Review
of the activities
2010/11

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OCAS strategically focused on society's needs

20 years of entrepreneurial innovation

On 20 September 2011, OCAS celebrated its 20th anniversary. Our remarkable 20-year track record is one of organic growth and continuous evolution, during which we have also launched 3 industrial spin-offs/joint ventures in the last 5 years.

Today, OCAS employs 140 researchers and technicians who serve the needs of over 100 companies that rely recurrently on our knowledge and infrastructure. OCAS continues to focus first of all on flat steel industrial applications, but technologies developed primarily for the steel and metal processing industry are starting to find their way to other material segments and markets too.

Our *product developments* include development of alloys and of metallic, organic and inorganic surface coatings as well as surface treatments.

Our *applications & solutions* focus on integrated solutions that often promote the use of new products or high-added-value products from a total approach (for example, combining cost-reductions, aesthetics

Sven Vandeputte, Managing Director
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and specific functionalities). The key here is co-engineering with customers. We also provide direct technical support for the ArcelorMittal plants and customer technical assistance in Europe for the industrial markets.

After the successes achieved with the Metal Processing Centre (a joint venture with CRM), and the positive market acceptance of the Metal Structures Centre (a consortium with the Belgian Welding Institute (BIL) and Ghent University's Soete Lab), OCAS also took the lead in setting up the Materials Research Cluster Gent, which was inaugurated on 20 September 2011 as well.

Bringing together more than 220 highly skilled researchers, the cluster currently consists of OCAS, CRM, BIL, SIM (Strategic Initiative Materials) and its department Flamac (Flanders Materials Centre), several departments of Ghent University, Sirris and Clusta – but it is certainly open to new partners.

In addition to sharing research infrastructure and state-of-the-art lab equipment, solutions are delivered for complex material challenges by bundling the know-how and expertise of the partners. This implies a clear reversal of the R&D landscape in material's research in Flanders: instead of fragmentation, the cluster facilitates intensive collaboration and the combining of strengths, in which each partner also reinforces its focus on key domains.

Challenging times call for bold decisions. In 2010-2011, OCAS undertook a profound strategic exercise with the goal of focusing on a limited number of developments that would propel the company into the years ahead.

Starting from a thorough analysis of our strengths and current opportunities, and taking our wealth of accumulated experience into account, the strategic exercise highlighted 3 technology maturation platforms within OCAS's own development portfolio. These 3 strategic axes – which we will develop further with carefully selected partners both at home and abroad – are focused on:

- Applications under the umbrella of the Metal Structures Centre (MSC), particularly in the fields of pipeline connection testing and fatigue-proof welding procedures (the first target market being the offshore

windmill parks),
- Electro-deposition applications, aiming first of all to find an environment-friendly alternative for Cr (VI) plating,
- Electro-technical applications, valorising our key expertise in electrical steels and application modelling.

In line with, and to support, this focusing of activities, we also renewed OCAS's mission statement:

"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."

Anticipating the challenges ahead

Fully aware of the fact that energy will be one of the greatest challenges to society in the coming decades, over 90% of our R&D activities are linked to 3 key themes: energy, environment and the durability of materials:

- Implementing high-strength steels or composite solutions to reduce weight, with reduced fuel usage for transport as a result;
- Materials for the generation, distribution and storage of energy (windmills, pipelines, pressure vessels, fuel cells…);
- Materials for a possible hydrogen economy (e.g. bipolar plates in fuel cells, storage tanks that do not become brittle over time and are constructed of affordable alloys);
- Electrical steels with lower losses, for more efficient engines and transformers;
- Materials for high-temperature applications in traditional thermal power stations, with better output as a result.

Our strategic exercise of the past 2 years focused OCAS on technology platforms in which we strongly believe we can make the difference and gain competitive advantage in the coming years. As we move forward through 2012, there are more and more indications that the strategic choices we made are the right ones. The 3 technology maturation platforms are highly relevant for our customers and society as a whole. Our competencies, combined with our state-of-the-art equipment and collaboration with our partners, provide us with unique opportunities.

1

Energy

Martin Liebeherr

Energy is one of the main drivers of the world's economy. The increasing global demand for energy requires exploration in remote areas for fossil energy sources, secure transport under harsh conditions, and more efficient power plants. At the same time, alternative energy sources and other smart technologies are needed to decrease CO_2 emissions. The efficiency of motors, the temperatures of furnaces and their exhaust systems, the efficiency of heat exchangers – all existing technologies are being challenged and need to be reconsidered. The materials involved – and the steel components, in particular – must be modified, as they may have already reached their limitations under the current service conditions. The list of required improvements is long: corrosion resistance, crack resistance, fatigue life, creep resistance and weldability are just a few examples. On the other hand, innovative steel product solutions can also lead to energy savings. One striking example is activating the steel surface by coatings to enable faster reaction during the enamelling process and, in turn, allowing a lower firing temperature.

