Review of activities

2012/13

OCAS

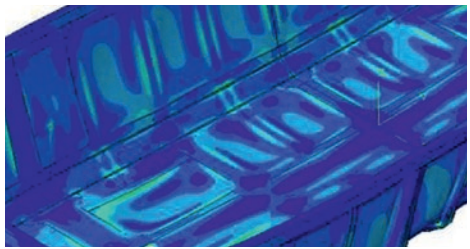
Text
OCAS team, Wright Communications

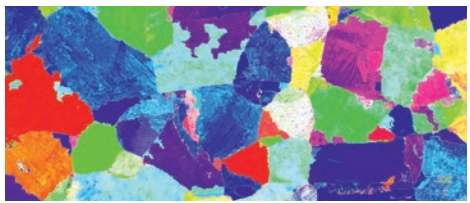
Editor
Katrien Meseure

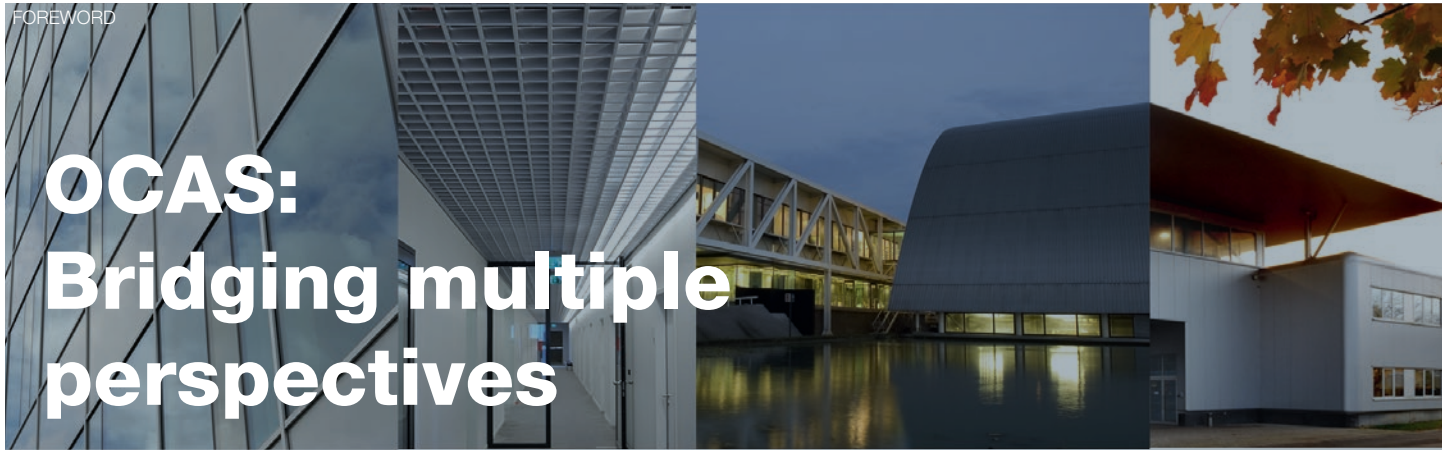
Graphic Design
Mr & Mrs Fly, Big Boom

Photography
Jeroen Op De Beeck (p.5, 98) - Roger Hubert (p.6, 7, 14, 30, 54, 92) - Verne Photography (p.10, 50, 78) - Steven Marquenie (p.12) - Andries De Geest (p.12) Koen Bracke (p.14)- Martin Liebeherr (p.16) - Katrien Meseure (P.18, 84, 90, 98, 99) - Olivier Raeymaekers (p.20) - Marc Vanderschueren (p.22) - With the courtesy of ArcelorMittal St-Chély D'Apcher (p.26) - With the courtesy of Valeo Electrical Systems (p.24) - With the courtesy of Flamac (p.28, 88) - Jeroen Van Wittenberghe (p.32, 72) - Xavier Veys (p.34) - With the courtesy of ArcelorMittal Europe Flat Products (p.42, 62, 64) - Christoph Gerritsen (p. 44) - With the courtesy of Volvo Construction Equipment (p.46) - With the courtesy of Greif (p.58) - With the courtesy of Ariston Thermo Group (p.60) - Charlotte Cassiman (p.74) - Ann De Vyt (p.98) - Gert Laureyssens (p.98, 99) - OCAS team

Responsible Publisher
Sven Vandeputte, Managing Director OCAS, Pres. J.F. Kennedylaan 3, 9060 Zelzate - Belgium







OCAS: Bridging multiple perspectives

Ever since our founding in 1991, and symbolised in the construction of our head office building in Zelzate, OCAS has served as a bridge between steel producer and customer. Over the years, the bridge metaphor has expanded in significance, until today we form a bridge among multiple perspectives: between our stakeholders, between our partners, between industry and academia, and between product and application. Carrying out OCAS's mission, our personnel put bridging, in all of its senses, into practice every day.

Focusing on society's needs

In general, 2012-2013 were not that much brighter for the European metals and steel industries than the difficult years we have experienced since the onset of the economic and financial crises.

Still, we continued with determination to follow our strategy and focus on society's needs, which are reflected in our major activities: energy, durability and environment. In turn, these activities are underpinned and propelled forward by our technical support efforts and our entrepreneurial R&D discoveries, which help our customers reach their goals. You'll read all about our progress in these areas over the past two years in the pages of this report.

Providing added value

As we said in our 2010-2011 activity report, "challenging times call for

bold decisions". At that time, we had undertaken a profound strategic exercise with the goal of focusing on a limited number of developments that would propel OCAS into the years ahead. Already in 2012, there were indications that we had made the right strategic choices. Our competencies, combined with our state-of-the-art equipment and collaboration with our partners, provided us with unique opportunities.

Today, the customer added value we provide to metal producers and processing companies is recognised by an increasing number of international clients. These organisations become highly loyal – repeatedly relying on our R&D services, as they seek our advice and solutions personalised to their particular needs.

Combining core strengths

Our structural partnerships with our partners in the Metal Processing Centre (MPC) and in the Metal Structures Centre (MSC) have proven to be real market successes.

The solutions we provide to our customers' complex, multi-disciplinary material development or application problems are simply better when we combine our core strengths with those of our various partners, to offer a total solution.

So, the further deepening of our relations with all of the partners of the Materials Research Cluster Gent[1] is the path forward for growth in the next few years. In addition, we will continue our R&D efforts on the

Serge Claessens,
Chief Technology Officer

[1] *SIM and its Flamac department, Sirris, Clusta, CRM, BIL, Ghent University departments*

"OCAS meets its customers' needs by developing alloys and coatings, by co-developing steel applications, and by processing and testing metal-based samples. OCAS valorises its know-how through product & solutions development, licenses, joint ventures and spin-offs."

Sven Vandeputte,
Managing Director

strategic topics that we have defined – strengthening OCAS's intellectual property portfolio, while at the same time striving for valorisation of this IP in collaboration with a variety of industrial companies along the value chains.

Powering renewal

At this point, 2014 shows signs of new growth. We continuously need creative thinking and fresh ideas to power this upswing.

One source we are keen on tapping is the rich potential of graduates from our universities. To this end, OCAS strongly supports any initiative to encourage young students to become enthusiastic about science and technology. As we move forward, we wish to extend an open invitation to people of all ages to investigate and understand the benefits of Materials Science & Engineering.

1

Energy

Martin Liebeherr

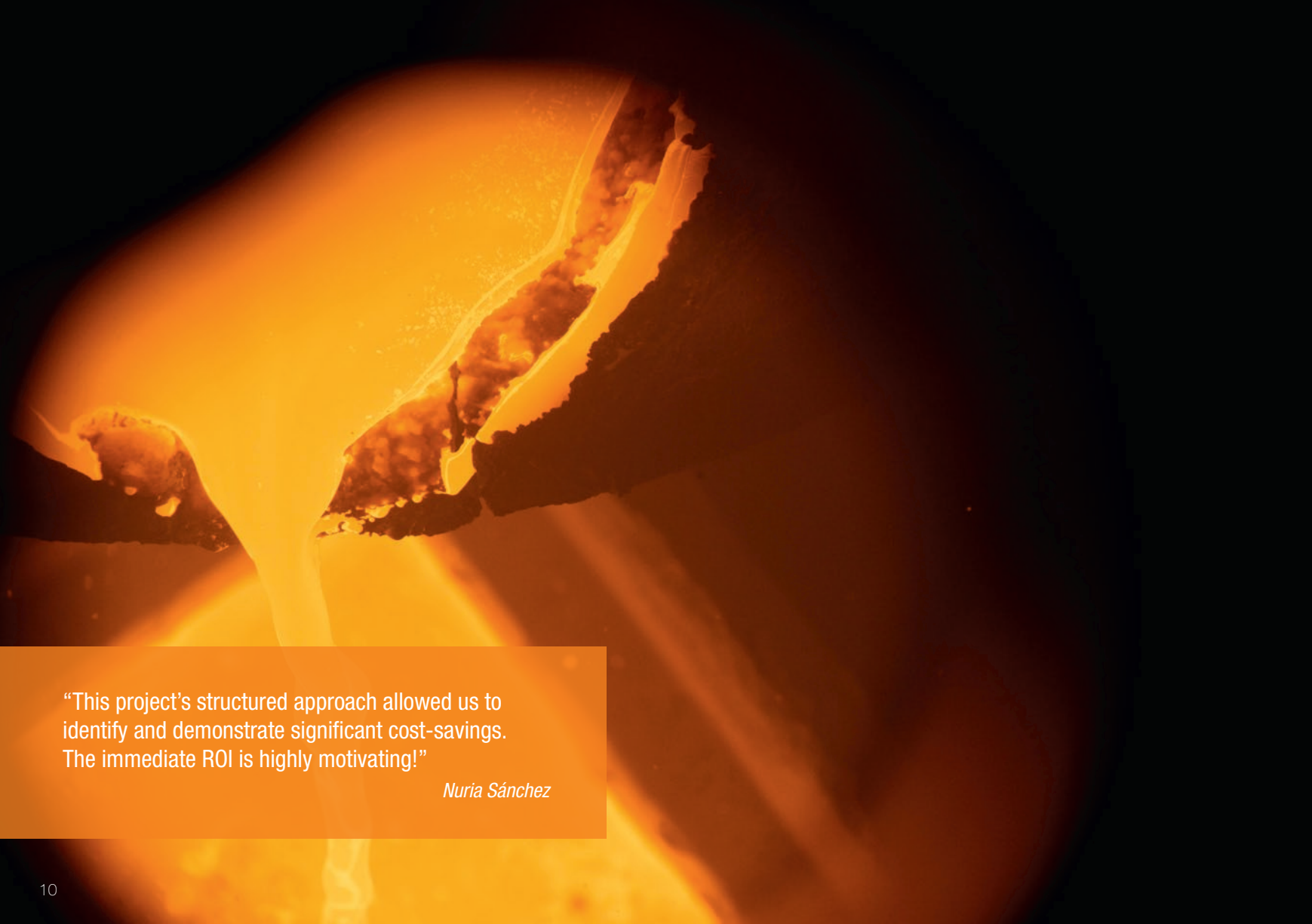
Energy is a challenge! New fossil energy sources are discovered in remote areas, e.g. in arctic regions or offshore, and the wells are getting deeper and deeper, approaching depths of 10 km. An increasing number of wells contain considerable amounts of hydrogen sulphide leading to so-called sour corrosion in steel structures. Transportation of oil and gas needs to be safe. Limited fuel resources require increasing efficiency of power plants and motors. Global warming implies reduction of CO_2 emission or, if possible, capture and sequestration in underground reservoirs. Alternative power generation needs to be reliable and affordable.

Being a research lab with a track record in the development of new steels, OCAS knows about the challenges arising from these topics. A number of new high-strength steels – with improved fracture toughness at low temperature for gas transport, improved weldability for offshore applications, and improved sour corrosion resistance for oil and gas wells – have been successfully developed and introduced

in our product offer. Every proposed metallurgical solution is tailored to the customer's requirements, the technical constraints of the respective steel production plants and the cost-reduction objectives.

Yet, complex technological problems require a comprehensive and dedicated approach. That's why we've built up extensive expertise in specialised technical fields of steel solutions and coatings. Together with our partners in the Metal Structures Centre consortium (OCAS, Belgian Welding Institute, Ghent University's Soete Lab), OCAS's goal is to become a major solution provider in the Energy market. Our active presence in the Energy market has enabled OCAS to support not only the needs of ArcelorMittal's customers but those of the end-users and other stakeholders as well.

We are ready to face the challenge.



"This project's structured approach allowed us to identify and demonstrate significant cost-savings. The immediate ROI is highly motivating!"

Nuria Sánchez

Cost reduction in line pipe steel production

One of the benefits of the continuous technological upgrades of the ArcelorMittal hot strip mills is the optimisation of the costs of the metallurgical routes for line pipe grades.

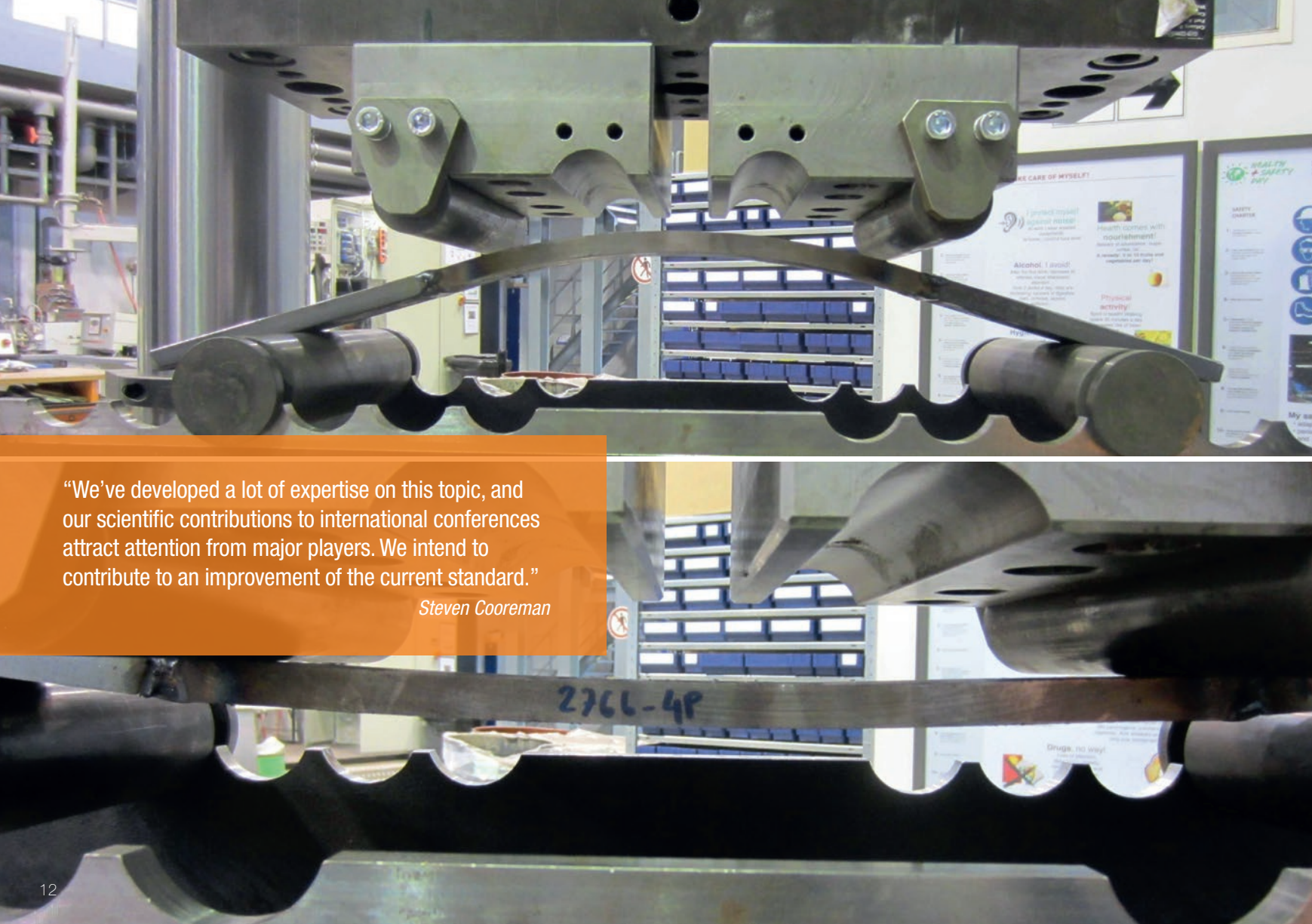
In 2012, OCAS initiated this project with a benchmark reviewing all metallurgical routes for line pipe grades in the European mills. After identifying the key products for which costs could be significantly reduced, OCAS assembled a workgroup, comprised of operational and commercial managers, to focus on the products with higher market demand.

ROI tomorrow!

With clear technological targets, we launched a large experimental campaign – including castings, rolling and testing of in-use properties – in which the potential of various lean metallurgical concepts was assessed.

Results of the laboratory simulations revealed several suitable leaner solutions – which were immediately up-scaled for industrial mill operation. The results from the first industrial trials not only verify the cost-saving potential, but they also demonstrate that lab experiments are a very powerful tool for screening the in-use properties of alternative metallurgical routes.

This project continues this year with further optimisation of other grades and formats for the line pipe market.



"We've developed a lot of expertise on this topic, and our scientific contributions to international conferences attract attention from major players. We intend to contribute to an improvement of the current standard."

Steven Cooreman

Making pipe properties predictable

While steel mills guarantee properties on coil, the pipe manufacturers making energy pipes from coil, must guarantee properties on pipe. As the process of pipe making changes the coil properties, both players have a strong interest in predicting pipe properties from coil properties. Such a metric would allow pipe manufacturers to provide more specific requirements to the steel mill.

