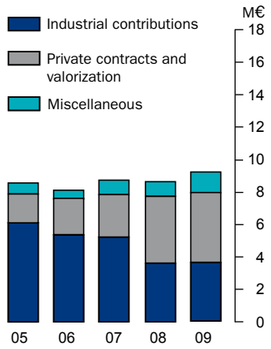
Support expertise and technical teams

# Income Data

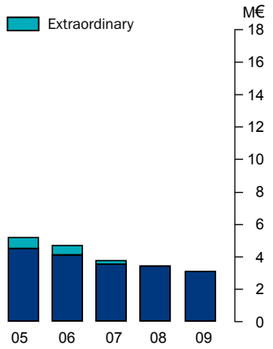
## Income



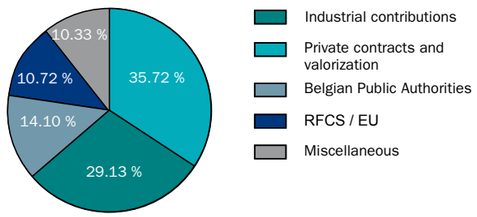

## Industrial participations



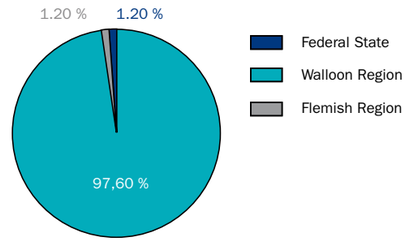

## Grants



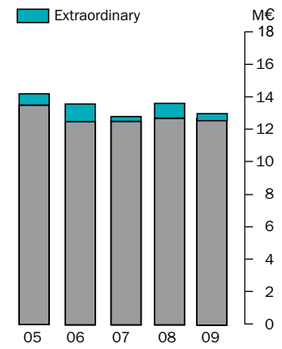

## Income by source : 12.436 M€



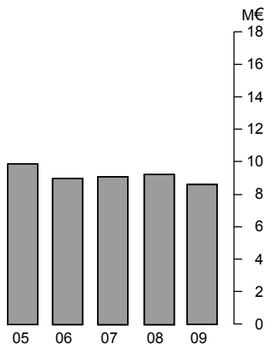

## Belgian grants : 1.753 M€



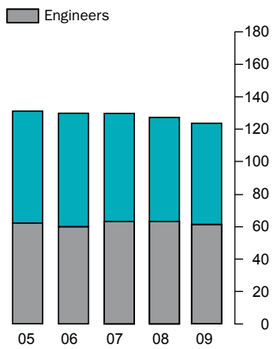

## Expenses




## Personnel




## Number of employees



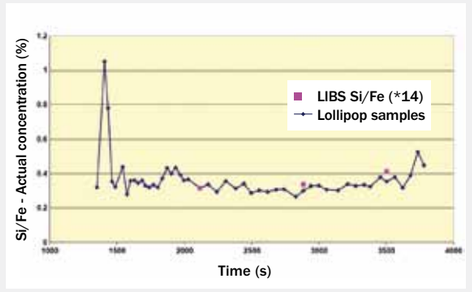

# Report on Research Activities

CRM

*Sinter permeability measurement*

*Supermagnag at ArcelorMittal Ghent*

*LIBS measuring unit at ArcelorMittal Ghent*




*On-line determination of the hot metal silicon content*

# Sustainable Production



The activities and competences of CRM in this field cover a wide range of industrial situations including not only the Steel Industry and its upstream processes but also sectors concerned by the supply of raw materials and goods, by high temperature processing, by recycling and valorisation of by-products as well as companies active in the plant manufacturing.

Based on dedicated laboratory and pilot equipment, expertise and projects are developed to propose new or improved production concepts, metallurgical modelling tools, innovative measurement units and sensors, coupled with industrial testing and implementation.
A special care is paid to the environmental issues and the finding of appropriate solutions.

Let us illustrate by some selected examples the main topics explored in 2009.

## Sintering of iron ores

A first important action deals with the development of a complete process control package integrating the CRM sinter model and the acquisition of missing process data through specific measurement campaigns. The sensor named “SuPerMagnag” can be especially pointed out. The pilot unit, implemented at ARCELORMITTAL Ghent, allows the fast on-line determination of the sintering degree all along the strand width and provides a complete and continuous mapping of the upper layer sintering quality. After several adaptations and long-term industrial trials, it has now reached a very high robustness and reliability.

A second action aims to support the industrial members to cope with new input materials (finer iron ores, plant reverts) whilst keeping high performances at the sinter plant in terms of productivity, sinter quality, energy consumption and pollutant emissions.

Based on adapted equipments, different critical aspects are considered:

- the balling behaviour of ores and reverts,
- the optimisation of the mix conditioning to keep a good permeability,
- the study of the granules resistance to strand feeding and thermal shock,
- the effect on emissions (CO, NOx, SOx, VOC, ...).