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. Deeply involved in the development of steel for the Energy market, we are also actively present in other parts of the value chain. 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 ArcelorMittal's product offer. Every proposed metallurgical solution is tailored to the customer's requirements, the constraints of the respective steel production plants, and the cost-reduction objectives. Our active presence in the Energy market and extensive expertise acquired in specialised technical fields have enabled OCAS to support not only the needs of ArcelorMittal's customers but those of the end-users and other stakeholders as well.

As the Energy market has many facets and will continue to challenge us in the future, OCAS is taking a responsible role in an energy-conscious world.

"As a metallurgist, it's challenging to develop steel solutions that fulfil such stringent demands with regard to strength, toughness and fatigue in harsh marine environments."

Philippe Thibaux

The winds of change

The European Commission wants 20% of energy generation to originate from renewable sources by 2020. Given northern Europe's geographical location and climate, wind energy is the most obvious choice.

Studies have shown that generating energy from wind is most effective in the North Sea. However, both installation and maintenance of these offshore constructions present challenges that include resisting marine corrosion, weathering storm conditions, and so on.

Today, offshore wind farms – such as Thornton Bank (BE), Ormonde (UK) and Alpha Ventus (DE) – are proof that overcoming these challenges is feasible. The North Sea wind data with regard to wind speed and availability are favourable, and the water is not too deep. Therefore, it is expected that, by the end of the decade, installation of new wind energy capacity offshore will exceed onshore installation. This green energy source consists of three parts: a generator, which is mounted on a tower, and the underwater foundation. At present, two different designs are competing for the foundation construction – monopile and jacket – and both are steel-based.

Cost-driven durability

Until recently, R&D for offshore applications focused on developing special high-purity grades of heavy plate. As these constructions also require a lot of manual welding, the risk of welding defects requires a material that is tolerant towards flaws. During 2010-2011, OCAS deployed resources to qualify these special grades for weldability and to extend the product range with plates of greater thickness. In addition, OCAS provided technical support to mills and customers concerning welding issues.

As offshore maintenance or repair is extremely expensive, these constructions have to meet the most stringent specifications. Qualifying a weld for an offshore application requires 10 times more work than for a weld in a civil engineering project. Furthermore, the qualification of the weld also includes the zone around the weld that is affected by the heat.

Offshore steel constructions represent a market with growth potential. In the next few years, OCAS plans to intensify its efforts with regard to providing welding guidelines as technical support for internal and external customers.

"Thanks to our running research programme, we made substantial progress in understanding the microstructure for both coil and plate development of high-strength pipe grades. We have adapted our lab-scale test facilities to characterise samples with increasing thickness in combination with increasing toughness."

Nuria Sánchez Mouriño

Hot rolled grades find their way to cold and remote regions

Despite successful energy-saving efforts in a number of markets, global energy demand is still on the rise: a 20-30 % increase is estimated over the next 25 years. Moreover, the available oil & gas sources are more remote than ever before. As oil & gas need to be transported over longer distances under higher pressure, new pipeline grades must meet more stringent specifications on toughness and strength.

Over the past few years, the team working on pipeline grades successfully developed high-strength, heavy-gauge steel grades in coil, withstanding Charpy impact and Battelle drop weight tear tests, down to arctic temperatures.

In 2010-2011, lab trials were performed to better understand the factors influencing steel's toughness and, moreover, to be able to simulate industrial hot rolling conditions of the several production lines for which OCAS provides technical support. Today, the coils of the X70 grade (with a strength of 70,000 pounds per square inch or 485 MPa) have low-temperature toughness on thickness up to 22.2 mm, and coils as thick as 25.4 mm are available. Even stronger X80 coils are well on their way.

Pipe mills form steel into large diameter pipes by spiral welding (in case of coil) or by longitudinal welding (from plate). Grades in coil are more versatile as different diameters can be produced by changing the pipe forming angle, whereas larger diameters made from plate require wide plate. Spiral welding is more cost-effective for the customer, however, due to coiling, thickness on coil is limited to about 25.4 mm. Therefore, under-ocean or offshore applications thicker than 26 mm are designed from plate.