In the past, OCAS developed a model that simulates pipe manufacturing with the aim to predict pipe properties from coil properties. However, to validate the model, we need input regarding mechanical properties.

Levelling the playing field

A possible method is to determine the required parameters by submitting a pipe segment to a ring expansion test. But not only is this test expensive, for obvious reasons the expansion is limited to about 2 – 3% without the possibility of recording ultimate tensile strength.

Therefore, most pipe manufacturers prefer tensile testing on so-called flattened pipe samples: in which strips are cut from pipe, flattened, and then machined into tensile samples, which are eventually tested on a standard tensile bench.

However, this flattening procedure is not yet specified in any standard. Moreover, it again alters the actual mechanical properties. So, OCAS researchers started a project to investigate the influence of flattening and sample flatness on test results.

Benchmarking to select best practice

As sample flattening clearly influences test results, we have developed a method based on 4-point bending. The new method ensures reproducible results, with only minor variation. Inspired by these findings, we participated in a joint industry project in which 13 labs from all over the world used their own method on two different pipes. The OCAS method looks highly promising. In a second round, all of the labs will use the same method.

Meanwhile, we continue to collect data to validate our method. Our team of researchers is determined to better quantify pipe properties – and to return the Bauschinger effect to its proper proportions: too often, it has been exaggerated as an explanation for low properties measured on pipe, without questioning the testing procedure.

"The recent revamping of our lab plate mill, and the further extension of our HIC/SSC lab capabilities, are boosting our product development in the field of energy pipes."

Nuria Sánchez

Energy pipes with sour service guarantee

The continuous optimisation of oil and gas transportation costs is presenting new challenges to the design of steel grades for pipelines. Transporting oil or gas from sour reservoirs, or designing a transmission pipeline across a sour environment like the bottom of the Black Sea, means that new pipeline grades must not only be strong and tough, but they also need to resist sour corrosion cracking to ensure line pipe integrity.

A significant number of pipelines installed around the world are exposed to 'sour' environments, which contain wet hydrogen sulphide. Hydrogen atoms from this corrosive environment can diffuse into the steel and cause various cracking phenomena.

Aggressive environments call for clean grades

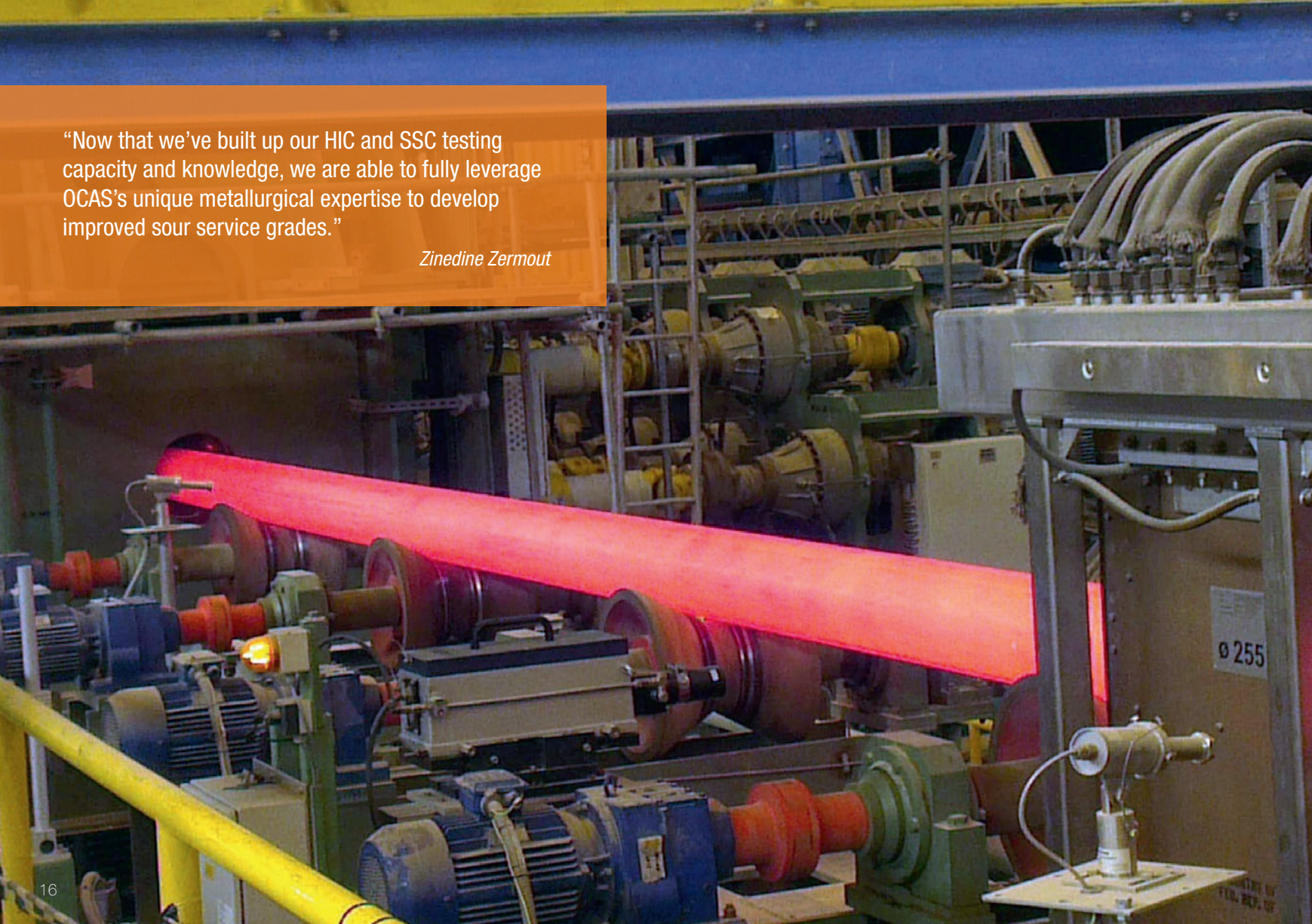
To prevent hydrogen embrittlement, successful energy pipe grade development focuses on avoiding inclusions and segregation. The 'cleaner' the grade, the more resistant it is to hydrogen-induced cracking (HIC) and sulphide stress corrosion (SSC). Yet, at the same time, the mechanical properties must still meet standard specifications.

To ensure sour resistance, the steelmaking and processing of these steel grades require extensive expertise, state-of-the-art technology, and a fine-tuned process window. Close collaboration between R&D and the steel plant is required to be able to translate the metallurgical concept into an industrialised grade.

In-house HIC and SSC testing

To verify the developed grades' resistance to sour environments, OCAS performs in-house HIC and SSC testing. The line pipe grades require a dedicated SSC test that simulates the loads to which the pipeline can be submitted during service.

Over the past two years, we have made great progress in aligning lab casting and rolling with industrial processing. Having an in-house test facility for HIC and SSC facilitates the development of these special grades significantly.



"Now that we've built up our HIC and SSC testing capacity and knowledge, we are able to fully leverage OCAS's unique metallurgical expertise to develop improved sour service grades."

Zinedine Zermout

Combining high-strength steels seamlessly with sour service

Seamless OCTG (Oil Country Tubular Goods) pipe is commonly used for oil and gas exploration. And because today's fossil-fuel sources are often explored in so-called 'sour' environments (containing hydrogen sulphide), and drilling must go ever deeper, these pipes require high-strength steel grades resistant to sulphide stress cracking.

OCAS has been making great progress developing high-quality high-strength grades that can perform in sour oil and gas drilling environments. So, in view of the start-up of its brand-new mill at Jubail (Saudi Arabia), ArcelorMittal Tubular Products called on us to develop top-end grades.

In-house testing

The ability to perform in-house tests to qualify grades in accordance with standard specifications is a great asset in studying and understanding the phenomena related to sour service. OCAS has a fully equipped sour corrosion lab capable of performing standard hydrogen-induced cracking (HIC) and sulphide stress cracking (SSC) tests, including the double cantilever beam test (SSC Method D), in both severe and mild sour conditions.

The SSC Method D test requires dedicated expertise, only a few laboratories in the world can perform this highly specialised test. The testing methodology is still a hot topic in standardisation committees and we hope to contribute to the ongoing discussions with our research results.

High-end sour service grades

Whilst the seamless tube mill in Jubail was still under construction, a team of OCAS metallurgists started searching for the right alloy concepts to provide high-end sour service grades. Two highly promising concepts were identified from lab casting, rolling and thermal treatment.

The lab results were recently presented during a 2-day R&D workshop at Jubail. The participants were impressed by the results obtained – and a first industrial trial of both concepts will be conducted soon. Despite the huge challenges ahead, Jubail management is convinced that the combination of high-strength and severe sour service is the way to go for the future.

"Welding energy pipes is much more than joining metal. We must ensure on-pipe and in-the-field performance of linepipe steel grades for utmost safety."

Özlem Esma Ayas Güngör

Welding energy pipes – much more than joining metals

Thanks to the new multi-wire submerged arc welding (SAW) facility, OCAS is able to develop welding guidelines for the most demanding applications in the energy sector. All data on steel properties and weldability are recorded to generate detailed product files.

OCAS is in charge to provide a fully documented submerged arc welding catalogue for selected energy pipe products. Priority is being given to heavy gauge linepipe grades, with chemistries complying with either European (former EN, now annex of ISO) or American and International (API / ISO) standards.

Welding guidelines matter

With the multi-wire welding station OCAS is capable to simulate exactly the welding configurations of the various spiral pipe mills. However, in-house welding results often outperform results obtained by the mills using non-optimised conventional procedures. Attention is also given to consumable selection. This service is highly appreciated, as was expressed for example by an international Oil Major operating an offshore pipeline in West-Africa.

Recently, OCAS presented spiral welding simulation results at a leading international pipeline conference. The fact that this attracted a lot of interest from the participants proves the relevance of this type of research – and it also gave OCAS an opportunity to highlight our expertise in this field.

In the meantime, OCAS has also launched girth weldability evaluation on industrially produced pipes from ArcelorMittal customers in order to provide technical data to the end-user for laying pipe in the field. Collaborating with external customers also enables OCAS to gather valuable feedback from in-the-field applications. The resulting guidelines will facilitate handling customer requests in short lead-times, providing spiral pipe and girth weld simulations for given chemical compositions and in-use conditions.

Preparing for new challenges

Today's oil and gas industry must tap fossil-fuel sources in environments that are more demanding than those in the past. Particular attention has to be given to the welds of the pipes. OCAS has launched a research project to gain better insight into the influence of welding parameters on the corrosion mechanisms. This project is currently up and running, with tests being performed in the in-house sour corrosion lab.

"The pre-qualification campaigns brought our partnership with the Belgian Welding Institute to a higher level. While OCAS took care of the welding, part of the sampling and testing, and overall project management, the Belgian Welding Institute conducted specific testing: in particular, the CTOD (crack tip opening displacement) tests. Together, we learned a lot, and we learned fast!"

Christoph Gerritsen

Diving into offshore qualification

Heavy plate mills interested in entering the offshore market should offer pre-qualified material – this is a must when submitting tenders for major projects. So, several European ArcelorMittal mills are considering having their offshore grades pre-qualified.

Off-shore steel grades are subjected to stringent criteria for pre-qualification, with which the base material's response to welding, for example, is tested, based on the behaviour of the heat-affected zone (HAZ). At the request of the ArcelorMittal Gijón mill, OCAS started the procedure to obtain offshore pre-qualification according to EN, API and NORSOK standards for some of their grades.

Added value of metallurgical expertise

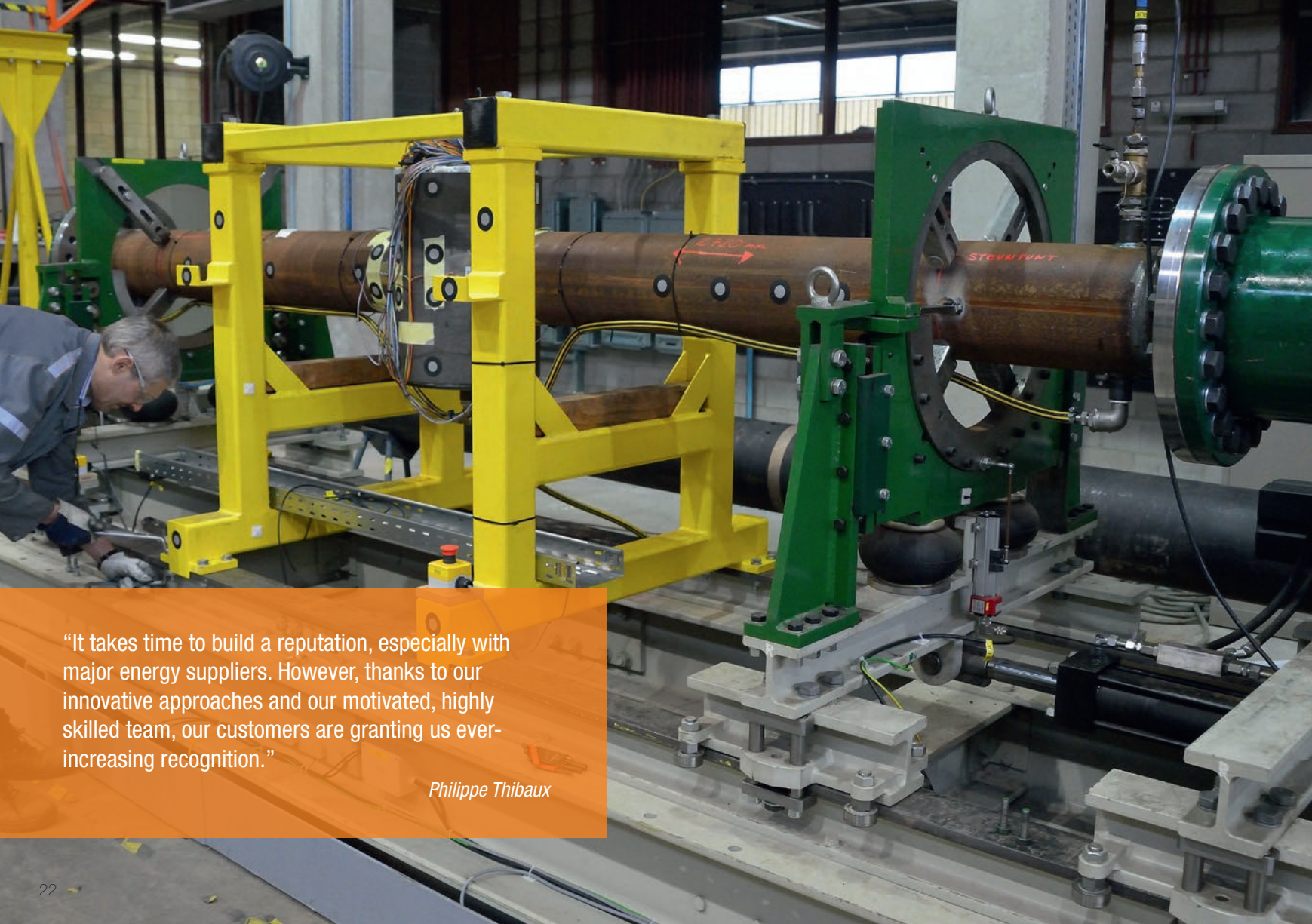
Although several specialised companies offer this service, the benefits of turning to OCAS were twofold: in addition to our state-of-the-art submerged arc welding facility, our metallurgical expertise enables better interpretation of the results and the formulation of recommendations for improving the tested grade in the future.

Steep learning curve

The pre-qualification calls for welds at a number of specified heat input levels to be made and tested. This requires highly skilled and experienced operators – for example, one side of the multi-pass weld needs to be very straight over the entire thickness of the plate to facilitate subsequent testing. Although this particular requirement was new to our welding team, they were able to master it quickly.

In less than two years, five qualification campaigns were carried out on heavy plates in 30, 50 and even 100 mm thickness. OCAS worked in close collaboration with the Belgian Welding Institute (member of the Materials Research Cluster), who performed various tests including the crack tip opening displacement (CTOD) tests.

As required by the standards, third-party witnessing was performed (in these cases, by Lloyd's Register) – which means that full traceability for each and every sample, and a plethora of operating procedures, need to be demonstrably in place. This has now also been achieved.



"It takes time to build a reputation, especially with major energy suppliers. However, thanks to our innovative approaches and our motivated, highly skilled team, our customers are granting us ever-increasing recognition."

Philippe Thibaux

Providing technical solutions to the energy market

OCAS is a solution provider in the energy market. Our services include technical support, failure investigation, research and development, finite element modelling, and materials testing. Results are obtained in such a way that they can easily be implemented in industrial applications.

Typical customer requests are for a better understanding of the mechanical behaviour of their metal structures or components. Often, neither existing equipment nor standardised tests are available to help solve the problem. OCAS's team specialises in measuring the mechanical properties of materials or welds under particular conditions: from laboratory-scale tests to custom-made full-scale testing; at room temperature, or at high or low temperatures; in cryogenic or other specific environments.