## Blast furnace operations

Based on the LIBS technology (Laser Induced Breakdown Spectrometry) available at CRM, the development of a continuous determination of the hot metal composition in the blast furnace runner has been pursued with the participation of ARCELORMITTAL Ghent.

Let us firstly recall that the LIBS equipment has been acquired with the financial support of the Walloon Region and the European Fund for Regional Development.

A specific LIBS measuring head, designed and built at CRM, has been tested during a successful industrial campaign at the blast furnace B of Ghent. The silicon, manganese and carbon concentrations of the hot metal were accurately monitored during two successive heats (more than 5 hours of test). No problem occured to the measuring head located directly on top of the runner thanks to the proper design of the cooling and cleaning units protecting the optical system. The next step of the development is the design of a compact unit dedicated to routine measurements.

In the frame of the large multinational European project “ULCOS”, CRM has actively contributed to the experimental campaign conducted end of 2009 at the pilot blast furnace of Luleä (Sweden) by providing its mathematical models to monitor the operations and contribute to the selection of the stable operation windows when a large portion of the top gas is recycled in the lower part of the blast furnace.

## Electric arc furnace

In the field of the EAF steelmaking, three main axes are followed to improve the efficiency and the control of the melting and refining operations.

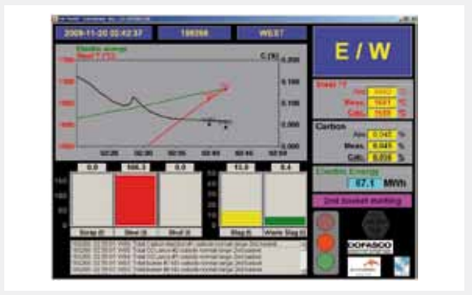
The implementation of a dynamic metallurgical model to allow an off-line and on-line monitoring of the furnace. A first deployment of the model has already been realized in two plants of ARCELORMITTAL. The development is continuing to complete the capabilities of the model, especially to allow the feeding of a broad and diversified range of charged materials (scrap, reduced iron, hot metal, ...) while keeping a good prediction in terms of final temperature and steel composition.



*Melting unit to test sinter mixes*

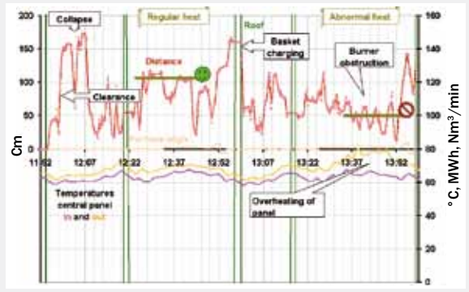
*Sinter pot designed to study hot permeability*

*Control room display of the EAF model*




*Experimental blast furnace*

*SERAFIN sensor at the back of a EAF burner*




*Scrap distance assessment during EAF melting*

*New briquetting press*

*Crushing and abrasion test equipment*



The development of specific sensors aiming to provide missing information and/or to prevent occurrence of incidents during the process:

Applied to optimize the burner/lance operation pattern in single or combined burners and to avoid blow-back phenomena, the "SERAFIN" unit, measuring the scrap pile distance in front of the burner tip, has been intensively tested at ARCELORMITTAL Esch Belval. It is reaching the final stage of development before its possible industrial deployment.

In close interaction with HERAEUS ELECTRONITE, a micro-spectrometer (7*4*2 cm) has been tested by CRM to develop an original and very fast on-line characterization of metals. Very good results have already been obtained in the measurement of chromium, nickel and aluminium in steels.

A more accurate characterization of the scrap and metallic charge quality. In the frame of two projects supported by RFCS (Research Fund for Coal and Steel), two different aspects are covered:

The set-up of a testing procedure to better assess the composition and behaviour of low quality scrap. After the application of a dedicated physical preparation prior to the melting in a 35-kg induction furnace under an inert atmosphere, the melting yield, the chemical composition and the effect on gaseous emissions of various individual scrap qualities can be established.

The use of a gamma neutron activation probe proposed by a German company for an on-line bulk analysis of scrap bundles or other massive scrap compounds. CRM contributes to this project by providing a comparative technique with the LIBS analysis. A device allowing the characterisation of large cross-sections of scrap bundles has been built by CRM.

## Recycling of by-products

New equipments for the conditioning and preprocessing of by-products and reverts have been acquired during the year 2009 in the frame of the project "PHOENIX" coordinated by COMET Traitements and financially supported by the Marshall Plan of the Walloon Region.

Let us firstly mention a briquetting press able to produce different briquette sizes at a maximal capacity of 450 kg per hour.

Two characterisation units aiming to determine the mechanical resistance of the produced briquettes and their behaviour to the abrasion/fragmentation have also been put into service.

These equipments complement the already available pelletizing disk, the roller compactor and the rotary hearth furnace (RHF).

Pilot campaigns to process self-reducing briquettes made from shredder residues have been successfully realized in the RHF unit.