The market gets tough

As the pipe's yield strength defines the ultimate internal pressure of the gas, the market is now demanding even stronger grades. And although plate steel is available to these specs, because of the advantages related to coil, new projects – such as the Alaska gas pipeline and the Eastern Siberia-Pacific Ocean oil pipeline – are pushing steel producers to develop grades using design temperatures well below -10°C in coil.

"Our in-house welding capabilities open doors. Thanks to our expertise, our customers not only trust our welding guidelines, they will also involve us at an earlier stage in their projects – a real win-win situation."

Özlem Esma Güngör

New linepipe steel grades call for expert technical support

OCAS's recent X grade linepipe steel developments have not only opened new markets but have increased demand for technical support. Combining existing expertise with investments in state-of-the-art equipment enables OCAS's researchers to provide support to internal as well as external customers worldwide.

With increasing thickness of linepipe grades on coil, pipe mills face welding issues on heavy gauge during spiral welding to shape pipe out of coil. The market is attractive, and spiral welding is more versatile than longitudinal welding of pipes from plate. In most cases, the adaptation of the chemical composition needed to reach these heavy gauge pipeline grades requires a new process window for the customer's welding parameters. In addition, European (EN) and American (API) standards stipulate different limits for the composition of the steel. In other words, optimised welding parameters may also differ for different concepts of the same steel grade.

Both spiral and longitudinal welding use the same welding technique for pipe making: submerged arc welding (SAW). Thanks to a new industrial multi-wire SAW facility, OCAS is able to develop welding guidelines for its customers. Along with advanced sample characterisation, OCAS is logging all data into a database. Today, the welding team is working on generating datasheets for all grades in its different thickness and composition range, and our customers appreciate the data provided. Furthermore, they are using their experience in qualification tests for specific markets such as offshore applications.

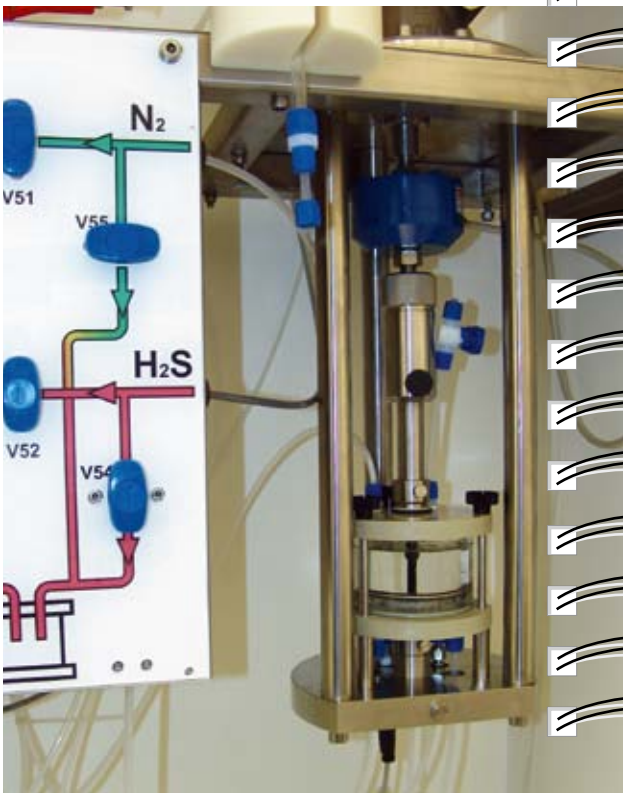
Another technique used in pipe manufacturing is high-frequency induction welding – but this kind of pipe is often excluded from certain projects due to inferior properties of the weld seam. OCAS has previously made some investigations, and the outlook is promising. In the long-term, OCAS believes that this process will be used more and more, as the oil & gas market becomes convinced by improvements to the properties of this type of weld.

Meanwhile, out in the field

The OCAS welding team's responsibilities are not limited to the pipe manufacturing processes. The laying of the pipe is also important, and welding pipes in the field can be even more critical than welding during pipe manufacturing. Therefore, the cold crack sensitivity of linepipe steel grades is being evaluated in the lab by simulating the most severe field welding conditions, and the potential risks are being assessed.

"NACE has asked us to help bring the quality standards up-to-date for testing steels in these highly aggressive drilling environments."

Muhammad Arafin



The sweet and sour of the drilling environment

An OCAS team is making great progress developing high-quality high-strength steels that can perform in a sour (H_2S hydrogen sulphide) oil and gas drilling environment.