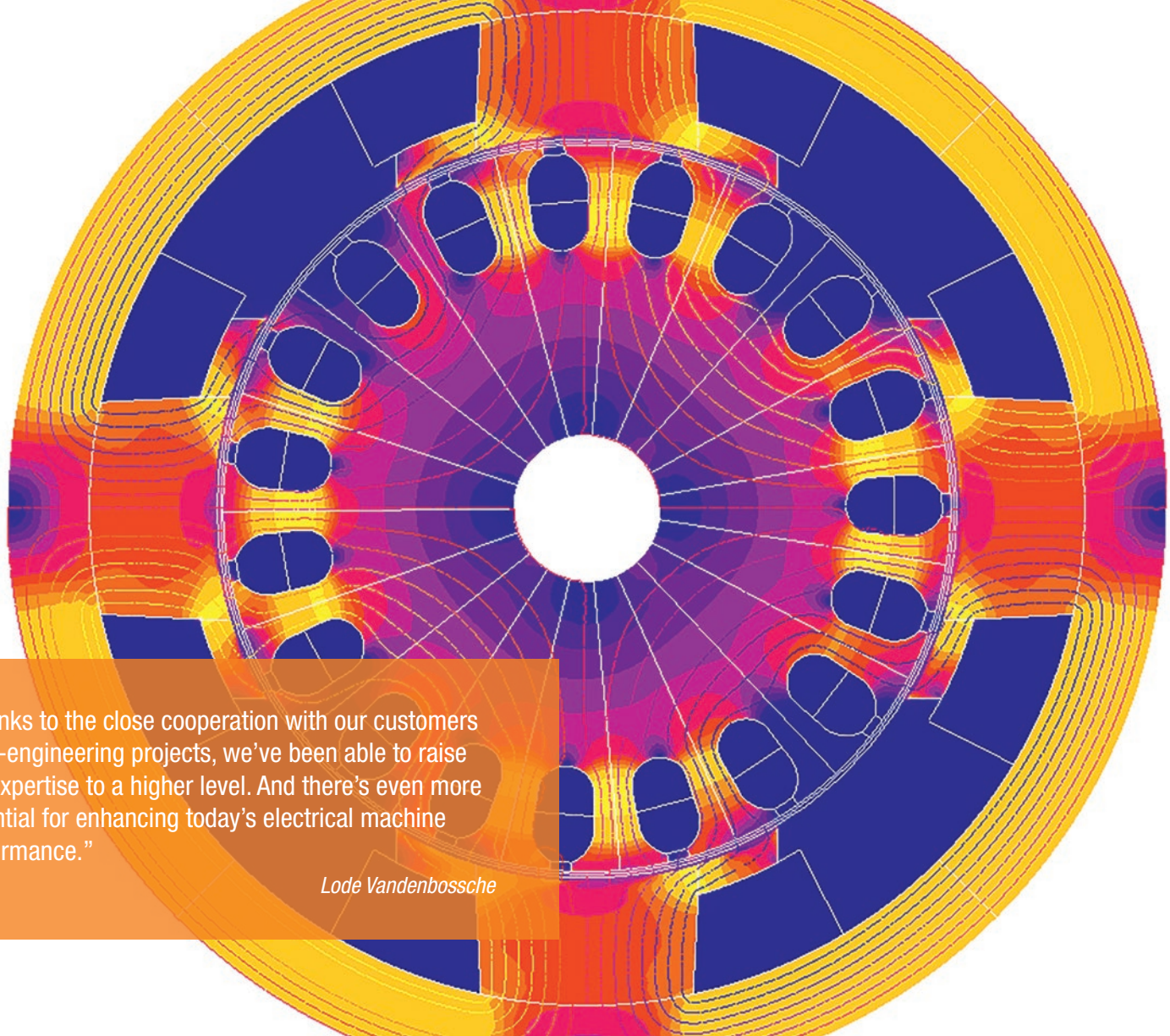
The outcome of these tests is then used as input for finite element modelling. The next step is to validate whether the component is able to sustain the expected loads during its lifetime. OCAS has specialised equipment available to submit such components to static or dynamic loads.

High-level research for customers and society

In addition to technical support, OCAS is currently active in a variety of R&D programmes. The research fields include: tribology, fracture mechanics, fatigue, plasticity, stability of structures, joining techniques, corrosion, coating adhesion, and more.

During 2013, OCAS started to develop a new technology for welds with improved fatigue-resistance for offshore applications. Whilst the welding methodology is in the optimisation phase, and the validation test for the welded structure is patent pending, we contacted potentially interested parties to collaborate in this research programme. Through local manufacturers and engineering firms, we've attracted the attention of several major renewable energy providers, and a consortium is being established.

Supported by the consortium members, OCAS will build a scale model of the test set-up in 2014-2015, which we will gradually up-scale. We expect that the results will eventually lead to design adaptations for these offshore structures as from 2016.



"Thanks to the close cooperation with our customers in co-engineering projects, we've been able to raise our expertise to a higher level. And there's even more potential for enhancing today's electrical machine performance."

Lode Vandenbossche

Towards highest energy efficiency at lowest production cost

Ever more stringent European Union regulations are driving the market trend towards higher efficiency electrical machines. As a result, our electrical steel customers are being compelled to make more than incremental improvements to their products.

In order to survive, these e-motor and generator producers need to model and design new topologies with higher accuracy and to reconsider their production processes. Simply switching to more advanced electrical steel grades will not yield the optimal results in terms of energy efficiency. Hence, there's a need for close cooperation between the electrical steel producer and the e-machine producer to tackle this issue with an integrated approach.

OCAS has vast expertise in developing advanced electrical steel grades to meet demands optimally. In addition, our researchers also assist customers in improving the accuracy of their modelling tools, in optimising the implementation of these advanced grades, and in characterising the effect of production steps on material and machine performance.

Need to reconsider 'taken-for-granted' technologies

Within a highly cost-driven market for industry applications of electrical steels, European directives urge our industry customers to increase the efficiency of their electrical machines. That's why established technologies and processes to produce electrical machines are currently being reconsidered and optimised.

This performance-driven approach requires an in-depth analysis of the customer's processing: it's important to quantify the (in most cases, deteriorating) effect each processing step has on magnetic performance – on the material level as well as on the final machine performance. Moreover, this know-how is very valuable too in emerging markets such as electric and hybrid vehicles for automotive.

Convincing accuracy

Thanks to our improved iron loss modelling, OCAS researchers are able to illustrate the benefits of smart material selection. Moreover, the model accuracy is increased by also including the effect of processing steps such as punching. With this approach we can help our industry and automotive customers in making the best choices for their design and processing improvements as well as for the optimal electrical steel grades.

"We are now able to up-scale results and predict final properties. This R&D effort – combined with the investment in the new industrial line – has put ArcelorMittal on the verge of becoming a world player in the market of electrical steel."

Tom Van De Putte

A new line in electrical steel grades

In the context of fighting climate change, OCAS focused its electrical steel research on key issues for sustainable electricity production and electromobility: thinner gauge grades, characterised by high permeability and low losses. Expanding existing expertise for industrial to automotive applications demanded additional efforts in the fields of metallurgy and material modelling.

To fulfil the increasing market demand for high end electrical steel grades, it was clear that ArcelorMittal Saint-Chély needed a new high performance continuous annealing line. OCAS helped the Saint-Chély plant prepare the specifications for their investment in the new line, and then, thanks to extensive lab annealing simulations, we provided support to facilitate the line's start-up and the transfer of products to the new line.

Lab simulations key to renewing the industrial product range

An important step was taken in simulating industrial processing via lab tests. First, the industrial and lab downstream processes were benchmarked. Aligning lab hot rolling with the industrial hot rolling process for electrical steel grades was far from simplistic. But, based on numerous tests, OCAS is now ready to develop a brand-new generation of high-efficiency electrical grades, starting from lab casting up to final annealing, supported by microstructural, mechanical and magnetic characterisation, and magnetic loss modelling. Renewable energy generation relies on top efficiency.

ArcelorMittal's recently launched iCare™ brand name comprises electrical steels which are specifically designed for the automotive market, responding to the trend towards hybrid and full electric vehicles. A first generation of iCare™ grades has been successfully launched, and R&D remains the driving force to extending the iCare™ catalogue for the next generations.

Translating concepts to new line capabilities

Another area of activity is the transfer of existing electrical steel grades to the new industrial annealing line. In addition, when switching to this new line, OCAS helps to identify potential improvements in terms of cost-reduction or robustness of the process window. Not only are annealing simulations needed in this project, but full support – from casting to rolling to annealing – is evaluated in detail. A first screening listed important cost-saving potential – a clear win-win.

"Thanks to high-throughput methodologies and early involvement of industrial partners from all along the value chain, we have achieved a cost-effective and market-driven technology development."

Vincent Stone

"A new patentable and industrially feasible technology was developed by combining our industry expertise in UV-curable coating technology and formulation with our know-how in energy pipe applications."

Philippe Legros

Shedding (UV) light on pipe coatings

The energy-reducing UV-curing technology has inspired OCAS to formulate novel internal coatings for steel pipes. With the help of high-throughput methodologies, a large number of experiments could be performed rapidly to accelerate this project.

Although UV-curing has become a standard technology for coating the external surface of pipes, its application to internal pipe coating is new. OCAS's coating team called on its Material Research Cluster partner Flamac to speed up the development. Thanks to Flamac's high-throughput platforms, a large number of formulations were rapidly applied and screened – using automation, miniaturisation and parallelisation – to fulfil the complex set of performances required by the targeted applications.

Finding the best formulation

All tested formulations were applied in one layer directly on blast-cleaned steel substrates, and then UV-cured for a few seconds before being submitted to abrasion resistance and hardness tests. Flexibility, corrosion resistance and chemical resistance were assessed by standard procedures on small samples.

Given the technical complexity of the challenge, only a few formulations were found to fully meet all performance requirements. Thanks to the statistical correlations derived between the requirements and the coating compositions, the best formulations could be further improved to optimise the performance-to-cost ratio.

Saving time and energy

The UV-curing technology enables ultra-rapid curing at room temperature – saving considerable time and energy. Coating and curing the inside of a pipe in an effective manner is this project's next challenge. In close collaboration with a UV lamp manufacturer, we've identified a novel approach to performing fast application that is fully compliant with the most stringent health and safety standards.

OCAS has filed patent applications for pipes coated with the new coatings, the method for curing the coating, and a generic coating composition.

"Carbon capture and storage is a very interesting technology. We're mastering pipelines for transport and storage of oil and gas – but CO_2 and its contaminating impurities present new challenges to overcome."

Jeroen Van Wittenberghe

Fight against climate change

The European Commission is looking into cost-effective ways to make the European economy less polluting and thus more climate-friendly. By 2050, the European Union could cut most of its greenhouse gas emissions. However, a low-carbon economy would have a much greater need for renewable sources of energy, low-carbon power generation, and geological storage technologies

Carbon capture and storage (CCS) is a technique for trapping carbon dioxide as it is emitted from large point sources, compressing it, and transporting it to a suitable storage site, where it is injected into the ground. But before CO_2 from power plants and other point sources can be transported and stored, it must be captured as a relatively pure gas.

Cutting-edge CCS projects

In addition to being active in the fields of renewable energy and energy-efficient materials – including electrical steel grades for hybrid and fully electric cars – OCAS is also currently a partner in two CCS R&D projects:

- CO2PIPETRANS, a joint industry project (JIP) coordinated by DNV GL, a major worldwide certification body and a leading expert in the energy value chain, including renewables and energy efficiency, as well as the leading technical advisor to the global oil and gas industry.
- CO2QUEST, a Europe-funded FP7 programme that brings international experts together to address the impact of the typical impurities in the gas or dense phase CO_2 stream captured from fossil fuel power plants on the safe and economic transportation and storage of the compressed gas.

Necessary knowledge

As part of the challenge to reducing the impact of global warming, pressurised pipelines are considered to be the most practical option for transporting captured CO_2 for subsequent sequestration. We've been invited to participate in these projects because of our expertise in the field of steel grade development for pipelines in particular environments and also for our knowledge of state-of-the art mathematical models backed by laboratory and large-scale testing.

This knowledge is needed to perform a comprehensive techno-economic, risk-based assessment of the impact of the impurities in the CO_2 stream on phase behaviour and chemical reactions and on pipeline and storage site integrities.

While most of the technologies needed to store CO_2 are mature and proven, operating experience, in Europe as well as the rest of the world, is still at an early stage. Extensive research pilot testing and demonstration projects are expected to be undertaken over the next few years. We're glad to be involved in this early stage, and we're looking forward to contributing to these new technologies.

"Our ULCF test set-up will provide us with valuable information for fine-tuning our numerical modelling. This is crucial for predicting and ensuring the safe and reliable operation of pipelines, both onshore and offshore."

Jeroen Van Wittenberghe

Strain-based design

To meet the rapidly growing demand for energy, fossil fuels are now being extracted in more hostile and remote locations. These out-of-the-way environments can be under permafrost or they can be susceptible to landslides, ground settlements, and even earthquakes.

Due to the extreme loading conditions in these remote areas, pipelines transporting fuel can be subjected to deformation beyond the elastic range of steel. Under such conditions, in addition to strength and toughness properties, the strain capacities of pipe and weld metal are also crucial.

From stress to strain-based design

More demanding environments require correspondingly demanding pipeline design guidelines. The design should ensure not only the safety and reliability of the pipeline but its economical and efficient operation as well.

Most of the current pipeline design codes are based on limiting stress criteria, which is considered acceptable for steel with a well-defined yield point. But stress in pipelines may exceed the limit under loads originating from earthquakes, landslides, or simply during the laying of submarine pipelines. In these cases, the design criteria for strength based on stress are no longer practical.

For spiral-welded line pipe sections, for example, the helical seam weld and anisotropic material properties pose real challenges to pipeline designers. To guarantee the structural integrity of the pipeline, line pipe sections should be able to deform beyond the elastic range without failure.

We investigated the tensile strain capacity and defect tolerance of high-strength high-toughness spiral pipes. To obtain both qualitative and quantitative insights, we studied each mechanical operation (forming, expansion) and each thermal operation (welding, coating) performed during manufacturing, because they affect the local or global strength, toughness and ductility properties of the pipe metal.

ULCF test set-up

Pipe reeling is a fast and efficient method for laying offshore pipelines. When reeling, a pipe is typically submitted to a low number of cycles of high plastic deformation. To validate the modelling work that has been performed over the last few years, OCAS has invested in a test set-up for Ultra-Low Cycle Fatigue (ULCF) in pipes.

We have developed this set-up as part of an RFCS project to study the damage mechanics of pipelines subjected to ULCF loading conditions, such as pipeline reeling. In the test set-up, pipes are subjected to a cyclic plastic deformation under bending.

The mechanical construction of the test set-up has been completed; the set-up is now being tuned and calibrated and will be ready for full-scale testing soon.

"Improving the mastering of the thermo-mechanical rolling parameters is acknowledged by the plant as key for its future."

Nele Van Steenberge

Mastering thermo-mechanical rolling

The heavy plate market is requesting a broadening of the product portfolio for structural grades for the construction and shipbuilding industries. Mastering the thermo-mechanical rolling process is the best way to open opportunities for structural grade product development, while increasing added value considerably.

Thermo-mechanical rolling is key to meeting more demanding customer requests with regard to weldability (lower carbon equivalent) and better toughness. So, a team of metallurgists from OCAS established a research project with the ArcelorMittal Galati mill and colleagues from the R&D Process team in Maizières to master this crucial process.

Fundamentals first

OCAS's role in the thermo-mechanical rolling project was to gain a better understanding of the correlation between rolling parameters, microstructure and properties, especially with regard to toughness. To obtain this fundamental understanding, a team of the quality department and researchers conducted a first industrial trial in close collaboration with the plant operators. The first objective was to determine a first processing window for different thicknesses.

Additional data on the industrial processing were gathered via back-calculation of metallurgical relevant parameters. Based on this valuable information, OCAS then started lab rolling simulations to study trends using different sets of rolling parameters for the trials and refine Galati's plant process window for the various grades. In addition, our team was able to discover major opportunities for further improving toughness – an asset in developing higher added value products for the energy market, in particular.

Technical plant support boosts progress

Using the lab tests as reference, new rolling schedules will be introduced in the plant. Meanwhile, data capture was improved during industrial processing in order to attain a higher level of traceability and quality control. Tackling this project stepwise continuously increases the expertise of plant operators, quality department supervisors and researchers as well – and the close collaboration is highly valued by everyone.

The outlook for 2014 is extremely promising. The plant's mastering of thermo-mechanical rolling will surely boost the development of heavy plate grades in thicker gauge for the more demanding market segments.

2

Durability

Tom Waterschoot

A key driver in the current economic environment, *durability* is important for OCAS and our customers in many ways. Durability encompasses our customers' continuous quest to improve the performance of their products as well as increase the life span of equipment and constructions.

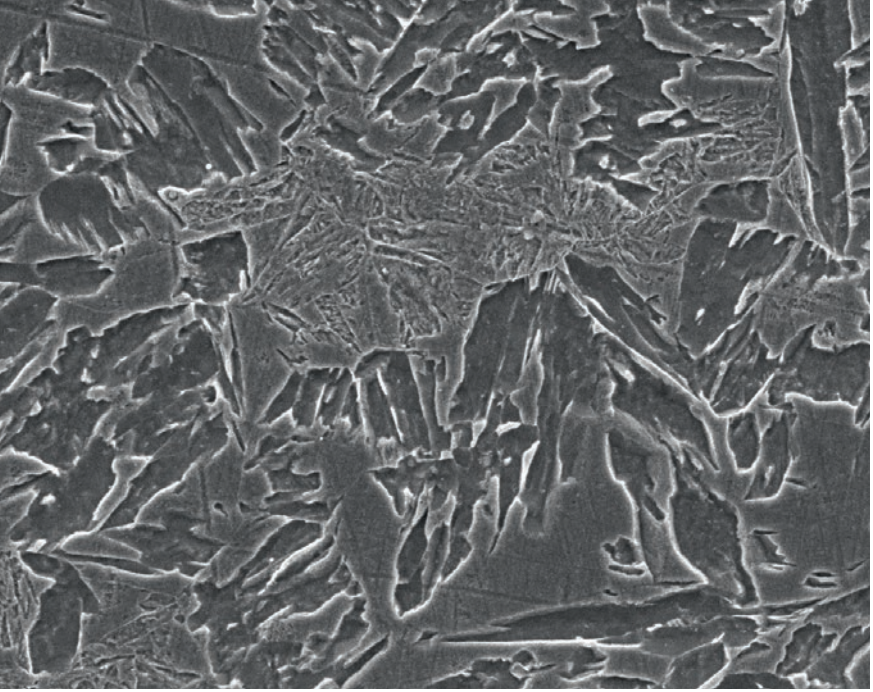
Within the metal works, mechanical engineering and construction segments, improving durability primarily means searching for steels with higher strength, better fatigue resistance, improved wear resistance, and guaranteed toughness at low temperatures – combined with essential 'in-use properties' such as the ability to cut and process the steel component, fire resistance, weldability and dent resistance.