## Air quality

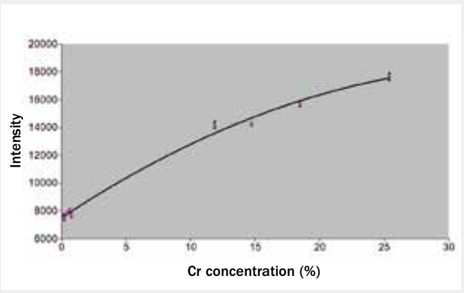
With the support of the Walloon region and the collaboration of two other collective research centres CENAERO and CERTECH, a second phase has been launched to further develop the concept of very fine dust (PM 10 and PM 2.5) agglomeration and abatement by application of powerful ultrasounds.

Nicknamed "PARAGGLO", the project aims at proposing technological solutions allowing a large industrial deployment in various sectors such as foundries, combustion systems (power generation, collective heating, ...) or chemical industries.

Besides the design of the ultrasound unit, the project also includes a numerical simulation model (fluid dynamics and acoustics), an optimized pilot scale test rig, the application of sol-gel sticking agents to enhance the particulate matters agglomeration.



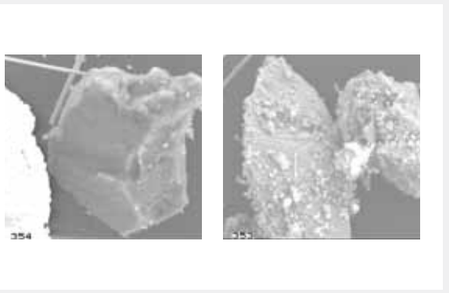
*Determination of the steel Cr concentration by micro-spectrometer*



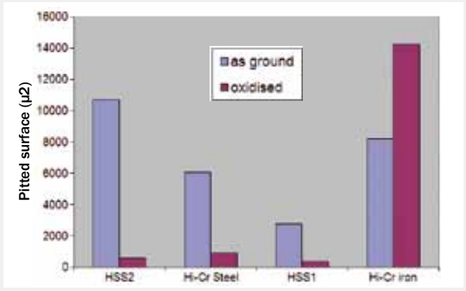

*Scrap melting induction furnace*

*Direct reduction of self-reducing briquettes*

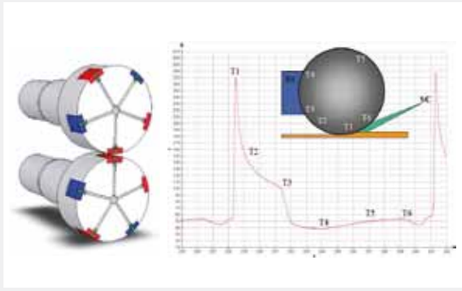
*Particles agglomeration by ultrasounds*



*Optical monitoring of the roll degradation at the roughing mill*




*Lower pitting proneness of roll after pre-conditioning*



*Heat transfer measurement during hot rolling*

*Scale prevention during heating by a glass coating*

# Product Technology



Based on a large experience in the management of projects with a tight interaction between process and products, the activities in the "Product technology" field cover all the processing steps between solidification, rolling and thermal treatment of hot and cold rolled products.

### Hot rolling

A first important objective is to further master the work roll degradation in order to decrease the production cost, to gain productivity and to improve the product quality.

The implementation of the camera based sensor called "Rollscope" at the roughing mill of ArcelorMittal Dunkirk and the development of a dedicated image analysis software allow to monitor in real time the roll degradation during long term campaigns and will be used to deduce rules for preventing incidents.

The pre-conditioning by thermal oxidation of the work rolls for the finishing mills (by the formation of a thin oxide layer before the installation in the stand) has been confirmed by laboratory trials as a very promising technique to extend the length of rolling campaign. Trials on the continuous pilot line are under preparation at CRM before to apply the concept for industrial testing.

Let us recall that CRM is supporting its affiliated roll manufacturers (Marichal Ketin, Äckers, Gontermann Peiper) in the development of new roll grades with improved properties.

A second field of activity concerns the rolling process itself.

During the year 2009, the continuous pilot rolling line has been upgraded in order to realize dual pass trials. A new central computing system has been implemented to simultaneously control the two stands as well as ancillary equipment like cooling units. A looper has been placed between the two stands to regulate the strip tension level. Both stands are now equipped with work roll cooling units and a pure oil lubrication system.

Several campaigns have been successfully realized as well in symmetrical as in asymmetrical configuration.

Measurements of heat transfer coefficients in the roll bite have been realized during continuous rolling trials using special instrumented top and bottom rolls.

This information allows to understand the evolution of the roll and strip surface temperature when modifying the processing parameters such as the reduction rate, the rolling speed, the mode of lubrication or the roll cooling.

### Strip surface quality

Aiming to limit the product oxidation all along the hot processing route, different approaches are studied:

A RFCS project called "OxMaPro" is focused on the use of protective coatings in the reheating furnace of semis.
Different coatings based on silica- or alumina-containing materials are tested under an oxidizing atmosphere at 1250 °C. Attractive results have been gained either to prevent the oxidation or to form a protective shell on the reheated product.