The seamless OCTG (Oil Country Tubular Goods) pipe is a certain type of pipe that is commonly used for oil and gas exploration and production. There are 3 main types of OCTG pipes: casing (large diameters), tubing (small diameters) and drilling pipes. In the past, the steels used for these pipes had no trouble performing well because they were drilling in sweet, rather friendly environments. However, in today's oil and gas industry, the search for fossil-fuel sources must go farther and farther afield – where environments that are not so friendly lie in waiting.

As exploration for oil and gas feeds go further south into sour environments, the aggressive corrosion reaction produces hydrogen which embrittles the steel. And this complicates the challenge: you need highly stable high-strength steels for these aggressive environments – but the higher the strength, the more effort is needed to obtain a specific microstructure to avoid hydrogen embrittlement.

Assisting the standards committee

The OCAS team has a couple of key objectives:

- First of all, they search for the right alloy design to provide steels with the required strength and toughness as well as the resistance to the sour H_2S environment.
- Second, they perform tests on the steel grades to qualify them in accordance with standards specifications (published, for example, by NACE, the National Association of Corrosion Engineers). These tests are performed in-house in the brand new sour corrosion lab.

One of the OCAS team's major achievements of 2011 is that they have identified some of the key issues related to testing these steels in these harsher environments – and the standards committee has included OCAS's recommendations for updating the standards to address these key issues. Even more than that: the NACE committee has offered OCAS voting membership on the committee itself – a highly prestigious honour.

"In a multiple partnership like this, you are coordinating missions – so you have to stay open-minded and identify the real benefits for each partner."

Marc Vanderschueren

"Thanks to this consortium, we can respond to more complex requests and provide answers more quickly – synergy is our strength."

Philippe Thibaux

Creating synergy to speed time-to-market

The 'Metal Structures technology maturation platform' brings OCAS, Ghent University and the Belgian Welding Institute into a strategic collaboration.

How do you develop and mobilise Metal Structures knowledge quickly and bring it to bear on a pressing problem in industry? OCAS decided to call on Ghent University's Soete Laboratory and the Belgian Welding Institute to form a strong consortium.

This 3-way collaboration started in 2009. During 2010-2011, additional lab and office space was built, existing equipment was centralised, and some new equipment was added. The Metal Structures team has recently hosted both scientific and academic events, and visitors are impressed by the combination of available equipment and skilled staff. The partners have carefully coordinated their efforts and have planned the way forward through 2012 and beyond.

Each partner contributes its special expertise to develop knowledge around metal construction, production, testing and failure analysis. The objective is to combine the different competencies of the three partners in order to perform tests that none of the three organisations could conduct alone, and then to mobilise their knowledge rapidly to solve industrial problems.

Technology on a fast track

The Metal Structures 'technology maturation' platform is tackling the challenge to develop technology that can be optimised and up-scaled to industrial applications very quickly – thus accelerating the valorisation process and getting into the market sooner. Currently, the team is focusing on the energy market, developing new welding methods for offshore structures, and seeking solutions to metal fatigue for a number of applications. The objective in the middle term is to develop technologies for valorisation in the pursuit of high added-value, sustainable energy products.

"I was really impressed by the worldwide response to our conference on steel and hydrogen. The renowned Prof. Murakami from the Japanese Hydrogenius Research Centre for Hydrogen Industrial Use and Storage, kindly agreed to give the keynote lecture. The 'Steely Hydrogen' conference confirmed that hydrogen will be a crucial topic for developments in steel in the next decade."

Lode Duprez

Hydrogen under pressure

In 2007, driving forces originating from various markets inspired OCAS to speed up knowledge building in the field of hydrogen. Today, OCAS has a dedicated hydrogen lab to study the fundamental mechanisms related to hydrogen embrittlement, and test set-ups for both hydrogen-induced cracking (HIC) and sulphide stress corrosion cracking (SSCC), as well as disk rupture test equipment using gaseous hydrogen at high pressures. A lot of competence has been developed over these past few years, and in September 2011 OCAS hosted a major international conference on steel and hydrogen, called 'Steely Hydrogen'.