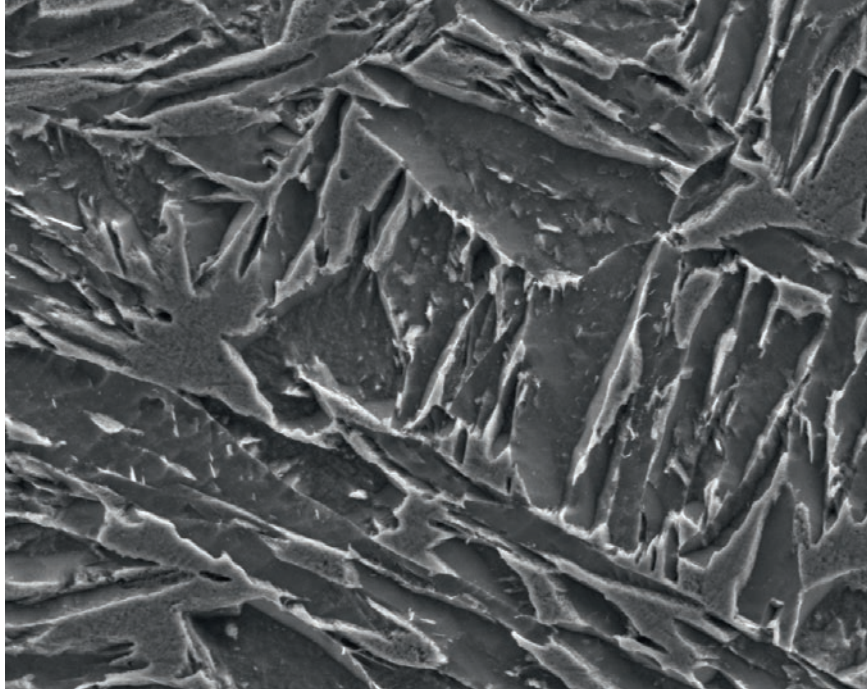
A special point of attention these past two years has been the fatigue resistance of welded high-strength constructions: we were able to achieve significant improvements by applying and optimizing several post-welding treatments.

OCAS is deeply involved in the metallurgical development of a whole new generation of steels – searching for innovative micro-structures that provide specific characteristics – to answer the market's needs. The challenge is not only to obtain the right material properties, but also to produce them within the plant's technical constraints in a cost-effective way.

In the field of energy transport, it is vital to apply smart design approaches to guarantee the integrity of the structure and avoid catastrophic failure even in the most extreme circumstances.

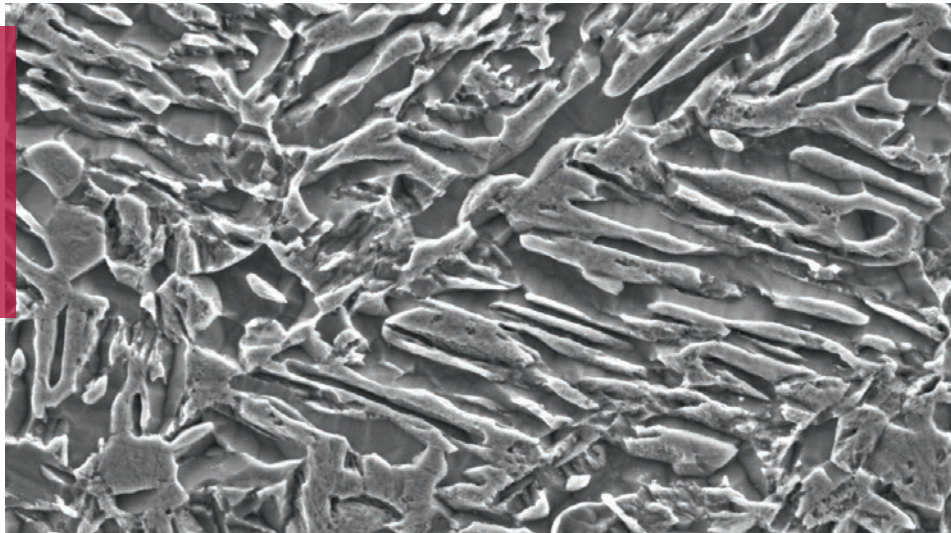
Durability can also be translated into improved corrosion resistance, for which every environment has its specific requirements. During these past two years as well, Magnelis® – the new metallic coating that out-performs existing metallic coatings in many environments – was successfully introduced into the market.





"The industrialisation of our recently developed wear-resistant steels has shown significant progress at the ArcelorMittal Bremen hot strip mill. Meanwhile, lab simulations reveal further promising potential."

Wei Xu



Pushing the limits for wear resistance

The so-called yellow and green goods markets are the main users of wear-resistant steel grades. These durable grades extend the lives of applications in machinery and equipment manufacturing.

Because of their microstructure, wear-resistant hot-rolled coils are quite difficult to process and push the hot-rolling mills to their limits. Nevertheless, OCAS successfully launched industrial trials for HB400 and HB450 grades in 2012-2013.

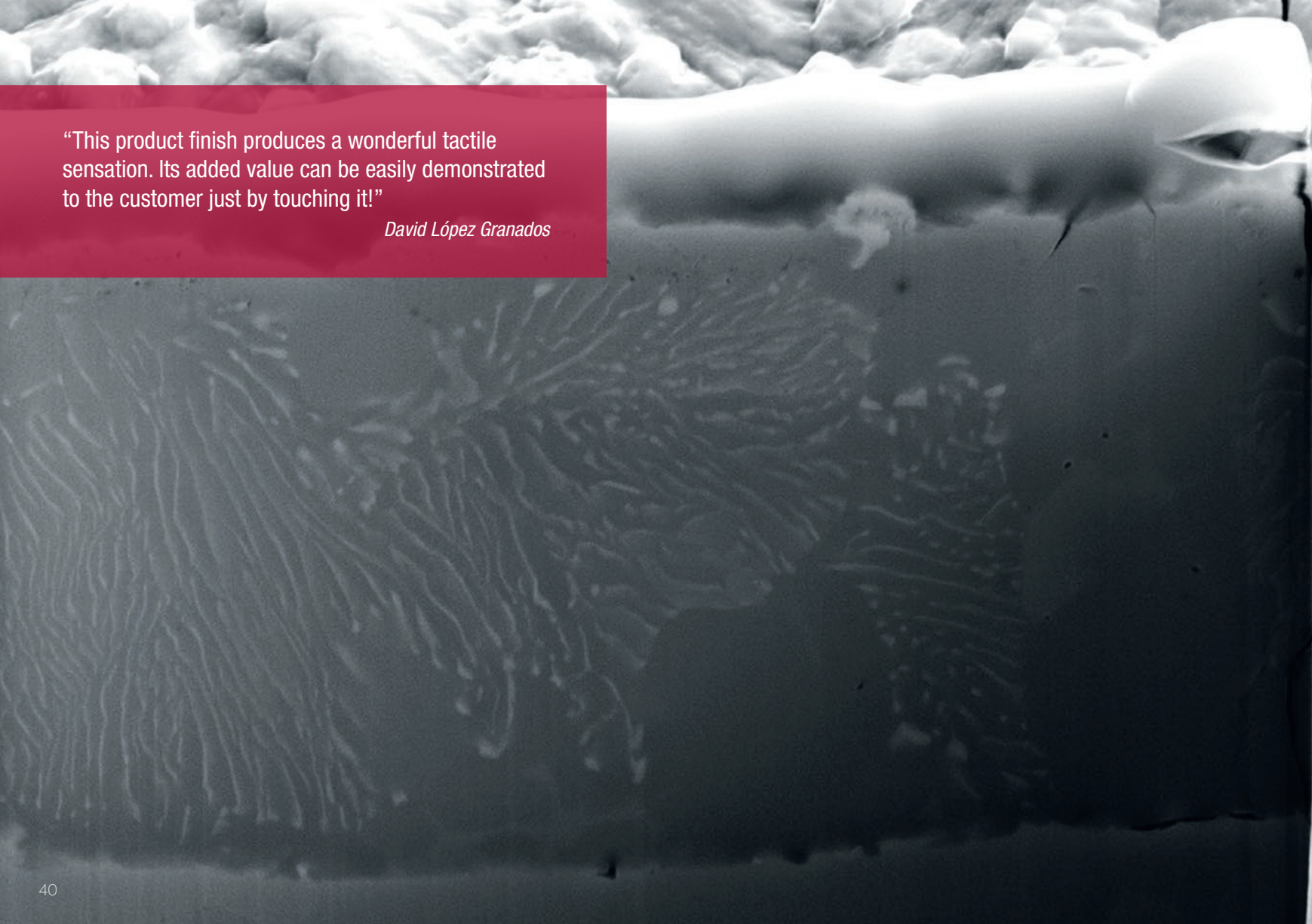
Cross-fertilisation

As a result of the successful industrial trials for HB400 and HB450, we were able to demonstrate that martensitic concepts are feasible on an industrial scale using existing hot-rolling mills. In addition to producing excellent wear-resistant steel grades, this achievement opens doors to introducing similar metallurgical concepts for different applications.

These metallurgical concepts enable acceptable combinations of mechanical strength, toughness, formability and wear resistance.

Changing a conventional mind-set

Today's lack of dedicated product specification standards in this product range allow for game-changing developments well beyond wear resistance. However, action will be needed to change the mind-set of conventional end-users. Traditional martensitic grades have made users accustomed to requesting guarantees on hardness and bendability only, whilst a new generation developments will enhance durability – which is not quite the same thing! As customers benefit most from grades with excellent durability in combination with medium hardness – and thus, enhanced machinability – we are quite confident about introducing new concepts in production plants and manufacturing sites in the near future.



"This product finish produces a wonderful tactile sensation. Its added value can be easily demonstrated to the customer just by touching it!"

David López Granados

Finishing touch to hot-rolled steels unveiled

A new surface mill finish was developed for thick hot-rolled steels. This micro-adherent scale – MASC® – provides cleanliness to the surface, resulting from the improved mechanical properties of the oxide layer. Customers have given us excellent feedback, as the product exceeds expectations.

Standard mill finish of hot-rolled grades risks becoming damaged during transport, material handling or processing. So, the market is showing considerable interest in an improved surface finish.

Fruitful collaboration leads to novel composite-like layer

OCAS started to develop this new surface finish to solve issues like powdering and de-scaling on hot-rolled grades. We investigated both the morphology of the scale layer as well as its adherence. Furthermore, we were able to work in close collaboration with an ArcelorMittal plant that has experience and process know-how in this field. This partnership shortened the time-to-market considerably.

The novel MASC® oxide layer that is formed resembles a composite material that increases the toughness of the scale and, at the same time, plays a fundamental role in the adhesion to the steel substrate.

MASC® convinces customers by its appearance

The first industrial trial material was very well received by the customers. Thanks to its features, market introduction of this new finish is proceeding well, and volumes are now ramping up.

Following the positive customer feedback, OCAS's team of surface and metallurgical researchers now plans to further extend this project so that MASC® will become available on a wider range of products, including ultra-high strength grades and heavy gauge thickness as well.

"The corrosion resistance of this magnesium-containing coating continues to surprise me. Even though we have been testing it in very specific and harsh environments, the results have never been disappointing."

Beril Corlu

Proven durability opens new markets

Thanks to the excellent corrosion resistance of Magnelis®, this magnesium containing zinc coating is used for a wide range of applications. To further widen its application, Magnelis® has been tested in very specific and harsh environments.

Having obtained convincing long-term outdoor exposure results, Magnelis® easily found its way to the market. Additional tests were launched during 2012-2013, using particular and more severe conditions.

Magnelis® catches the sun

Applications such as structures for renewable energy producing solar fields require a combination of structural strength and durability. The Magnelis® coating offers long-term resistance to corrosion, weathering and abrasion, while the steel substrate ensures the structures' mechanical properties.

So, OCAS's researchers tested all in-use properties related to this solar application. Recommendations, such as re-protecting the welded area, are soon to be summarised in a best practice guide.

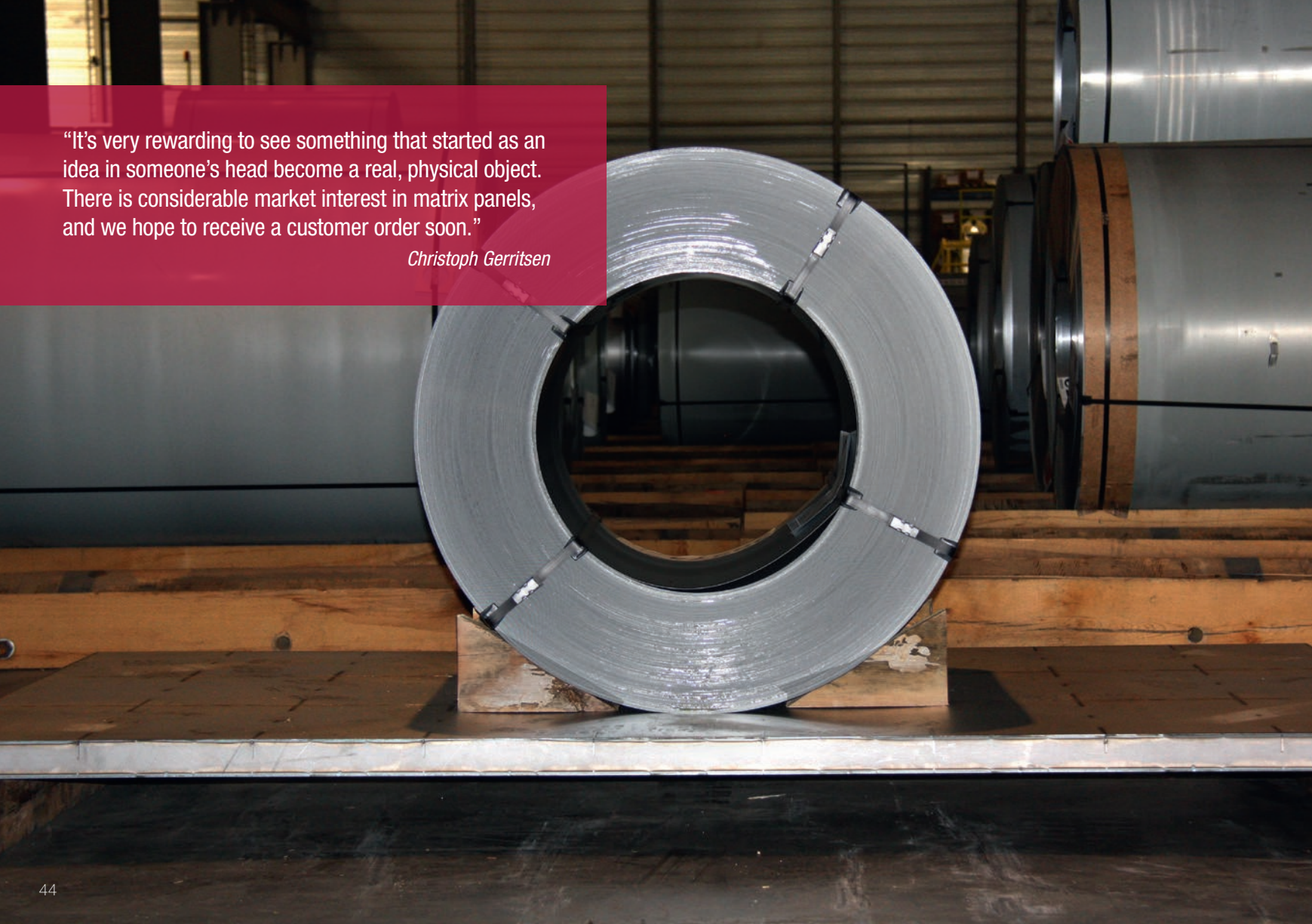
Inspired by the outstanding corrosion resistance of Magnelis®, a new zinc-aluminium-magnesium alloy especially for pre-painting has been developed. Combined with a paint finish, Optigal™ offers excellent performance and sustainability.

Buried applications unearth new opportunities

Promising results are also achieved when testing soil corrosion resistance. Magnelis® proves to be a cost-effective and green alternative to batch galvanizing. As it uses less zinc, it helps preserve natural resources.

OCAS currently provides technical assistance to customers manufacturing buried applications such as light poles, culverts, structures for vineyards, etc. Durability testing in specific or harsh conditions is not limited to small size panels. OCAS is fully equipped to submit components to corrosion testing.

In addition, OCAS is also investigating extending the Magnelis® range of products to heavy gauge applications. To ensure excellent cut edge protection for thicker substrates, the coating layer needs to be made thicker as well. However, the minimum required coating weight is still considerably lighter than that of batch galvanising.



"It's very rewarding to see something that started as an idea in someone's head become a real, physical object. There is considerable market interest in matrix panels, and we hope to receive a customer order soon."

Christoph Gerritsen

Matrix panels meet market demand for flexible solutions

With so-called 'matrix panels', OCAS has created a unique, patented solution for all-metal stiffened sandwich panels. We devised the concept for matrix panels a few years ago with two objectives in mind: to increase the added value of our products, and to defend the position of steel in industries where light-weight solutions are important. They are now offered commercially by ArcelorMittal Tailored Blanks Genk.