A second approach deals with the creation of a non-oxidizing atmosphere at the entry of the finishing mill in order to limit the scale growth. A significant decrease of the scale thickness has been observed during continuous pilot trials when the oxygen level inside the protective box placed in front of the stand is lower than 5% thanks to the injection of nitrogen gas. This positive effect is nevertheless somewhat reduced when the rolling speed increases.

### Cold rolling

Controlling the surface cleanness of cold rolled strip and reducing the roll wear are two major objectives of a RFCS project (dedicated to these issues).

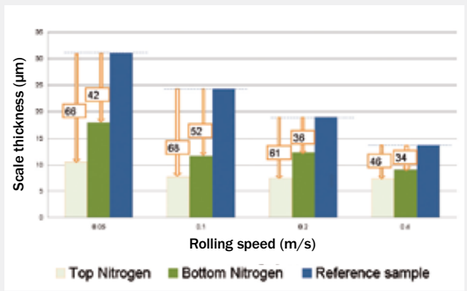
The influence of a chromium plating of the roll on the lubricant plate-out during cold rolling has been assessed using the ad-hoc simulator designed by CRM. A better behaviour is observed with chromium plated material (the amount of oil adhering to the roll is doubled with Cr-plated material) that explains the reduced wear and a cleaner strip surface.



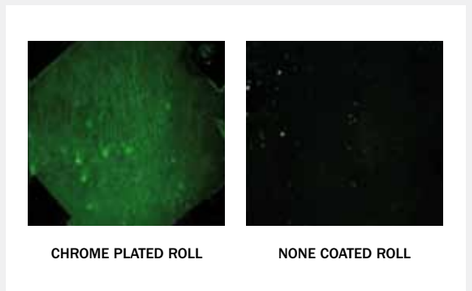
*Dual stand continuous rolling*

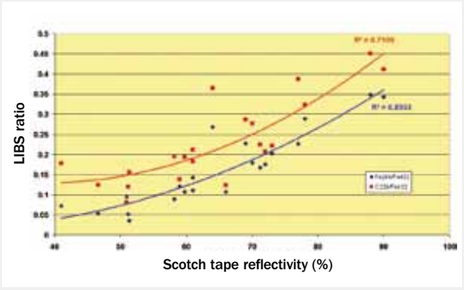
*View of the new looper*

*Reduction of the strip scale growth at the finishing mill*

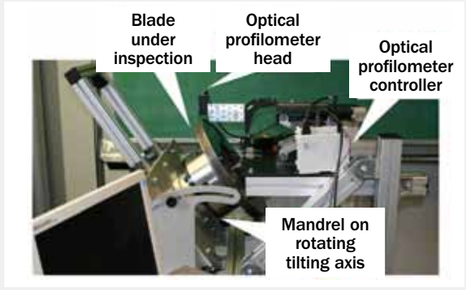



*Improved oil plate-out during cold rolling with Cr-plated roll*

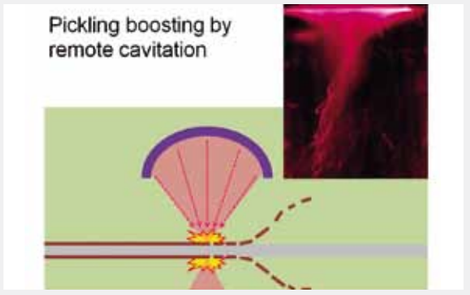




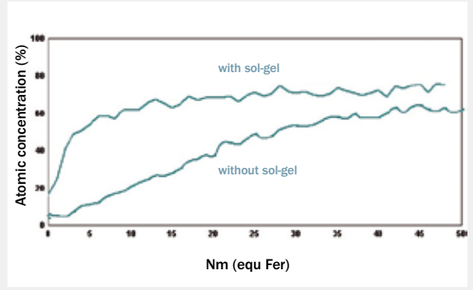

*Measurement of the strip surface cleanness with the LIBS equipment*




*Monitoring of the shear blade wear*




*Pickling boosting by remote cavitation*




*Formation of a thin iron oxide layer at the strip surface*

# Finishing and Coating



Using the LIBS equipment of CRM, measuring campaigns have been conducted on the pilot cold rolling mill of CORUS at Ijmuiden to continuously assess on-line the strip surface cleanness. Through a suitable setting of the iron and carbon spectral lines, a very good correlation has been established between the LIBS cleanness index and the conventional "scotch tape reflectivity", the later being an off-line and manual method. No negative impact of the LIBS measurement on the strip surface quality after galvanizing has been observed.

The project "MINT", supported by the "Marshall Plan" of the Walloon region aims to develop an innovative and integrated approach of the "intelligent maintenance".

It is coordinated by CMI with ArcelorMittal as industrial partner.

In the frame of this project, CRM is developing a sensor, based on a 2D laser triangulation, in order to accurately monitor the wear of the edge shear blades and thereby avoid strip quality problems.