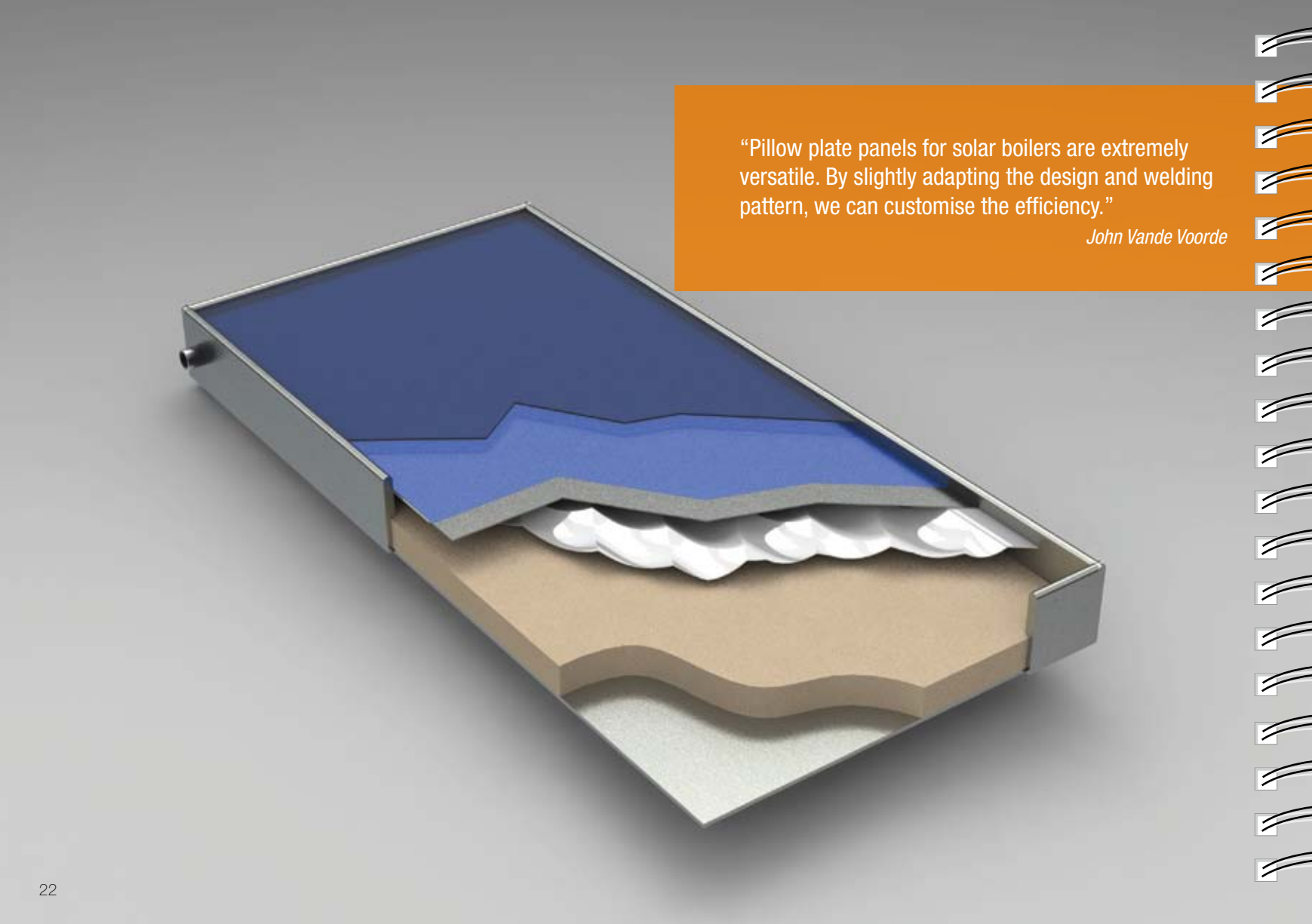
Damage to high and ultra-high strength steels due to hydrogen is already a crucial topic. Pushing the strength of steel grades beyond 1000 MPa makes them more sensitive to hydrogen embrittlement. Some of the markets affected are: energy pipes, pressure vessels, automotive, bolts, heavy sections, and so on.

Long-term energy trends highlight the importance of making non-fossil fuels an increasing portion of the world's energy supply to respond to climate change and reduce greenhouse gas emissions. Although the hydrogen economy is not yet a fact, evolutions like fuel-cell-powered cars are creating growing interest in materials that can be used to safely generate, store and transport hydrogen. OCAS has extensive competences and facilities to tackle the material-related aspects.

'Steely Hydrogen' and beyond

Being involved in various projects on the effects of hydrogen on steel – from internal development projects and technical services to funded knowledge building projects with various European research institutes – OCAS took the initiative to organise the very first conference dedicated to steel and hydrogen in Europe. And it turned out to be a huge success.

OCAS is confident that, based on its acquired competence and state-of-the-art test facilities, it will be able to answer today's challenge without compromising on safety for ultra-high strength steel. In addition to mechanical properties, resistance to corrosion, high temperatures and coating-related issues are among the challenges ahead.