The matrix panel concept is a very flexible solution. Because the panels are made simply of sheets, which are then laser-cut to the required stiffeners and skins, the ability to tailor them to the solution is virtually infinite. (For very large volumes of standardised panels, by the way, we can employ a cheaper solution than laser-cutting for preparing the stiffeners.)

Fully metallic and weldable

In contrast to many other types of sandwich panels, matrix panels are fully metallic and are assembled by interlocking and welding alone. So, the panels thus created are not only very stiff, but they have the added advantages of being fireproof and weldable. This means that end-users who need to incorporate matrix panels in larger structures can do so not only via bolting or glueing, for example, but also via welding. This can be a considerable benefit in industries – such as shipbuilding and railway rolling stock – in which welding is the predominant joining technology.

Full-size prototypes

After initial proof of concept in the lab, experiments to produce matrix panels industrially were conducted at the ArcelorMittal Tailored Blanks Genk facilities, which have laser-cutting and -welding lines available. The main issues to be resolved were the assembly accuracy required for laser-welding and the control of distortion. Both of these issues can be resolved via specific assembly and welding procedures – and full-size prototypes for potential end-users have already been successfully made.

"Using ultra-high-strength instead of commodity grade for the redesigned dipper arm and bogie beam, we achieved an average weight reduction of 20% – yet fatigue resistance was better as well."

Sofie Vanrostenberghe

Achieving fatigue-resistant ultra-high-strength grades

Advanced high- and ultra-high-strength steel grades risk losing part of their fatigue resistance after welding as a result of tensile residual stresses and geometrical notch effect at the weld toe. It's important to overcome this issue for customers to fully benefit from the added value of these new grades.

Since 2010, OCAS has been coordinating a Europe-funded collaborative project studying fatigue in modern (ultra) high-strength steel grades. Research institutes as well as application centres and end-users are contributing to this project.

Regaining fatigue resistance with post-weld treatments

The project team is evaluating the effectiveness of post-weld treatments in reversing the deterioration of a welded component's fatigue resistance due to tensile residual stresses and geometrical notch effect at the weld toe.

Re-melting weld toes to improve the surface profile – and thus reduce stress concentrations – is one well-known fatigue improvement technique. This project is studying a novel method of redressing that uses laser instead of TIG to enable better control of the local heat input.

High-frequency mechanical impact treatment is the second technique under consideration. The professional literature indicates that it is possible to regain at least part of the initial fatigue resistance as a result of these post-treatments.

50% improvement

A significant number of welded samples treated with laser and high-frequency mechanical impact have been submitted to fatigue resistance tests. Evaluation of the test results confirms the beneficial effect of the weld post-treatments.

For strength levels above 355 MPa, tests indicate that high-frequency mechanical impact treatment improves fatigue resistance by about 50% for the specimen geometry studied in this project. Two demonstrators – dipper arm and bogie beam – were selected and redesigned in high-strength steel to reduce weight. Fatigue testing of these full-scale components confirmed the trends observed for the lab-scale specimens.

Further testing is planned to check the reproducibility of the test results. Once validated, the positive effect of post-treatment on ultra-high stength grades will be added to the design guidelines for steel structures.

"Motivated by commitments for hot-rolled grades applications that require excellent strength, toughness, formability and wear resistance, our R&D effort to develop martensitic grades got a real boost."

Lieven Bracke

Hot-rolled steel grades getting stronger and tougher

Introducing ever higher strengths – in combination with excellent toughness – gives hot-rolled coils a competitive advantage over plates up to a certain thickness.

OCAS's metallurgists are helping develop ever stronger hot-rolled grades, which were branded as Amstrong® by ArcelorMittal in 2012. Amstrong® high-strength steels are available as thermo-mechanically hot-rolled, cold formable grades. Their main properties include high yield strength and tensile strength, excellent formability, and good toughness at low temperatures.

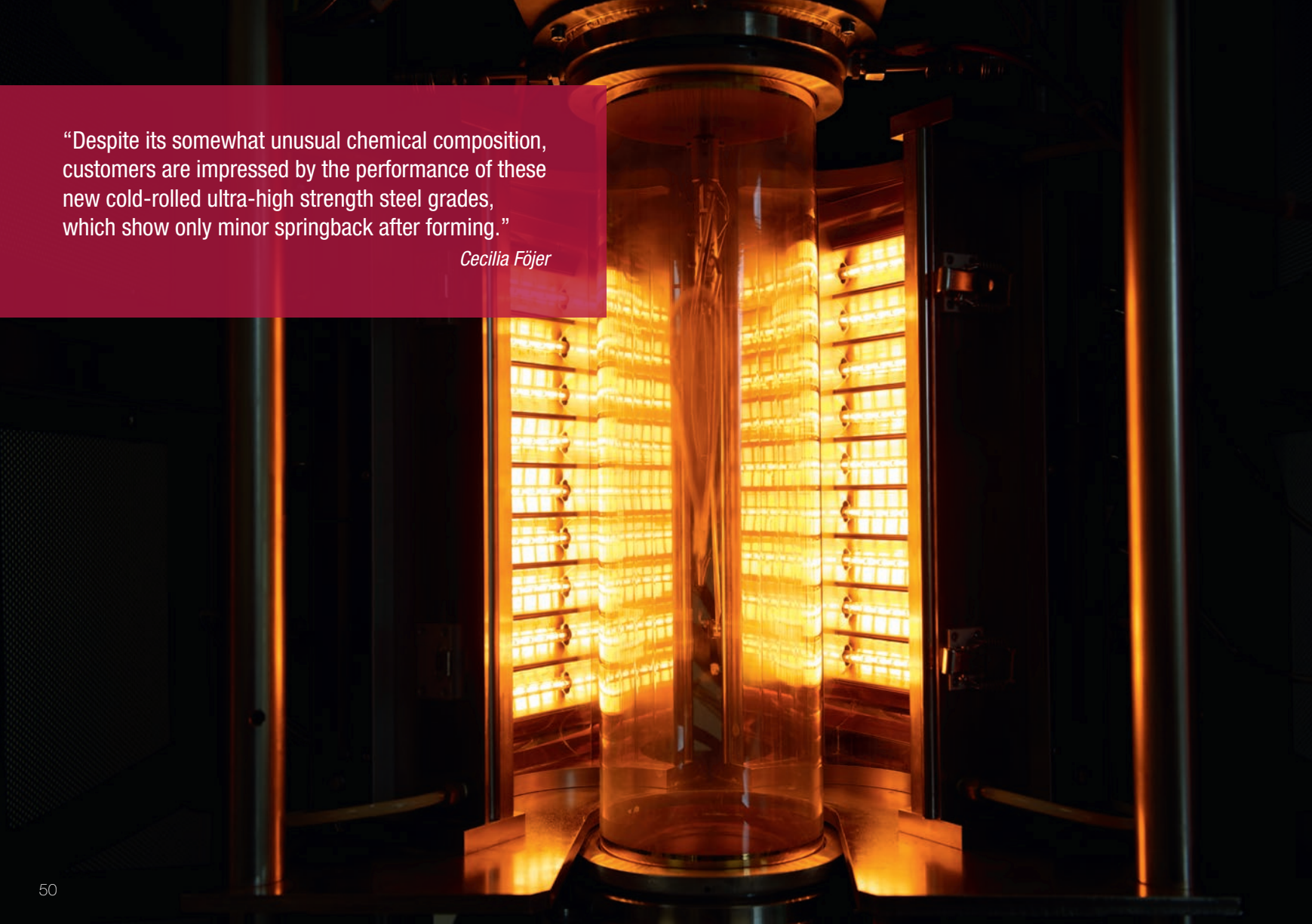
Therefore, a grade such as Amstrong® S700MC is an excellent choice for reducing structural thickness and weight whilst improving load-bearing capacity. The additional benefits: cost savings and market advantage.

Toughness guarantee both ways

Because of their cost-conscious focus, plate customers are showing an interest in switching to hot-rolled coil. However, standards for hot-rolled coil specify toughness levels in the rolling direction only. That is why, in the development of hot-rolled grades, OCAS concentrated on optimising strength and formability in combination with toughness in both longitudinal and transverse directions.

Martensite booster

Current state-of-the-art metallurgy uses a quench and tempering (Q&T) process to achieve the target. In addition to Q&T developments for the near future, OCAS researchers believe that new metallurgies – like the martensitic concept of quench and partitioning (Q&P) – will add to hot-rolled grades new combinations of properties: strength, formability and toughness as well as extreme wear resistance. These new metallurgies might require investments before possible industrialisation – but initial lab concepts include very convincing properties.



"Despite its somewhat unusual chemical composition, customers are impressed by the performance of these new cold-rolled ultra-high strength steel grades, which show only minor springback after forming."

Cecilia Föjer

High-strength high-formability cold-rolled steel goes global

Following the successful introduction of the HC500LA ArcelorMittal cold-rolled micro-alloyed high-strength steel grade, OCAS has jointly developed ever stronger, yet ductile, cold-rolled steel grades.

Over the past few years, OCAS has put a lot of effort into building knowledge based on the smart use of existing grade compositions, applying known processing steps in an innovative manner, and making full use of the OCAS lab simulation possibilities. This powerful combination of elements has proven to be an effective way to speed up the development phase of high-strength high-formability cold-rolled grades.

High- and ultra-high strength steel grades

In addition to a concept in which micro-alloyed steel is annealed using an innovative annealing cycle, we also identified a robust concept to achieve ductile ultra-high-strength levels on cold-rolled steel via so-called quench and partitioning technology up to 1200 MPa. This research provided excellent preparation for the industrialisation phase of a whole new range of cold-rolled (ultra) high-strength steel grades.

Developing market-specific grades

Creative thinking, making use of the findings from the knowledge-building programme, and close cooperation between OCAS and the ArcelorMittal Gent plant resulted in a quick win-win for both the customer and ArcelorMittal. The development track for the new cold-rolled ultra-high-strength grades for industry was remarkably short – and the concept provides a robust, yet cost-saving, process window.

Thanks to its excellent mechanical properties – and its flat tensile curve, in particular – these high-strength cold-rolled grades exhibit only minor springback. In addition to its high yield strength, the benefits for the customer include: its good formability, its availability in thin gauges, and its splendid surface finish.

3

Environment

Tom Waterschoot

Not so long ago, the steel industry and its products were regarded as out-dated and environmentally-unfriendly. But this perception – likely created by the heavy-industry image of steel production – is far from fair. Steel and its material solutions often score significantly better in terms of carbon footprint and life cycle assessment than alternatives in aluminium, plastic or composites.

Today, steel production is subject to all kinds of stringent environmental regulations – including restrictions on CO_2 and toxic gas emissions, for example – that are pushing the industry to reinvent itself.

Our industry does not view its environmental responsibilities merely as obligations but as strong drivers for material developments and innovations. So, the climate around steel has been changing in recent years, and steel products have become more popular.

As a key player in the world's search for green products, OCAS develops and implements environmentally-friendly steel substrates and surface functionalities. We have successfully developed effective alternatives for toxic hexavalent chromium passivation systems and hard chrome coating processes.

Furthermore, OCAS has developed several 'Ready-to' solutions, creating value and environmental advantages for the customer. Ready-to-Paint® and Ready-to-Enamel® surface treatments on cold rolled steel obviate the need for degreasing and pre-treatment at the customer site – and, in the case of enamelling, the required firing temperature has been lowered dramatically.

In the field of enamelling, another breakthrough REACH-compliant environmentally-friendly approach to obtaining enamelled steel is on its way to industrialisation. The development of MASC surface quality on hot rolled steel is an important step towards enabling similar advantages for the hot rolled steel family.

The successful introduction of light-weight boilers shows that carbon footprint and total cost of ownership can also be reduced by combining newly developed steel grades with smart designs.

The pursuit of green products is accelerating as we move further into the 21st century – and OCAS is poised to perform a pioneering role.

"2014 is the tipping point for us. The new pilot line is a strong asset for further up-scaling OCAS's chrome plating technology and convincing the hard chrome plating market."

Rob van de Coevering

Hexavalent chromium-free alternative for hard chrome plating within REACH

As the sunset date for hexavalent chromium substances is 2017, a variety of industries are compelled to look for alternatives for hard chrome plating. So, to find a solution, OCAS launched a project in the framework of its electro-deposition technology maturation platform.

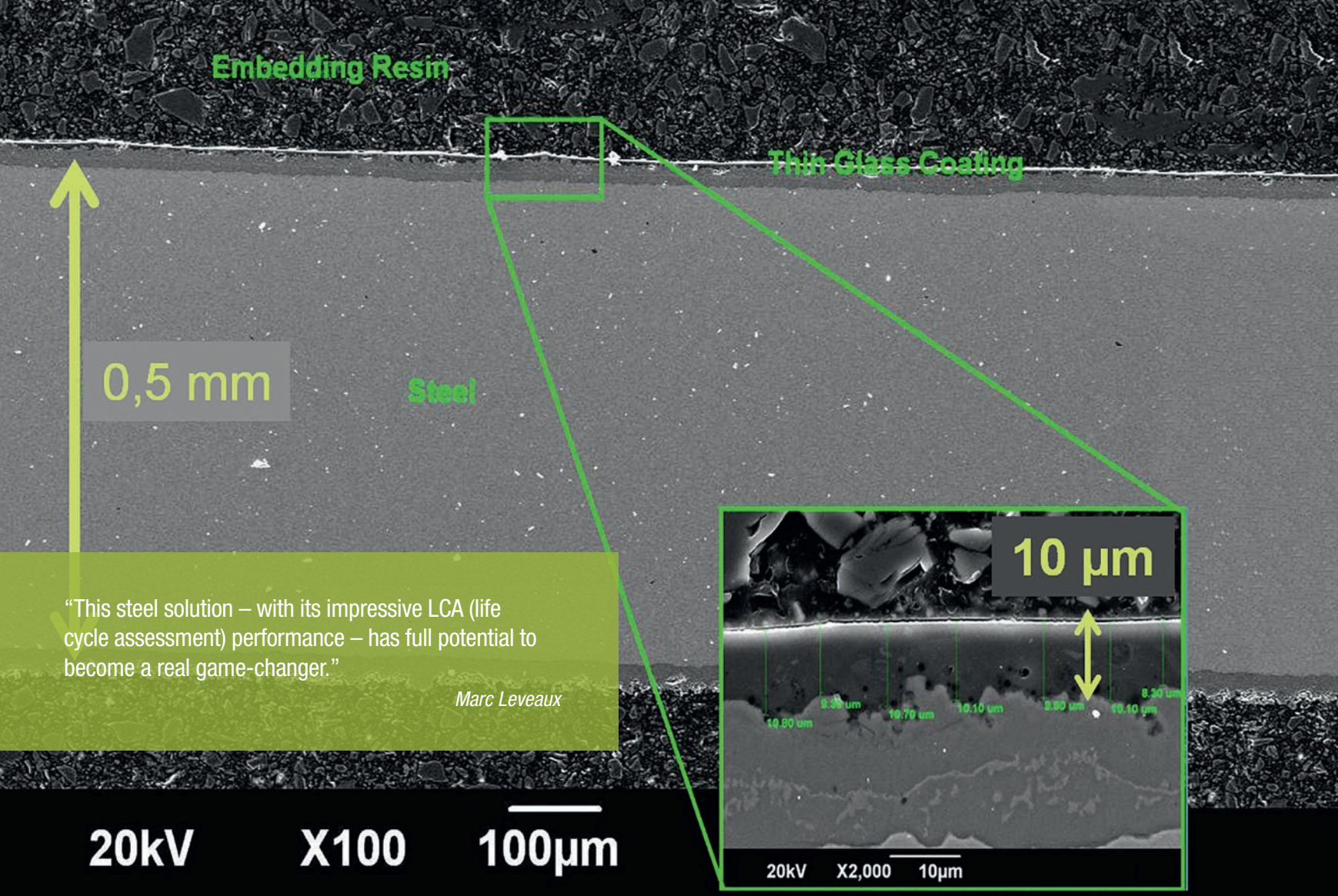
During 2012, it became clear that OCAS's REACH-compliant chrome plating process offered important advantages: the final coating is still hard chrome, which is what the market demands, but no Cr(VI) is involved during plating. Extensive testing on small-scale in-house built plating cells has demonstrated the feasibility of the technology under study.

While the multi-disciplinary OCAS team – comprising experts in the field of surfaces, engineering, toxicology and chemistry – matured the technology towards an industrial deployable level, an OCAS business development team analysed the technology's business potential.

Convincing samples reveal market interest

Using demo samples to showcase the properties of the product, OCAS attracted quite a lot of interest from potential customers. The work performed over the past two years enabled OCAS to turn the first leads into co-development partnerships. Based on positive feedback from several reference players, the decision was taken to build a pilot installation to prepare larger prototype samples for industrial field tests.

This pilot line will enable OCAS to further up-scale this promising technology.



"This steel solution – with its impressive LCA (life cycle assessment) performance – has full potential to become a real game-changer."

Marc Leveaux

Game-changing glass coating scores peak LCA performance

A completely novel approach to coated steel has resulted in a concept of a thin glass layer on steel. The new product aims to reconcile the durability of an enamel layer with the formability of thin steel sheet. Its composition and production process are fully REACH-compliant.

Striving for a durable steel-based solution on thin substrate, OCAS combined its vast experience in the fields of coatings and metallurgy. The result has great potential to become a breakthrough green innovation.

Thin, thinner, thinnest

From the early days of this research project, it was clear to OCAS that the coating had to be very thin, and its desired performance corresponded best with vitreous enamel.