## Product metallurgy

The positive effect of the asymmetric hot rolling on the mechanical properties of ferritic stainless steels has been confirmed after a detailed metallurgical characterization and analysis, with especially a significant reduction of the roping problem.

A study aiming to develop low cost hot rolled high strength steel based on a martensitic structure has indicated that integrating the quenching and tempering treatment in the existing hot rolling process is a possible way to reach an appropriate balance between strength and formability with the right selection of composition and rolling parameters.

The production of ultra-fine bainitic steel grade with a reduced consumption of expensive alloying elements has been deeply investigated with the aim to identify the most critical factors to be controlled during the thermo-mechanical treatments. The evolution of both yield strength and elongation in function of the coiling temperature depends on the presence of fine ferrite and precipitation state of Niobium.

Multiple fields of competence are involved in this area covering a large range of processing steps: pickling, annealing, metallic coating, surface conversion… but also looking to develop new coating concepts and advanced materials.

## Pickling

In order to suppress or drastically reduce the use of acidic media for the pickling operation, alternative techniques are investigated. The boosting of the scale removal by remote cavitation is one of the way studied by CRM in the frame of the NEXTEP RFCS project.

## Metallic coating

In order to improve the galvanizing ability of advanced high strength steels, a new concept to prepare the strip surface during the heating/soaking phases is studied. It consists in the application of sol-gel solution to create a thin iron oxide layer prone to favour a good reactivity of the strip surface during the hot dip coating.
This development is conducted in collaboration with Corus and other partners in the frame of a RFCS project.



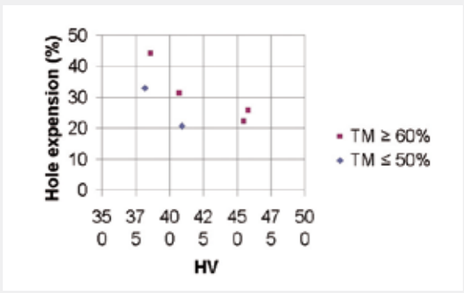
The morphology and the corrosion performance of new zinc coatings containing magnesium has been deeply investigated during a RFCS project.

The positive role of magnesium to modify the surface structure of Zn-Al coating and to drastically improve the corrosion resistance has been confirmed.

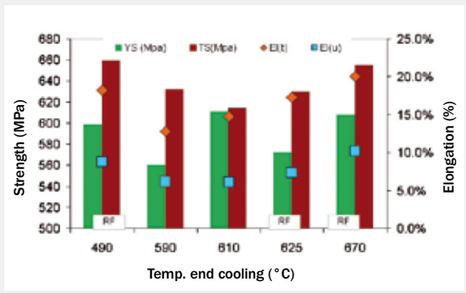
The measurement equipment designed to on-line determine the waviness of galvanized products at the exit of the line has been industrially tested during two campaigns successfully conducted at Corus-Segal and ArcelorMittal Avilès.

Good results have been obtained confirming the correlation determined at the laboratory level with a reference static method. It has been shown that the setting of the sensor has to be adapted as a function of the processed strip quality and its reflectivity.

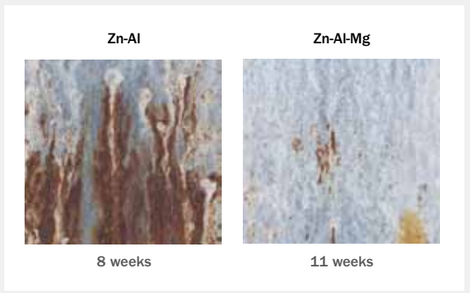
*Strength and formability of low cost martensitic grades*



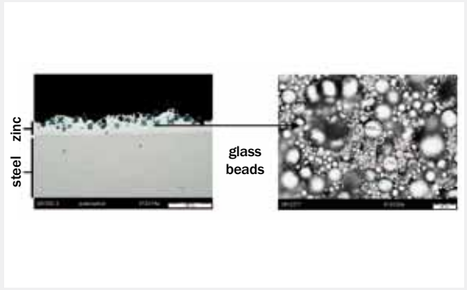

*Mechanical properties of bainitic steel*



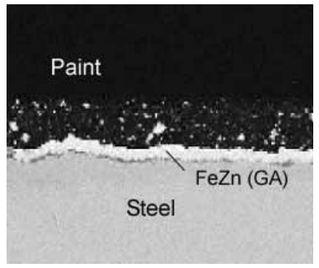

*Improved corrosion resistance of Zn-Mg coatings*




*Strip waviness measurement at ArcelorMittal Avilès*

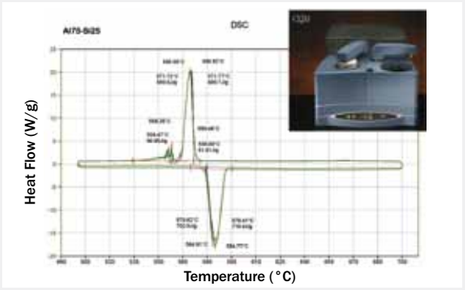



*Injection of particles in zinc coating*




*Example of Duplex product*

*High temperature descaling by shot blasting*




*Characterization of high temperature phase change material*



### New coating process

The incorporation of particles in the zinc layer just after the wipers before the zinc gets solidified is one of the new route studied by CRM to propose new coated products. The first phase of a project supported by the Walloon Region has pointed out the possibility to operate such a concept with the successful injection of glass particles of around 30 µm during tests on the pilot galvanizing line. A second phase of development, also supported by the Walloon Region has been launched to develop a technology able to inject finer particles (~5 µm)