"Pillow plate panels for solar boilers are extremely versatile. By slightly adapting the design and welding pattern, we can customise the efficiency."

John Vande Voorde

Broadening horizons for tailored blanks

Inspired by its success in automotive applications, ArcelorMittal Tailored Blanks is starting to transfer its experience in laser welding and laser cutting to other markets. Over the last 2 years, OCAS has been involved in several interesting projects to introduce laser-welded blanks into cost-effective steel solutions for different end-uses.

A first rather straightforward extension of the possibilities was to use ArcelorMittal Tailored Blanks' laser welding equipment to make extra-wide sheets from ultra-high-strength steel. Since industrial vehicles such as trailers, tippers, etc. are wider than cars, the availability of XXL sheets facilitates stamping and assembling these large formats.

Combining finite element modelling and welding expertise from OCAS with processing laser welding on an industrial scale resulted in more complex and very innovative steel solutions. One example was the development of a fully steel-based low power heat exchanger. The idea starts with two sheets, which are stacked, welded and later inflated. Possible applications for these 'pillow plate panels' are industrial double-walled coolers for the food and drink industry.

Promising developments under the sun

OCAS has also tested and fine-tuned pillow plate panels for use as cost-effective solar boilers. Traditional expensive copper or aluminium structures welded on tubes can be replaced by a steel pillow. The pillow's well-designed welding pattern guarantees perfect water flow and, at the same time, provides the plate with its superb stiffness. Thanks to this improved stiffness, the solar boiler structure no longer needs an expensive stiffening frame.

Of course, issues such as corrosion and temperature resistance and solar radiation absorption need to be addressed. However, cost-effective solutions are available today, and a prototype has been successfully produced and tested. Other applications seem very tempting: why not use building façades, or entire roofs, as heat exchangers?

"We're working on blending in the right amount of yttrium oxide (Y_2O_3) to achieve the high temperature properties we need for more efficient power generation."

Nico De Wispelaere

ODS: combating creep during high temperature energy generation

Here's a challenging project: invent a steel grade for use in the energy plants of the future. With the aid of yttrium oxide, the OCAS team is tackling the problems that arise at high temperature and pressure.

ODS stands for Oxide Dispersion Strengthened steel, in which adding very small – nano-size – oxides to the steel enhances its high temperature strength. Which is a key property when generating electricity: today's power generators operate up to a limit of about 550°C when using steel components, and the OCAS team wants to raise that to 600°C or higher to gain in energy efficiency.

Stopping that steely creep

With increasing temperature and pressure, standard steels lose their properties causing material problems: the steel becomes weaker, and the phenomenon called 'creep' sets in.
Creep happens when operating at high temperatures and when force is applied (which can simply be the weight of the installation itself): the steel plastically deforms under its own weight. This creep can be quite small – perhaps only 1 mm per year. But the installations will need to operate for several decades. In nuclear reactors, ODS steels have an additional strong point: resistance to swelling. Swelling, which is caused by irradiation generating helium inside the steel is unacceptable in the fuel tubing (cladding) in a nuclear reactor. When swelling of the cladding prevents the coolant to flow around the tubes and the heat extraction becomes problematic – this becomes a serious issue.

Towards a new grade of steel

OCAS has worked hard over the past several years to find solutions to these problems. The goal is to develop a T91 steel grade (9% chromium), which is one of the standard grades for use in power generators. The current technique for producing an ODS variant of this type of steel – via powder metallurgy and then extruding the tubing – is quite difficult to do and very expensive. Other problems arise as well: the steel oxidises internally, and the properties of the extruded steel are not the same transversally and longitudinally.

The OCAS team wants to produce this steel in the conventional steel making manner (casting and hot rolling), by introducing yttrium oxide (Y_2O_3) into the liquid steel. In partnership with SCK-CEN (the Belgian National Research Centre for Nuclear Energy) in Mol, they are working on getting the right amount of oxide into, and then homogeneously spread throughout, the liquid steel.

"In GO, there's only one direction to go for improvement: lower magnetic losses and higher magnetic permeability. In NO steels, the variety of applications asks for more differentiation. Each part of a machine requires a different compromise for magnetic and mechanical properties, thickness and cost."

Tom Van De Putte and Elke Leunis

Getting oriented to electrical steels

The difference between non-oriented (NO) and grain-oriented (GO) electrical steel is primarily related to their application: non-oriented electrical steels are mainly used in rotating machines (motors and generators), while grain-oriented are used in transformers. Both steels are used for their magnetic properties which is the ability to guide electromagnetic flux. Nevertheless, these two types of electrical steels exhibit different properties and also their production processes are totally different.