But traditional enamel layers are quite thick – and simply changing the thickness of the layer is impossible without completely reviewing the adherence mechanism at the enamel/steel interface. Furthermore, today's adherence mechanism for enamelling is based on heavy metals, which are soon to be replaced to fulfil REACH regulations.

Breakthrough research about to solve all major drawbacks

The novel product under development will be durable, ecological, easy to shape and light-weight. Thanks to the new concept, warping will no longer be an issue for thinner panels and its excellent resistance to bacteria and ability to repel graffiti is assured. This innovative steel-based coated product furthermore shows outstanding recyclability.

"After completing the development phase of this product, we recognised the many benefits of working with our customers to smooth the transition to this alternative in their processing lines."

David López Granados

Ready-to-Paint® drums regular grades into high-added-value applications

Environmental issues were the primary drivers for the development of the Ready-to-Paint® treatment, but this green alternative provided customers with a highly durable product of superior quality as well. So, OCAS is now focusing efforts on delivering technical assistance to turn the deployment of this product into a success for the customer.

Ready-to-Paint® enables customers to reduce the carbon footprint of their processing without compromising quality. It avoids oiling, degreasing and the application of a phosphate or passivation layer.That's why customers producing steel furniture, drums or household appliances are eager to switch to this green alternative. Although Ready-to-Paint® is compatible with their manufacturing operations – such as cutting, slitting, bending, profiling, light stamping, welding and clinching – precaution is needed to keep the product clean and dry during the processing.

Dry run technical assistance

As Ready-to-Paint® is the first dry surface treatment available for cold rolled steel, the processing differs from that for standard oiled surfaces. Therefore, OCAS is providing technical support to help customers keep the surface dry during the manufacturing process. Once the production line is free of oil and dirt, the transition to Ready-to-Paint® is straightforward.

New markets welcome this high-added-value solution

Apart from the dry processing requirement, no major technical drawbacks have been encountered. Thanks to its compatibility with various paint systems and other post-treatments, Ready-to-Paint® is also inspiring other markets.

Customer trials are currently ongoing in the building and construction sector. And users in the appliance and metal furniture markets are considering Ready-to-Paint® as an alternative for a much wider range of applications than they first envisioned.

"It was very rewarding to fine-tune new developments together with the customer. It sharpened my creativity. I'm already looking forward to translating some ideas into other applications!"

Marc Leveaux

Hot applications call for cold rolled

The new cold-rolled enamelling grade HC300EK, specifically developed for water boilers, reduces the wall thickness by 0.2 mm, whilst keeping the strength level well above 300 MPa after firing the enamel. A highly novel approach for a traditional application.

Replacing a hot-rolled commodity steel with a cold-rolled grade with outstanding mechanical properties benefits customers in multiple ways. Cold-rolled grades are available in a much wider range of dimensions, which leads to a simplified supply chain.

The increased strength allows the wall thickness to be reduced – making the boiler lighter. As a result, transport is cheaper and installation is easier.

Co-development speeds time-to-market

The transition to thinner sheet called for adaptations in our customer's process. New sheet metal dies were needed, and so a team of OCAS experts worked in close cooperation with the customer to redesign the tools. This sharing of resources and knowledge was highly appreciated by the customer.

Furthermore, in addition to helping redesign the tools, OCAS optimised the sheet metal forming process by selecting the best oil in combination with an optimised sheet roughness. These recommendations were immediately implemented by the ArcelorMittal Gent production plant, offering additional value to the customer.

New development inspires other markets

This success story inspired OCAS to start developing a comparable steel grade specifically for enamelled architectural projects.

Thanks to its guaranteed minimum yield strength after enamel firing, the future grade would present a perfectly flat facade envelope. Its reduced thickness would enable cost savings of up to 30%, whilst at the same time the panels and cassettes would be easier to handle on-site thanks to the lower weight.

“One test coil convinced the customer. He then prepared his factory and his operators to switch to this new product – after which Ready-to-Enamel® was introduced successfully. He can now skip the pre-treatment steps that were required previously. Plus, firing is done at lower temperature without compromising quality.”

Marc Leveaux

Ready-to-Enamel® tomorrow's domestic appliances

The patented Ready-to-Enamel® post-treatment for steel has been developed to simplify the customer's enamelling process. At the same time, it reduces traditional firing time and/or firing temperature.

Following the final fine-tuning of the Ready-to-Enamel® steel solution, the new product has been undergoing customer trials. A dozen domestic appliance customers throughout Europe are currently discovering the benefits of Ready-to-Enamel®.

R&D assisted technical support during the customer's transition

Ready-to-Enamel® allows the customer to skip oiling – and thus degreasing as well – so this solution is an attractive environmentally friendly alternative. However, switching to a treated surface that needs no further cleaning or rinsing is relatively new to most customers – it requires a change of mind-set. That's why OCAS offered technical support to help the customer overcome any possible challenges resulting from the transition.

Energy-savings turn Ready-to-Enamel® into a win-win

Successful results were obtained during the customer trials, especially when attention was paid to keeping the parts clean during handling in the manufacturing lines. In addition, cost-savings on energy are considerable and make this product a cost-effective alternative to traditional enamelling.

Given this positive feedback, the OCAS coating team is already planning to develop a high-durability version of Ready-to-Enamel® based on the same concept.

"Our recent development of E-passivation for glueing was particularly well received by a customer producing window spacers. This customer support is very rewarding and inspires us to keep looking for ever better solutions."

Nathalie Van den Bossche

Performance of green passivation products provides competitive advantage

ArcelorMittal's product range of passivation treatments is now fully REACH-compliant. The driving force behind new developments in this field of application is to improve the performance and thus optimise operational excellence.

The knowledge OCAS has acquired over the years in the field of green alternatives for preventing steel products from rusting during transport is invaluable. Not only has the range of green passivation products been completed, its performance was improved considerably without impacting cost.

Sealing the transition to E-passivation

Thanks to the expertise gained by working in close collaboration with production lines and end-customers, OCAS was able to further develop a number of interesting specialties. The E-passivation for glueing (or EPG) is highly appreciated for its excellent adhesion to sealers. This treatment is compatible with most glues and sealants, and its introduction to different production lines has gone very smoothly.

Meanwhile, research is ongoing to make the pre-treatment products even greener. Novel developments have been successfully tested on industrial lines. Although their performance is convincing, the cost is still slightly above target – so, further improvements to this economic aspect are being investigated.

Taking steps to further reduce our footprint

In another approach to greener solutions, OCAS researchers are continually striving to further reduce the carbon footprint of their developed products. Alternatives to the current Easyfilm® range on hot dip coated steel are currently under investigation – and first results look promising.

4

Technical Support & Entrepreneurial R&D

Nico De Wispelaere & Frans Van Camp

Even in a period of economic downturn, it is of utmost importance for companies to continue to innovate in order to create value and be ready when the economy re-emerges. Only reducing costs without product innovation is often the start of a downwards performance spiral.

But keeping up with the fast technical evolution is not easy; OCAS's broad expertise and state-of the art infrastructure can facilitate companies in their R&D endeavors. Co-development projects and state-of-the-art technical support available at OCAS opens unexpected opportunities.

OCAS assists its customers successfully in a variety of sectors with a wide spectrum of technical issues. To maximise value creating for our customers we encourage being involved in an early stage; this enables us to "think together" instead of merely deploying a test program.

With our multi-disciplinary teams, we support customers from product design all the way to the optimisation phase.

Our technology maturation platforms (TMP's) are the core of the OCAS entrepreneurial research and development. In these TMP's OCAS develops and 'matures' its own ideas or ideas obtained from third parties towards an industrially deployable level.

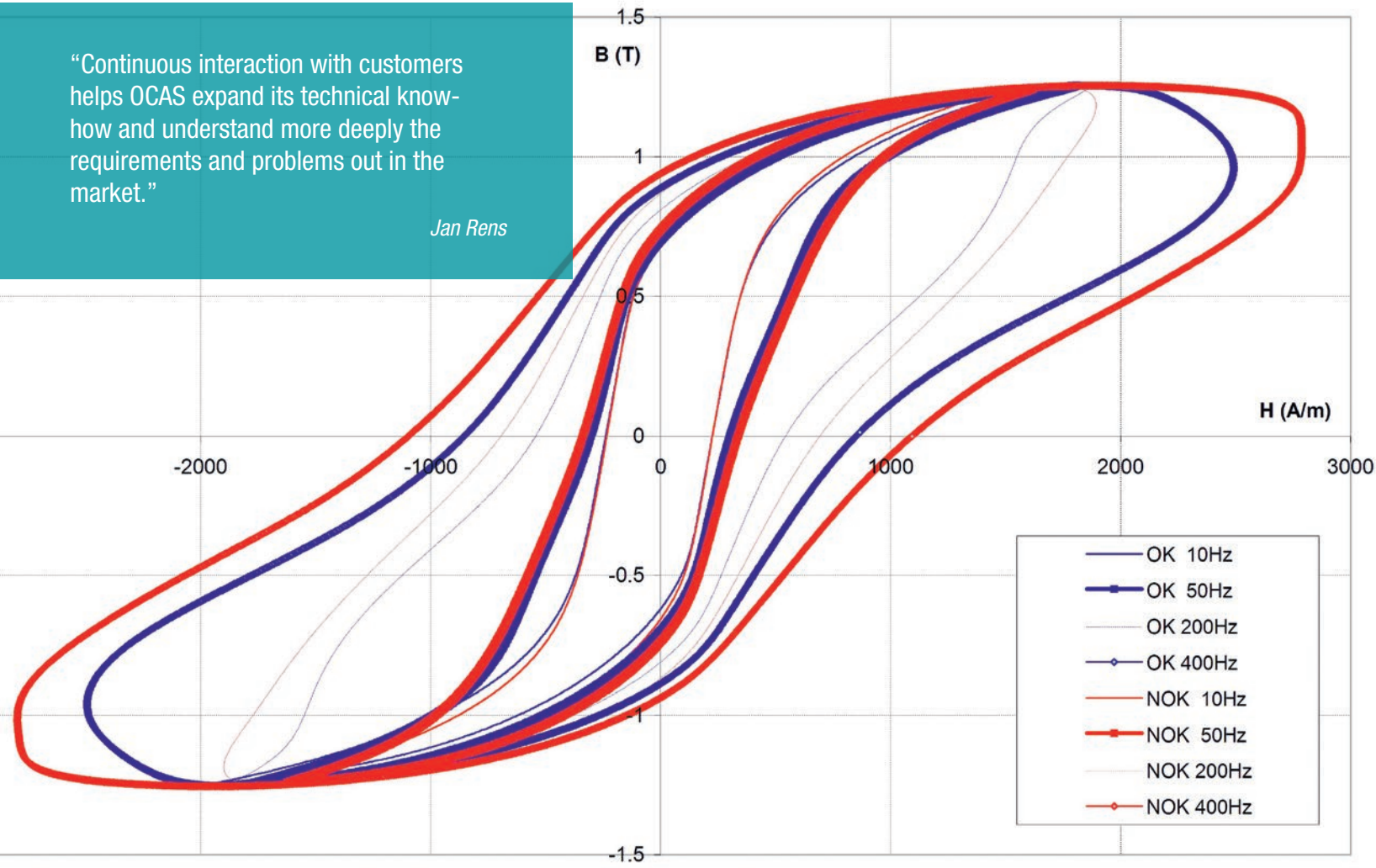
In addition to medium and long term projects, OCAS has a dedicated team handling assignments for which we already have the equipment and expertise. This approach ensures efficiency with short response time.

With the assistance of the Finindus investment fund, OCAS creates spin-offs and joint-ventures to valorise its knowhow and expertise. Several of these initiatives have drawn international attention and are building solid customer portfolios – so the outlook for growth is quite promising.

At OCAS, we look forward to continuing to provide technical support and innovative solutions for our customers' challenging issues!

“Continuous interaction with customers helps OCAS expand its technical know-how and understand more deeply the requirements and problems out in the market.”

Jan Rens



When measurements get magnetic

OCAS uses its unique expertise in magnetism, materials and characterisation technology to provide services in the field of magnetic measurement systems, modelling and design of electromagnetic applications, and research into magnetic material optimisation processes for our customers.

Thanks to this expertise, customers gain insight into the detailed operation of their systems and are able to improve the efficiency and reliability of their products.

Magnetic measurement systems

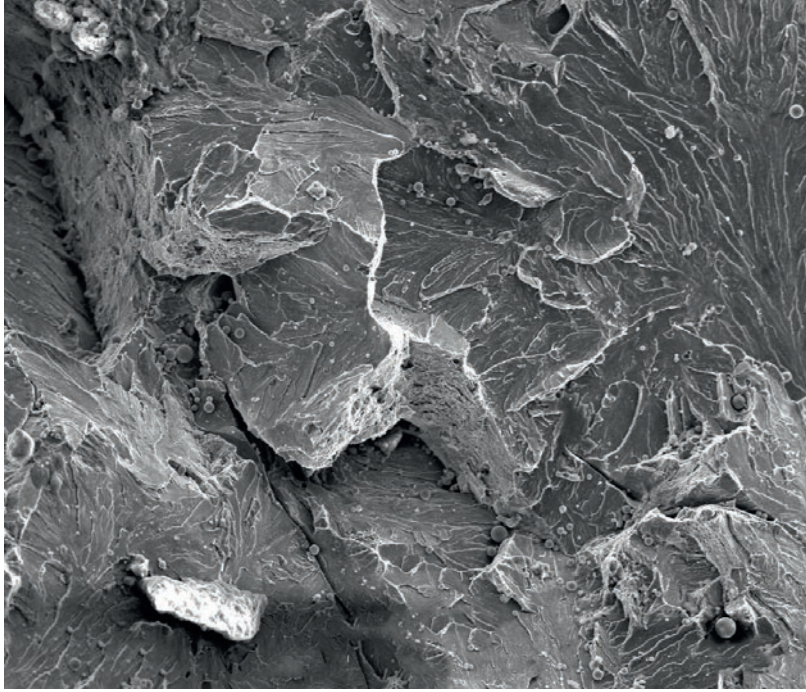
We have a long history in the development of standard and specific *magnetic measurement systems* for all types of magnetic materials – both for laboratory use and for in-line quality control of continuous production processes. These systems enable material characterisation at high temperatures, high frequencies and variable mechanical stress.

Multi-disciplinary modelling

Modelling and design services for electromagnetic equipment are centred around a multi-disciplinary approach and materials know-how. We use state-of-the-art software packages and in-house developed material models to carry out detailed electromagnetic, mechanical and thermal analyses of electrical motors, generators and transformers. Our modelling approach is unique in that it is combined with advanced characterisation capabilities for various magnetic, mechanical and thermal material properties.

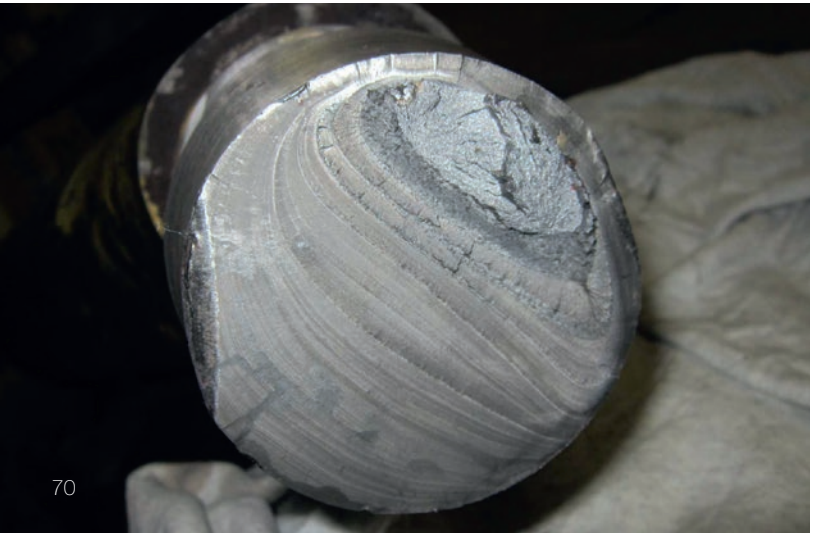
Optimising magnetic materials use

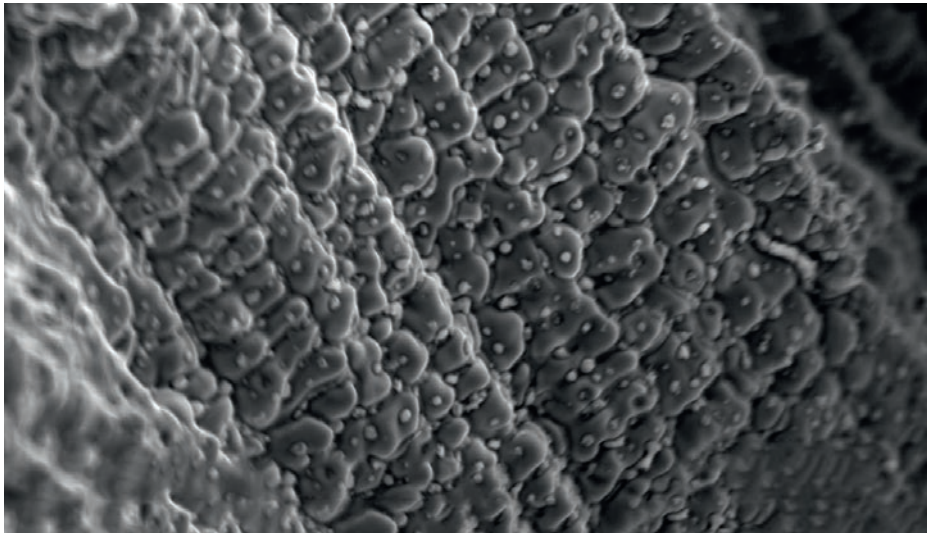
We also assist our customers through *research on process techniques* that can improve the properties of magnetic materials for specific applications and that can be implemented at the customer's facilities. Recently, we helped a customer develop an annealing cycle that improves the magnetic properties and corrosion resistance of their magnetic material.