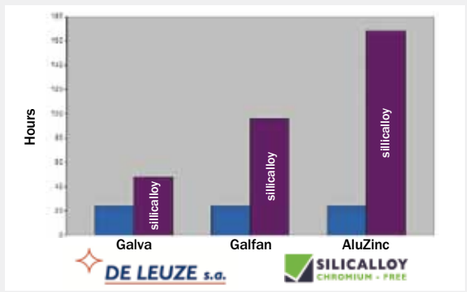
In the field of the batch galvanization, Umicore has proposed a new coating concept based on the evaporation of zinc inside a vessel operating under a moderate vacuum level. Called “EVAPLEX”, this process aims to compete with the commercially available Duplex products thanks to a more friendly environmental and lower cost production route. The pilot installation will be built and operated by CRM. The project supported by the Walloon Region also associates Drever, ArcelorMittal and CoRI.

### Surface conversion

The “Silicalloy” concept (a chrome-free solution for the conversion of metallic surface developed by CRM and commercially valorized by Deleuze SA) remains the subject of continuous development with the support of the Walloon Region. Several projects are running either in the Marshall Plan or in the programme dedicated to the collective research centres aiming to enlarge the field of applications (new zinc-magnesium coating, steel shots, aluminium containing coating,…). This very thin hybrid polymer/silica coating offers transparency and hydrophobicity in combination with a high corrosion resistance. Depending on the nature of the zinc coating, salt spray tests indicated a corrosion resistance to the white rust appearance between 48 and 168 hours, a performance allowing to meet the present most stringent requirements.

The design of a new protective coating, free of zinc, is another important topic on which CRM is actively working on with the support of the European Fund for Regional Development and the Walloon Region.

*High corrosion performances of Silicalloy treated products*




*New zinc-free protective coating*


# Energy efficiency



The last World economical crisis has again underlined the crucial importance of the energy issues and the need to further extend the effort for reducing the consumed energy and valorising all the available heat sources.

To contribute to this challenge, several projects are running at CRM, not necessarily focused on specific process or part of process but aiming more to develop a transversal knowledge and concepts applicable to different industrial or domestic situations.

Some examples are illustrated here below:

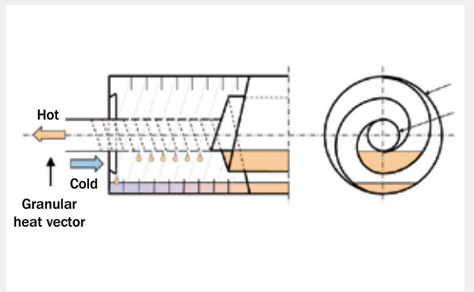
The application at high temperature of a new steel shot descaling technique to mechanically remove the oxide layer present on metallic products (RFCS project “HIDES” conducted in collaboration with Corus and WheelAbrator).
If successful, a significant energy gain can be expected by substituting the energy-intensive high pressure water-based solution together with a minimisation of the surface heat loss.

The recovery and storage of energy at relatively high temperature considering two main different situations and options:

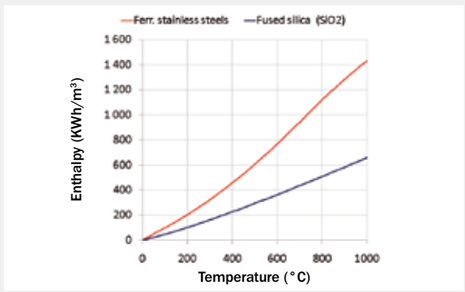
The static application of Phase Change Material (PCM) to recover the heat contained in combustion fumes or process gas (Temperature range: 600 to 900 °C). The study of adapted materials by Differential Scanning Calorimetry (DSC) and the building of a suited simulator are made in the project “Everfire” supported by the Walloon Region.