The target for *non-oriented* electrical steel grades is to guarantee isotropic magnetic properties. The major development axis is to lower the magnetic losses and thus the energy losses in the application in combination with high permeability in order to have a better magnetic response.
In 2010-2011, the team has been working for automotive and industry applications to develop products with additional requirements such as guaranteed high frequency properties, high mechanical strength or very high permeability levels.

In-depth investigations yielded that the metallurgical aspects needed for these properties require a compromise on the standard 50 Hz properties and consequently an adapted production process. A close collaboration between the production plants, commercial people and R&D resulted in a range of new high-added value products.

In addition, the metallurgical implications of the new annealing line that will be operational in 2013 at ArcelorMittal St Chély d'Apcher have been studied extensively for existing and new grades to be prepared for the future product range.

Stepping outside the windows

With one of the most complex metallurgies and most complex processing routes, *grain-oriented* electrical steel is often regarded as a speciality steel. Grain-oriented steels have large grains with an identical specific crystallographic orientation, optimal for conducting magnetic flux in the most efficient way. The degree of perfection of this orientation reflects the properties: the magnetic permeability and the energy dissipation related to magnetic losses.

Unlike other steels, there is almost no differentiation according to functionality (as in structural steels, for example, which come in different grades of strength or toughness). There is only one direction of product improvement: better crystal orientation for higher permeability and lower losses.

During the past two years, the OCAS team accomplished an great leap in their work with GO steels. They moved from product characterisation and understanding of the complex production process towards product improvement and process optimisation, beyond the known process and product chemistry windows. They also went from investing in lab equipment and producing new analysis methodologies to applying them on a regular basis for product and process improvement.

"We strive for those opportunities that increase our in-house capabilities. At the same time, we use the market exposure as a breeding ground for combining multiple ideas into improved applications."

Lode Vandenbossche

At your service to improve efficiency

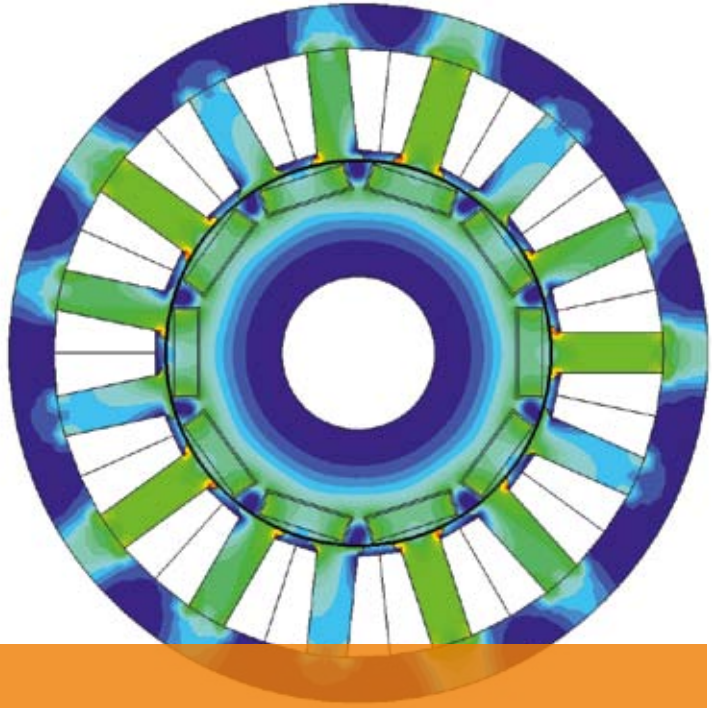
The ‘Electro-Technical technology maturation platform’ deals with electro-technical applications in which electrical energy is converted into another type (mechanical energy, for example, as in a rotating motor or generator), or in a different kind of electrical energy (as in a transformer).