"Having a dedicated TS&S team helps to see potential links with former comparable cases (as history has a tendency to repeat itself…), which allows us to further speed up our response time."

Nico De Wispelaere





Your wish is our command

Since its creation in 2011, OCAS's Technical Support & Services (TS&S) department successfully formalised and centralised the direct support activities for several industrial plants. Such jobs had been handled ad hoc in the past.

TS&S has been assigned to provide direct technical support to a number of companies. Not only can they benefit from the staff's expertise, but they also get access to state-of-the-art equipment, in the most efficient way and within short response time.

Universal, yet specialised

In case of product quality related problems of a production line, it is of utmost importance to quickly identify the cause. These requests demand a rapid, yet sometimes specialised approach. That explains the success of TS&S: in addition to a team of dedicated staff only dealing with this kind of assignments, the department can call in the help of experts from other OCAS teams to solve the problem whenever needed.

Having access to unique analysing techniques enables TS&S to perform advanced quality control in addition to the plant's regular test procedures. This is a service often used to support the introduction of new products, once the R&D phase of the project is finalised.

A broad scope

Typical demands range from failure analysis or welding issues, to corrosion problems or customer complaints etc. Thus, the given recommendations are sometimes related to material selection or to production parameters, but can also involve health & safety precautions. Again a wide variety of topics and the approach used is as often as possible result-driven with a short response.

"We've overcome the growing pains of the partnership's early days, and our collaboration is now stronger and more mature than ever. Today, our customers keep coming back to experience the benefits of our multidisciplinary partnership!"

Marc Vanderschueren

Optimising steel structures beyond the standard

The Metal Structures Centre – a consortium consisting of OCAS, Ghent University's Soete Laboratory and the Belgian Welding Institute – combines competencies in the design, use and evaluation of the behaviour of steel structures for its customers worldwide.

The Metal Structures Centre unites the strengths and skills of three independent R&D labs working in the fields of pipelines, plates, steel structures and machine components:

- OCAS – an R&D centre with a proven track record in metallurgy, welding, corrosion and numerical simulation design,
- Soete Laboratory (Ghent University) – widely recognised as a leading lab in experimental fracture mechanics and pipeline engineering,
- Belgian Welding Institute – a state-of-the-art welding research institute investigating welding procedures for pipelines, pressure vessels, windmills, bridges, etc.

Starting from identified needs, the Metal Structures Centre's mission is to provide a complementary and specialised range of capabilities for metal structures engineering – from design and simulation, to processing, characterising materials and component testing, to integration in the final application.

The consortium was started in 2009 – however, each of the partners already had a distinguished track record and first-class reputation for service through its skilled teams of scientists, engineers and support staff.

A growing partnership

Over the past two years, collaboration has intensified considerably, to the benefit of the customers. Recently, the Metal Structures Centre received a customer request that required a specialised large-scale test set-up. Ghent University's Soete lab granted OCAS access to an existing test set-up. OCAS revamped the test set-up to the new customer's standard.

To allow the customer to have a single point of contact, one partner always takes the lead in each work package of a project. Internal meetings ensure open communication and the involvement of all three partners at all times.

"OCAS has the right skills and processes to commercialise high-tech material research. This is essential to building trust and confidence with our customers, so that they partner with OCAS."

Frans Van Camp

The pillars of our valorisation strategy

To serve our customer and partner base, OCAS can count on a state-of-the-art R&D infrastructure and high-level experienced staff. But to continue to provide cutting-edge products and services, OCAS needs to continuously expand – and finance – its R&D capabilities.

OCAS has various ongoing possibilities for creating R&D revenue streams:

- Contract research: OCAS performs contract research (from relatively small assignments to multi-year contracts) for a recurring customer base.
- Test centre: OCAS performs a myriad of industrial and scientific tests for its customers with its unique, state-of-the-art testing equipment.
- Partnership R&D: OCAS's partnership programme offers timesharing of its laboratory infrastructure.
- IP licensing: OCAS develops a number of projects within its strategically selected technology domains with the goal of valorising the Intellectual Property resulting from these projects through different licensing scenarios.

Still, material-related research can be a lengthy and risky endeavour before it creates any substantial revenue. So, OCAS bases its valorisation strategy on two main pillars:

Industry intimacy

OCAS invites industry to collaborate and form partnerships. Industry's involvement in the early stages of a project ensures that our research is focused and enables OCAS to tap into a wealth of industrial expertise and experience. Our industrial partners are also invited to co-invest in our projects and, if desired, to set up a commercialisation agreement. The key to a successful cooperation that maximises ROI for all stakeholders is to work out a win-win scenario from the very beginning of a project.

Experienced staff

To ensure successful project valorisation, OCAS's senior business development staff relies on a profound market analysis, a well-defined value proposition, and a thorough understanding of the value chain. Together with all stakeholders, OCAS is open to develop new business models to realise the desired ROI.

finindus

“Der Aufbau eines Spin-Off Unternehmens und das Upscaling aufgebauter Technologien ist nicht völlig risikofrei. Hier hat sich Finindus nicht nur als Investor sonder auch als verlässlicher Partner herausgestellt, mit dem auch mal Engpässe überwunden werden können. Kann das eingeschlagene Konzept bestätigt werden, so ist die langfristige Investionsausrichtung von Finindus eine verlässliche Wachstumsgrundlage.”

Dr. Dirk Bohmann, founder of Borit GmbH,
inventor of the Hydrogate press and partner in Borit NV

Materializing innovation

Finindus is an investment company funded by ArcelorMittal and the Flemish Region and a sister company of OCAS.

Finindus invests in early stage and growth companies at the forefront of industrial process and material innovation with a particular focus on the steel and metal value chain. Its hands-on experience, industrial mindset and co-operation with OCAS turn Finindus into a valuable partner for its portfolio companies and its co-investors. Finindus' front row view on new technology innovations offers OCAS a bridge towards the applications and markets of tomorrow.

At present Finindus has an active portfolio of three companies:

Borit (BE) is manufacturing high precision formed components and assemblies used in fuel cells, electrolysers and thermal solutions and lightweight structural parts. Borit uses a unique hydroforming process combining the advantages of hydroforming (quality and accuracy) with the productivity of traditional deep drawing technology.

Calyos (BE) tunes a capillary loop heat pipe technology with a proven track record in space to terrestrial applications such as cooling of power electronics (in railway, windmill and industrial drive applications) and processors (supercomputers and datacenters). Its products have high heat transfer capability and operate in a closed loop system requiring no maintenance or energy.

Powercell (SE) combines its unique reformer and fuel cell technology to convert commercial diesel into electric power in a highly efficient, clean and silent way. Powercell targets in a first step stationary power generation (back-up power, primary off-grid power, micro-grids) and in a second step mobile power applications (marine and truck).

Next to these investments, Finindus also facilitates the implementation of new innovative technologies on an industrial scale at the plant of ArcelorMittal in Gent. Examples of these are xcelcoat (aesthetic coatings developed at OCAS), an industrial implementation of the flame assisted chemical vapor deposition technology (developed by OCAS) for adding easy clean properties to organic coated steel. And the primary energy melting project which enables to use more and less noble scrap in steel production.

"The shift in customer requests from service provision to microstructure development shows that OCAS's reputation in metallurgical processing for 3rd parties is gaining recognition."

Nico De Wispelaere

Small-scale metal production shows steady growth

OCAS's mission is to develop alloys and process metal-based samples. Over the years, we've accumulated vast experience in metals and their metallurgy. Moreover, we have access to a unique combination of equipment for producing and characterising metal samples on lab scale.

In collaboration with our partners CRM, Flamac and members of the Materials Research Cluster Gent, OCAS has experienced steady growth in turnover and number of customers for these activities.

From service provider to microstructure developer

Our unique range of equipment enables us to simulate, on a laboratory scale, industrial metallurgical processing of virtually every alloy. This service appeals primarily to universities and research institutes interested in using our lab facilities as a flexible production tool for tailor-made alloys.

But there's more to creating a metallic microstructure than casting, shaping and annealing: to achieve the right final microstructure, a good understanding of the metallurgical transformations is essential.

For this reason, we've seen a shift in our customers' requests for service. Our customers today are requesting more collaborations – in which OCAS is asked to contribute metallurgical know-how to pro-actively help in defining the best chemical composition, thermo-mechanical parameters and heat treatment.

Tackling hot topics

In our integrated hydrogen lab, we have been studying the behaviour of steel in environments containing hydrogen – and we have acquired fundamental knowledge about hydrogen trapping and hydrogen embrittlement in steel.

Thanks to this knowledge, OCAS can also address hydrogen-related topics. This asset has attracted customers from Asia as well as from Europe and America. And as these customers have come to us repeatedly with job requests, our expertise is clearly appreciated.

5

Knowledge building

Roger Hubert

Knowledge building is essential for R&D. It not only provides the necessary methodology, or fundamental insight, it also nourishes researchers' creative ideas, and vice versa. To equip OCAS with the proper tools to anticipate the challenges ahead, creative generation and use of knowledge is all-important.

At OCAS, we support several efforts to drive this continuous cycle of knowledge building. Some relate to the development of new methodologies that enable better, or more rapid, characterisation. In the past few years, OCAS has empowered its collaboration with Flamac – a member of the Materials Research Cluster – to accelerate materials development using high-throughput platforms for automation, miniaturisation and parallelisation in order to fulfil the complex set of performances required by the targeted application.

Knowledge building is also the driving force behind pre-competitive research: studying phenomena by collaborating on generic compositions

proves to have an important leverage effect. The results obtained – which are accessible to all participating members – can be turned into valuable new applications for smart product development and can even lead to patents. Furthermore, from our knowledge building, ideas arise for portfolio renewal.

Major issues of importance to society at large are often tackled in European or regionally funded programmes such as RFCS, FP7 and SIM and soon Horizon 2020. Thanks to our growing expertise and international recognition, OCAS is invited to participate in an increasing number of these funded programmes. The focus of these programmes is purely on 'research' – interesting phenomena can be studied for which no dedicated application has yet been identified. Still, it's valuable to be able to test, and possibly exclude, some hypotheses at an early stage. Findings can be used to generate new ideas, which do find their way into applications for daily life.

Even though 'knowledge building' is such a broad concept and difficult to define precisely, it is the key activity that fuels R&D.

"We have already made huge progress in the past two years with regard to austenite reconstruction. But we are confident that we can further improve our model and our microstructure predictions."

Nuria Sánchez

Getting tough with austenite

The key to the properties of steel grades lies within their microstructure. So, metallurgists are very keen to know what the microstructure looks like in order to improve the properties of the steel.

However, during the processing of hot-rolled grades, the final microstructure – and, consequently, the steel's properties – depends strongly on the successive deformations taking place during hot rolling, especially before the decomposition of the high temperature phase called austenite.

The main issue to be resolved, of course, is that the austenite itself has disappeared after transformation. To reveal the "original" austenite from the transformed structure, our team studied various methods – such as chemical etching of the phosphorus segregation where the austenite grain boundaries were located, or oxide etching of the austenite grain boundaries at high temperature – but these methods can only be used if certain conditions are met. Now, thanks to diffraction tools, a new and more reliable method can be used based on crystallographic calculations.

Reconstructing microstructure

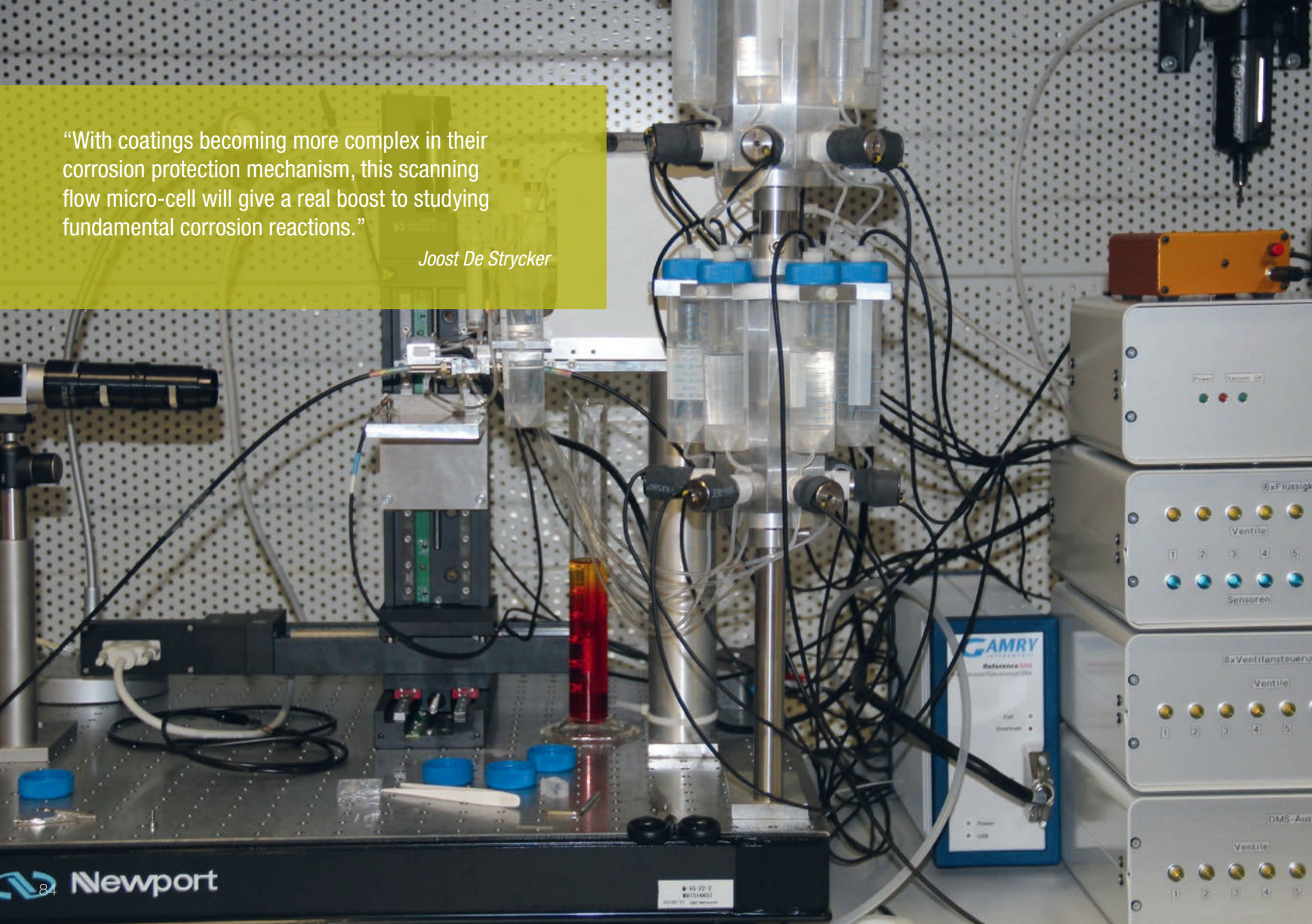
Recovering the grain shape and orientation of the pre-transformed phase is crucial for understanding microstructural evolution during any hot deformation process (hot rolling, welding, etc.). In turn, this enables better control over the material properties to be obtained.

In 2012, OCAS developed a model, based on crystallographic considerations and using experimental electron backscatter diffraction (EBSD) mappings as input. This original method succeeds in overcoming the limitations of traditional techniques and has already received international recognition.

Making toughness predictable

In 2013, our project proposal "AUSTOUGH: Austenite reconstruction tool for low-temperature toughness control in heavy gauge steels" was accepted for funding by the Research Fund for Coal and Steel (RFCS). Together with the other project partners, fundamental knowledge of austenite microstructure and toughness will be gathered so that the model can be refined. The objective is to optimise the rolling parameters to improve the toughness of steel even further.

For OCAS, the outcome of the AUSTOUGH project will be valuable in further improving our lab-scale rolling simulations of our customers' industrial processing.



"With coatings becoming more complex in their corrosion protection mechanism, this scanning flow micro-cell will give a real boost to studying fundamental corrosion reactions."

Joost De Strycker

Automated parameter screening boosts corrosion testing

Corrosion studies often leave a gap between electrochemical or accelerated tests and natural exposure. This is due to the complexity of the passivation and dissolution processes that occur at the surface of metallic coatings.

To assess this issue, an ever-increasing number of experiments are required to study the surrounding electrolyte's sensitivity to various parameters, such as composition and pH.

New electrochemical tool

In close collaboration with the Max-Planck-Institut für Eisenforschung, OCAS launched a PhD project to develop a new tool that allows high-throughput screening of corrosion properties to identify key parameters adjusted to real-life exposure conditions.

As a result, a scanning flow micro-cell – including a dynamic electrolyte renewal system – has been built that addresses all issues. Its main features are:

- Fully computer-controlled high-throughput experimentation
- High lateral resolution obtained by confining the measurement locally
- Electrolyte flow that allows stabilisation of experimental parameters

This high-throughput approach enables us to either vary the measurement parameter on a homogeneous substrate or to perform electrochemical screening along a heterogeneous substrate.

Downstream analytics

First, the new set-up was fine-tuned to allow semi-automatic parameter screening of zinc dissolution in variable corrosion conditions. Meanwhile, further automation has been implemented and reproducibility has been improved. The analytics of the micro-cell set-up have also been extended to enable the detection of other elements in addition to zinc.

"This project is the direct result of out-of-the-box thinking: from creative idea straight to patent!"

Jan Wielant

Nanostructures promote adhesion

Optimising adhesion to metal substrates can be accomplished by cleaning the surface, modifying the surface chemistry, or increasing the specific surface area. OCAS recently patented a method for creating nanostructures that increase specific surface area significantly – and, consequently, promote adhesion performance.