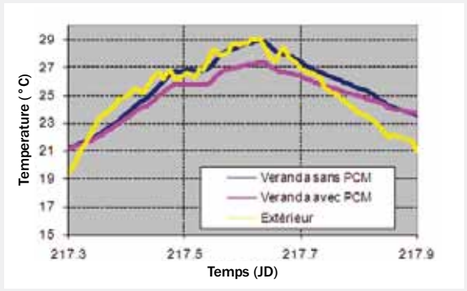
The dynamic use of a solid granular thermal vector to be heated up, transported and cooled down when needed. For the heating phase and the release of the contained thermal energy, a novel heat exchanger design is proposed based on an original rotary drum spirally shaped. A liquid metal confined inside the exchanger enhances the heat transfer from the source to the solid vector before moving it after metal filtration in the transport zone.
(Project supported by the Walloon Region)

*New heat exchanger concept*



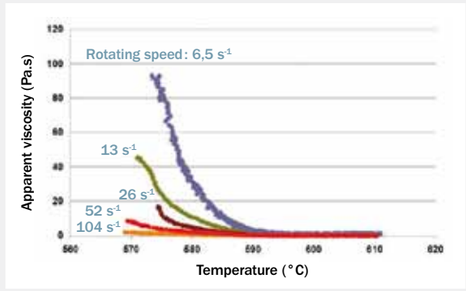

*Heat capacity of solid granular material*



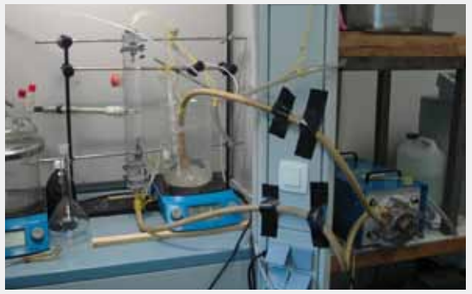



*Thermal room control with steel panels containing PCM*

*Steel seat designed to contain PCM*




*Viscosity behaviour of Magnesium alloys*



*Electrochemical corrosion test cell*

As well metallic as ceramic materials showing a high heat exchange and storing capacity per volume are considered for the solid thermal vector. This development is also supported by the Walloon Region.

The improvement of the thermal comfort in buildings thanks to the use of PCM working at the current temperature ranges.

Developed in the frame of two different projects ("Mirage" and "Retermat"), steel panels and household appliances containing PCM are tested in real situation to assess their capacity to regulate the temperature in a room on a daily basis.

Let us particularly point out the steel seat designed in collaboration with Naos Design (Damien Bihr), a Belgian designer, that was presented during the exhibition "Le Génie de la Matière - Nouvelles formes de design industriel" organized by the "Centre Wallonie Bruxelles" at Paris in February and March 2010. This seat contains PCM allowing to absorb excess heat during the sunny days and to keep a thermal comfort during the evening when the temperature goes down.

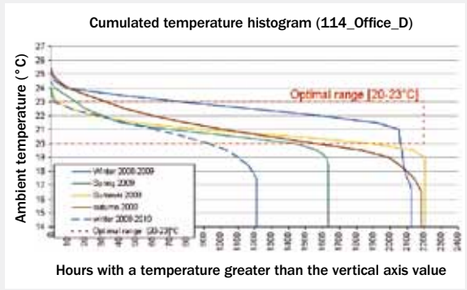
The promotion of steel solutions in the construction favouring a reduction of the energy consumption is conducted in the RFCS project "ETHICS" with the building CRM 4 used a demonstration unit.

Extensively instrumented, this building is the subject of a continuous monitoring to assess on a daily basis its performances in term of thermal comfort, acoustic behaviour and energy consumption.

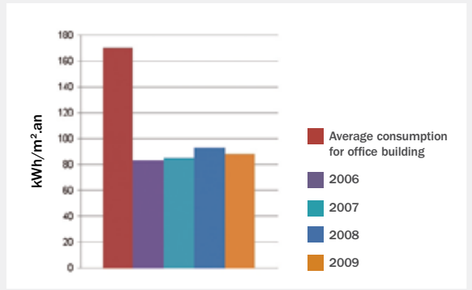
Steel has been massively used for the framework, the facades, the internal partitioning and the ceiling. Most of the air is internally recycled with the possible recovery of the internal and solar heat by the ventilation system.

Remarkable performances are observed to control the room temperature inside the aimed comfort zone whilst showing a low heating energy consumption compared to reference Belgian standards.

*Mastering the thermal comfort inside CRM 4*




*Heating energy consumption of the building CRM 4*




# Support to Federal and Regional Economy



As already illustrated, CRM is largely contributing to the research initiatives of the Federal and Regional Belgian Authorities in partnership with other research centres, universities and industrial companies.

Let us mention additional examples of such collaborative activities:

### Advanced materials characterization

The characterization of non-ferrous alloys containing aluminium and magnesium for their application in semi-solid injection and forming (Project "SIMSEMSO" in collaboration with SIRRIS). CRM is notably charged to measure the rheological properties of semi-solid slurry.

The set-up of a methodology to monitor the corrosion resistance of metallic materials (Project "PREDICOR" with Materia Nova and CoRI). Electrochemical corrosion tests associating dedicated monitoring sensors enabled to determine the uniform corrosion and to assess the risk of localized corrosion.

A new furnace co-owned with the University of Liege has been acquired to allow the heat treatment under vacuum and protected atmosphere of a large range of materials.

### Guidance and technological watch

A team of almost 6 engineers is providing a direct technical support to small and medium size companies thanks to the support of the Walloon Region with more than 250 direct significant actions in 2009.

The possibility for these SME's to take profit of the "Chèques Technologiques" offered by the Walloon Region under the management of AST (Agency for Technological Stimulation) in their search of solution for technical problems and introduction of innovation his to be particularly pointed out.

As an example of support action, let us mention the solving of a white rust problem in joining roofs due to cyclic corrosion aspects with the finding of a better protection treatment.

*New vacuum heat treatment furnace*


*White rust problem on joining roofs*

# Publications



## Product Technology

**D. ESPINOSA, G. LANNOO, J. MALBRANCKE, G. MOREAS, M. PICARD,**
***Study of the scale behaviour in the finishing mill to improve the strip surface quality,***
Revue de Métallurgie, CIT, November 2009, Vol. 11, pp. 518-528.

## Finishing and Coating

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***Analysis of the deposition of Si-based coatings by a cold plasma jet at atmospheric pressure,***
Proceedings ISPC, Bochum, 2009.

**J. CRAHAY, S. LECRAZ, X. VANDEN EYNDE,**
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**L. SUAREZ, Y. HOUBAERT, X. VANDEN EYNDE, R. COLAS,**
***High temperature deformation of oxide scale,*** ELSEVIER, Corrosion science Vol. 51, pp. 309-315, 2009.

## Sustainable Production

**G. DANLOY, A. BERTHELEMOT, M. GRANT, J. BORLÉE, D. SERT, J. VAN DER STEL, H. JAK, V. DIMASTROMATTEO, M. HALLIN, N. EKLUND, N. EDBERG, L. SUNDQVIST, B.E. SKÖLD, R. LIN, A. FEITERNA, B. KORTHAS, F. MÜLLER, C. FEILMAYR, A. HABERMANN,**
***ULCOS - Pilot testing of the Low-CO2 Blast Furnace process at the Experimental BF in Luleå,***
Revue de Métallurgie, CIT, January 2009, Vol. 1, pp. 1-8.

**G. DANLOY, J. DELINCHANT, U. JANHSEN, E. LECTARD,**
***New characterisation tests of the coke behaviour at high temperature,***
Revue de Métallurgie, CIT, February 2009, Vol. 2, pp. 48-59.

**S.A. ZAIMI, T. CAMPOS, M. BENNANI, B. LECACHEUX, G. DANLOY, D. POMEROY, R. PEREZ-CHUST,**
***Blast Furnace models development and application in ArcelorMittal Group,***
Revue de Métallurgie, CIT, March 2009, Vol. 3, pp. 105-111.

**G. DANLOY,** ***Modelling of the blast furnace internal state with MOGADOR,***
La Revue de Métallurgie, CIT, September 2009, Vol. 9, pp. 382-386.

**G. DANLOY, P. DESNEUX, J.P. FISCHBACH, J.F. NOVILLE, D. STEYLS, E. LECTARD, H. PIERRET, J. DELINCHANT, B. VAN DER VELDEN, J. STUURWOLD, U. JANHSEN, A.Y. GÜNBATI,**
***New characterisation tests of the coke behaviour at high temperature,***
European Commission, Research Fund for Coal and Steel series, Final Report, EUR 23748 (ISBN: 978-92-79-11253-9).

# Conferences



## Finishing and Coating

**B. VERVAET, D. AVEDIAN, C. PESCI,**
***Pure oil lubrication in the hot strip mill,***
European Rolling Conference, London, UK, June 23-25, 2009.

## Sustainable Production

**S. HOCQUET, S. ANDRÉ, J. TIRLOCQ, F. CAMBIER, M. WAUTERS, B. VANDERHEYDEN,**
***Slag from Steelmaking Industries as Substitute of Sand in Fired Clay Bricks,***
ECERS 11th International Conference and Exhibition of the European Ceramic Society, Krakow, June 21-25, 2009.

**B. VANDERHEYDEN, D. STEYLS,**
***Valorisation des résidus ultimes issus du broyage des véhicules hors d'usage et des déchets d'équipements électriques et électroniques,***
Contribution to paper prepared by Comet Traitements for the press conference on the Phoenix project (Marshall Plan, Walloon Region), Campus Automobile Spa-Francorchamps, December 4, 2009.

## Application of Metals

**P. H. BOLT, D. BATAZZI, N.P. BELFIORE, C. GASPARD, L. GOISET, M. LAUGIER, O. LEMAIRE, D. MATTHEWS, T. NYLÉN, K. REUVER, D. STOCCHI, F. STORK, J. TENSEN, M. TORNICELLI, R. VALLE, E. VAN DEN ELZEN, C. VERGNE, I.M. WILLIAMS,**
***Damage resistance and roughness retention of work rolls in cold rolling mills,***
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EUROCORR, Nice, France, September, 2009.


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