Inspired by a paper on the deposition of semiconductive nanostructures for electronic and photovoltaic applications, one of our surface team researchers decided to reproduce the described method in small-scale lab experiments.

It soon became clear that zinc-based nanostructures form rapidly on a wide variety of metals. Only a few seconds of deposition time are needed to form a nanostructured layer that improves adhesion dramatically.

Bonding metal and polymer

As the deposit itself is mechanically strong and adheres well to metal substrates, the structures that are formed have a direct effect on the bonding of metal substrates to various polymer materials.

Due to the deposition of zinc-based nanostructures, a dramatic change in the substrate's surface morphology is observed in no time. It is now well understood which morphology is required to enhance adhesion.

Sticking to Teflon®

Convinced by these preliminary results, further testing was carried out, using other substrates. The new experiments demonstrated that the nanostructured zinc-based layer is able to enhance adhesion on a wide range of metals, even on substrates that are quite rough.

Furthermore, the formed layer enhances adhesion to various polymers – even to apolar materials such as polytetrafluorethylene, better known as Teflon®!

These striking patent-pending findings introduce a whole new approach to a wide range of applications for which adhesion is key.

"I was amazed by the time-saving, cost- and energy-reducing effects our tool has on parallel rolling. In contributing to this FP7 project, OCAS hopes to contribute to the future of alloy development."

Nele Van Steenberge

Accelerating the discovery of alloy formulations

Metallurgy has become a highly sophisticated research field that influences almost all sectors of industry. But, to accelerate the discovery of smarter, safer, more sustainable, more recyclable, energy-efficient alloys, we must employ new high-throughput techniques.

In contrast to the traditional time-consuming and expensive trial-and-error approach, the Europe-funded FP7 'Accelerated Metallurgy' (AccMet) project is striving to speed up the process considerably by rapidly and automatically synthesising large numbers of compositionally varied alloy samples, followed by high-throughput testing of their structures and properties.

Small samples, great results

Although our role at the kick-off of the AccMet project was limited to characterising alloy samples, it soon became clear that OCAS could also provide a significant contribution to alloy screening. As thermo-mechanical treatments, for example, play a major role in mechanical properties, the emphasis of our contribution has been on this processing step.

We developed an innovative tool for parallel rolling of different alloys. The methodology was refined to ensure reproducibility and to determine the best size for the samples concerned. On the one hand, our goal is to treat as many alloys as possible per campaign; while, on the other hand, the resulting samples still need to be large enough to allow accurate characterisation.

On to heat treatment

The novel methodology will be further exploited in close collaboration with Flamac, a top research centre in high-throughput methodologies (and a member of the Materials Research Cluster).

Confident with the approach used, we are now developing the methodology to heat treat the rolled alloys.

"The equipment and the models we've developed on hydrogen diffusion and trapping have given us a better understanding of hydrogen embrittlement mechanisms and hydrogen-microstructure interactions."

Laura Moli Sanchez

Trapping hydrogen

Long-term energy requirements, combined with the changing climate, highlight the importance of developing non-fossil fuels. Although the 'hydrogen economy' is not yet a fact, significant efforts are being made to design steel grades that can be used to safely generate, store and transport hydrogen. However, to develop new materials with the necessary resistance to hydrogen, it's crucial to understand the mechanisms of hydrogen embrittlement and the interactions with microstructure.

Over the past few years, OCAS has developed a great deal of competence in terms of methodology, knowledge building, modelling and understanding the hydrogen embrittlement phenomenon.

Plus, we organised the very first European conference dedicated to hydrogen and steel. Thanks to the huge success of SteelyHydrogen2011, we have decided to launch the second International Conference on Metals & Hydrogen, to be held in Ghent from 5-7 May 2014.

Fully equipped for the future

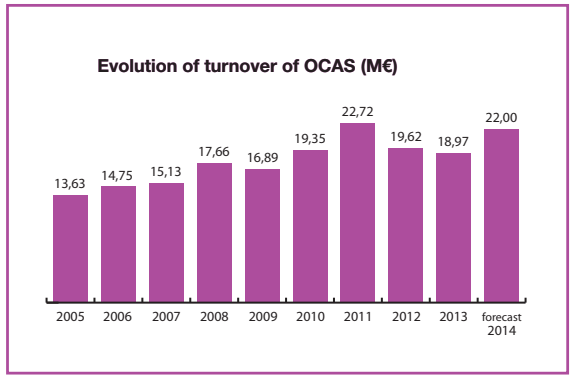
To be prepared for future challenges, OCAS developed a new approach to thoroughly analyse the results of thermal desorption spectroscopy (TDS). During the past year, we developed a trapping-desorption model for hydrogen and adopted the use of deuterium as hydrogen tracer. So, we're now equipped with electrochemical permeation, TDS (hydrogen and deuterium), determination of hydrogen concentrations, disk rupture tests, tensile tests on in situ hydrogen charging, and equipment that allows hydrogen charging at high temperatures and/or pressures.

In-house models add value

In addition, the in-house models we have developed for hydrogen trapping and diffusion bring added value to our work: they enable us to better understand the hydrogen-microstructure interactions and to optimise the testing that must be performed.

A good example of the contribution our knowledge can make was determining the amounts of hydrogen pick-up during the processing of high-strength steels. During austenitisation at different atmospheres, we found hydrogen in sufficient quantity to cause hydrogen-induced cracking of the steels. This finding will allow us to develop better hydrogen embrittlement resistant high-strength grades.

Fact Sheet


Evolution of turnover of OCAS (M€)
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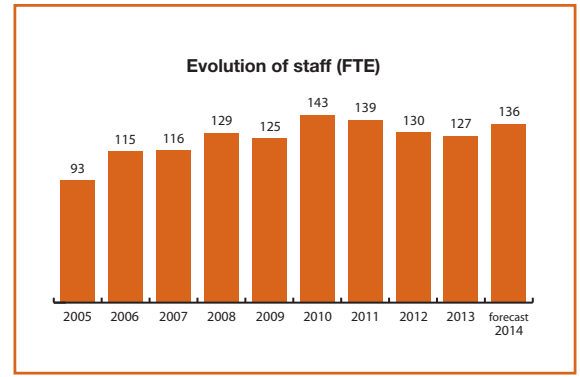
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forecast 2014

List of publications 2012/2013

Papers published in Scientific Journals

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J. Vercammen, V. Winne and M. Madani	How to Analyse Unknown Samples by Pyrolysis GC/MS?	Separation Science	Vol. 4 (2012) pp. 11-14
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R. Hausbrand, T. Van der Donck, J. Celis, F. Clarysse	Properties of FA-CVD silica coated steel sheet after deformation: coating integrity and corrosion related forming limit curve	Corrosion Engineering, Science and Technology	Vol. 48(7) (2013) pp. 530-36
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V. Carretero Olalla, N. Sanchez Mouriño, P. Thibaux, L.A.I. Kestens, R Petrov	Physical Simulation of Hot Rolling Steel Plate and Coil Production for Pipeline Applications	Materials Science Forum	Vol. 762 (2013) pp. 70-75
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N. Bernier, C. Xhoffer, T. Van De Putte, M. Galceran, S. Godet	Structure analysis of aluminium silicon manganese nitride precipitates formed in grain-oriented electrical steels	Materials Characterization	Vol. 86 (2013) pp. 116-126
D. Kowal, L. Dupré, P. Sergeant, L. Vandenbossche	The effect of electrical steel properties on the temperature distribution in direct-drive PM synchronous generators for 5MW wind turbines	IEEE Transactions On Magnetics	Vol. 49 (10) (2013) pp. 5371-5377
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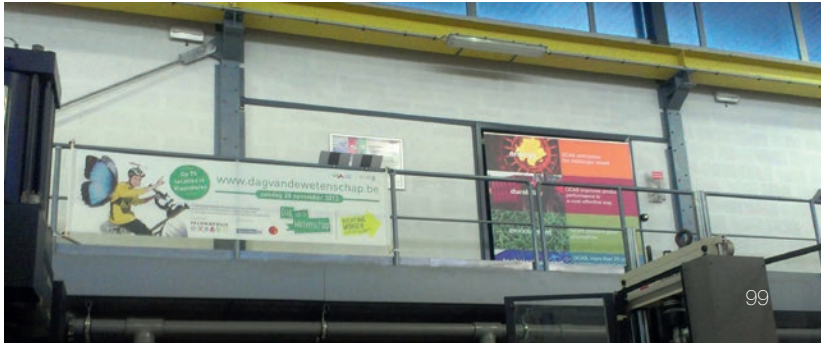
L. Vandenbossche, S. Jacobs, D. van Hoecke, B. Weber, E. Attrazic	Extending the drive range of electric vehicles by higher efficiency and high power density traction motors, via a new generation of Electrical Steels	2012/05/06 - Los Angeles CA, USA - Electric Vehicle Symposium (EVS26)
S. Cooreman, Ph. Gousselot, M. Leveaux, P. Pol, J. Antonissen	Understanding thermal warping and sagging in enameled steel parts through an integrated FE simulation	2012/06/03 - Köln, Germany - 22nd International Enamellers Congress
E. Leunis, L. Vandenbossche, D. van Hoecke, S. Jacobs, E. Attrazic	A new generation of high performance electrical steels for automotive applications	2012/06/20 - Gent, Belgium - WMM12: 5th International Conference Magnetism and Metallurgy
L. Vandenbossche, S. Jacobs, R. Andreux, N. Labbe, E. Attrazic	An innovative approach for the evaluation of iron losses in magnetic laminations, applied to the optimization of highly saturated electric motors	2012/06/26 - Berlin, Germany - INDUCTICA + CWIEME 2012 Berlin, Germany - 26-28 June 2012
C. A. Laska, S. O. Klemm, K. J. J. Mayrhofer, M. Madani, J. De Strycker	Effect of chloride and sulfate on zinc corrosion investigated by a scanning flow cell system with dynamic electrolyte change	2012/09/09 - Istanbul, Turkey - EUROCORR 2012

D. Perez Escobar, M. Verhaege, L. Duprez, K. Verbeken	Evaluation of Hydrogen Trapping in Iron-Based Alloys by Thermal Desorption Spectroscopy	2012/09/09 - Moran - Wyoming, USA - 2012 International Hydrogen Conference
T. Depover, E. Wallaert, Z. Zermout, K. Verbeken	Evaluation of the Effect of in-situ Hydrogen Charging on the Mechanical Properties of Iron-Based Alloys	
E. Wallaert, T. Depover, B. Pieters, M. A. Arafin, K. Verbeken	TDS evaluation of the hydrogen trapping capacity of NbC precipitates	
L. Moli-Sanchez, F. Martin, E. Leunis, M. Wery, J. Chêne	On the influence of tempering on hydrogen permeation in a 34CrMo4 martensitic steel	
L. Moli-Sanchez, F. Martin, E. Leunis, L. Briottet, P. Lemoine, J. Chêne	Comparison of the tensile behavior of a tempered 34CrMo4 steel exposed in situ to high pressure H2 gas or to cathodic H charging	
M. A. Arafin, M. Janosec, J. Bár, R. Pachlopník, Z. Vasek	Current Findings from the SSC Testing and their Implementation for the Trial Production of Casing Pipe Grade T95	2012/09/10 - Ostrava, Czech Republic - New methods of damage and failure analysis of structural parts
V. Carretero Olalla, N. Sánchez Mouriño, P. Thibaux, R. H. Petrov, L.A.I. Kestens	Effects of rolling reduction schedule on microstructure and properties of pipeline steel grades	2012/09/10 - Sheffield, United Kingdom - TMP 2012 - 4th Int. Conf. on Thermomechanical Processing of Steels
N. Sánchez, D. van Hoecke, M. Liebeherr	Mechanical anisotropy of hot rolled linepipe steel coil	2012/09/24 - Calgary, Canada - International Pipeline Conference IPC 2012
N. Sánchez, M. Liebeherr, N. Ilic	Characterization of X80 grade linepipe steel coil with 24 mm thickness	
F. Van den Abeele, J. Peirs, P. Verleysen, F. Oikonomides, J. Van Wittenberghe	Dynamic behaviour of high strength pipeline steel	
P. Thibaux, J. Van Wittenberghe	Modelling of slant failure using small size specimen	
D. De Knijf, R. Petrov, C. Föjer, L.A.I. Kestens	Optimization and characterization of a quenching and partitioning heat treatment on a low carbon steel	2012/10/07 - Pittsburgh, USA - MS&T 2012
L. Vandenbossche, S. Jacobs, D. van Hoecke, B. Weber, E. Leunis, E. Attrazic	Improved iron loss modelling approach for advanced electrical steels operating at high frequencies and high inductions in automotive machines	2012/10/15 - Nürnberg, Germany - EDPC - International Electric Drives Production Conference and Exhibition 2012
C.H.J. Gerritsen, S. Vanrostenberghe, H. Ahmed, T. Baaten	Verbeteren van de vermoeiingssterkte van lassen in hogesterktestalen	2012/11/06 - Gorinchem, Netherlands - NIL-BIL Lassymposium 2012 6-7 November, Gorinchem, Nederland
J. Van Wittenberghe, Ph. Thibaux, P. Goes	Reduced-thickness CVN testing to represent slant failure of pipelines	2013/02/20 - Gent, Belgium - SCAD 2013: Sustainable Construction & Design
D. Van Hoecke, B. Weber, S. Jacobs, E. Attrazic, S. Bergamo, R. Montaudon	Fatigue characterization of Electrical Steels for designing high efficiency electrical machines for automotive traction	2013/05/22 - Paris, France - SF2M-JIP 2013 - Fatigue behaviour: from specimen to structure (Paris, France, May 22-23, 2013)
D. De Knijf, R. Petrov, C. Föjer, L.A.I. Kestens	Austenite Stability Study by Micro-Tensile Testing of Q&P Steel	2013/06/23 - Vail, Colorado, USA - Int. Symposium on New Developments in Advanced High Strength Sheet Steels

C. Föjer, J. Mahieu, N. Bernier	Industrial Production of Quenching and Partitioning Steel	2013/06/23 - Vail, Colorado, USA - Int. Symposium on New Developments in Advanced High Strength Sheet Steels
D. Vangeneugden, B. Verheyde, J. Wielant	Atmospheric DBD plasma processes for production of lightweight composites	2013/08/04 - Cairns, Australia - International Symposium on Plasma Chemistry
F. Tankoua, J. Crepin, P. Thibaux, M. Arafin, S. Cooreman, A.F. Gourgues	Delamination of pipeline steels: determination of an anisotropic cleavage criterion	2013/08/26 - Bordeaux, France - 21ème Congrès Français de Mécanique
L. Vandenbossche, S. Jacobs, M. Van Poucke, Emmanuel Attrazic	Improving traction motor performance via ArcelorMittal's iCARe electrical steel range for automotive applications: a numerical comparison	2013/09/25 - Pordenone, Italy - Coiltech 2013 September 25-26, 2013 Pordenone Italy
Ö. E. Güngör, M. Liebeherr, P. Fize	Weldability Assessment of 24 mm X80 Linepipe Steel for Spiral Welded Pipe	2013/10/07 - Ostend, Belgium - Pipeline Technology Conference 2013 October 7-9, 2013
V. Carretero Olalla, A. Gervasyev, N. Sanchez, P. Thibaux, L.A.I. Kestens, I. Pyshmintsev, R. H. Petrov	Microstructural control of fracture splitting in HSLA pipeline steels	
N. Sanchez, N. Ilic, M. Liebeherr	Development of 24mm X80 linepipe steel for spiral pipes with low-temperature toughness	
M.A. Arafin, M. Liebeherr, N. Sanchez, B. Michel, P. Fize	Advanced pipeline steels for severe-sour applications	
S. Cooreman, D. van Hoecke, M. Liebeherr, P. Thibaux	Measurement of mechanical properties on line pipe: difficulties and pitfalls	
P. Legros, E. Bauters	New UV-curable paints for metal: high throughput experimentation for coating development	2013/10/15 - Basel, Switzerland - RadTech Europe 2013
L. Vandenbossche, S. Jacobs	Improved magnetic modelling of high-efficiency induction machines, taking into account the impact of electrical steel lamination punching on the magnetisation curve and iron loss	2013/10/29 - Nürnberg, Germany - 3rd International Electric Drives Production Conference and Exhibition 2013 (October 29th - 30th, 2013, Nuremberg, Germany)
L. Vandenbossche, X. Jannot, M. Mcclelland, S. Jacobs, J. Saint-Michel, E. Attrazic	Iron loss modelling which includes the impact of punching, applied to high-efficiency induction machines	
D. van Hoecke, S. Jacobs, L. Vandenbossche, B. Weber, E. Attrazic	Effect of punching and stress concentrations on mechanical behaviour of electrical steels	2013/11/18 - Barcelona, Spain - EVS27. Electric Vehicle Symposium and Exhibition
C. Gerritsen, S. Vanrostenberghe, M. Doré	Diode laser weld toe re-melting as a means of fatigue strength improvement	2013/11/27 - Senlis, France - Fatigue design 2013
E. Pinto Da Silva, W. Xu, C. Föjer, Y. Houbaert, J. Sietsma, R. H. Petrov	Combined martensite and bainite formation from austenite decomposition in HSLA steel	2013/12/02 - Las Vegas, USA - THERMEC 2013

OCAS strongly supports any initiative to encourage young students to become enthusiastic about science and technology. As we move forward, we wish to extend an open invitation to people of all ages to investigate and understand the benefits of Materials Science & Engineering.



OCAS nv

Pres. J.F. Kennedylaan 3
9060 Zelzate - Belgium
services@ocas.be
www.ocas.be

ArcelorMittal

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