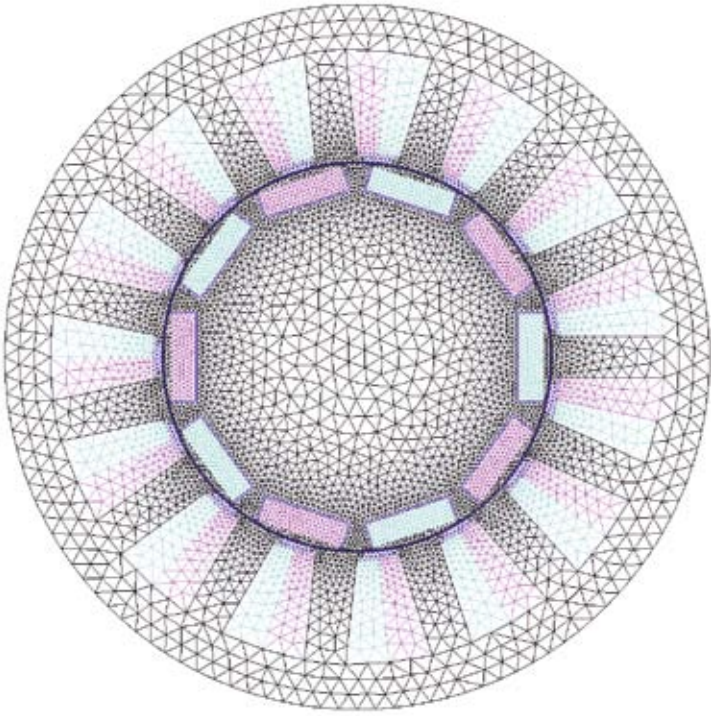
OCAS gained a great deal of experience over a number of years from projects on the applications of electrical steels. The team is using that experience within the electro-technical platform to expand its scope into applications related to electrical energy conversion where there is a need for materials that can guide magnetic flux and electrical current efficiently.

In order to meet the application’s requirements in terms of material specifications, OCAS has a wider scope than electrical steels alone. This search can be very far-ranging and multi-disciplinary: all kinds of soft magnetic materials and different conductive materials. Moreover the assessment is not only limited to electrical or magnetic properties. For example: a customer asked for a specific filter inductor design to define a certain magnetic core material and a certain conductor material, globally optimised for minimal dissipation, mass, volume and cost.

The in-house competences available for such studies are threefold: improved numerical modelling and design approaches by refining the multidisciplinary material property inputs, advanced electromagnetic characterization with focus on the end application specifications, and the development of non-standard magnetic measurement set-ups. On top of that, the OCAS team always keeps an eye open for innovative improvements of efficiency and performance of electrical machines, mainly improvements triggered by multidisciplinary material and steel know-how.

So, this platform is multidisciplinary – not only does the team investigate the material’s electromagnetic properties, but all the properties that matter. They look particularly for projects that provide services to a third party while at the same time contain a promising valorisation path as well.





"We can validate our modelling approach to estimate magnetic losses with machine measurements from the customer's prototypes, which allows them to shorten their overall design process – a pure win-win situation."

Lode Vandenbossche

Supporting the evolution towards hybrid cars

This activity is one of the axes of OCAS's Electrical Steels (ES) programme, in parallel with its development activities of new ES grades. Electrical steels (also known as magnetic steels) are excellent at guiding magnetic flux lines in electro-technical applications in a highly efficient way.

The ES solutions and modelling team is supporting major ArcelorMittal customers in automotive and general industry. At the moment, the projects in this area are focused on improving efficiency of industrial drives and on the electrification of road transport – to move away from the internal combustion engine towards hybrid and even fully electric vehicles.

For example, the OCAS team is working with a large OEM on how to estimate the magnetic losses that occur in electrical steels when the electrical traction motor is in operation. In contrast to industrial machines – which are stationary and run mainly at constant frequencies – a machine installed in a vehicle imposes much higher constraints regarding mass and volume: a high torque needs to be produced with a very compact motor, in the most efficient way possible, taking into account the battery volume, cost and hence vehicle range. These constraints push the steel towards its maximum performance. So, in the design phase, it's essential to be able to estimate the losses, by modelling them as accurately as possible so that the overall design (including the cooling) can be adapted to dissipate those losses.

And that's not easy. It involves the interplay of the material's properties, the motor's operational aspects, and even the mass production processes in making the engine (which deteriorate the steel's original properties).

A win-win modelling approach

During the past year and a half, the team developed a modelling approach in which they first perform advanced material characterisation in the pre-processing stage. Second step is obtaining the relevant data from the customer's design calculations. For this task the OCAS team has installed a tool into the finite element modelling software of the customer, to provide the OCAS researchers with the input they need to estimate the losses in a separate procedure that can then be run in post-processing at OCAS. Importantly, this co-development modelling approach is designed so that the customer only needs to submit the relevant data to OCAS, which protects the customer's confidential developments. Thanks to this generic modelling approach OCAS is capable to collaborate with customers both on applications within automotive and general industry markets.

2

Durability

Tom Waterschoot

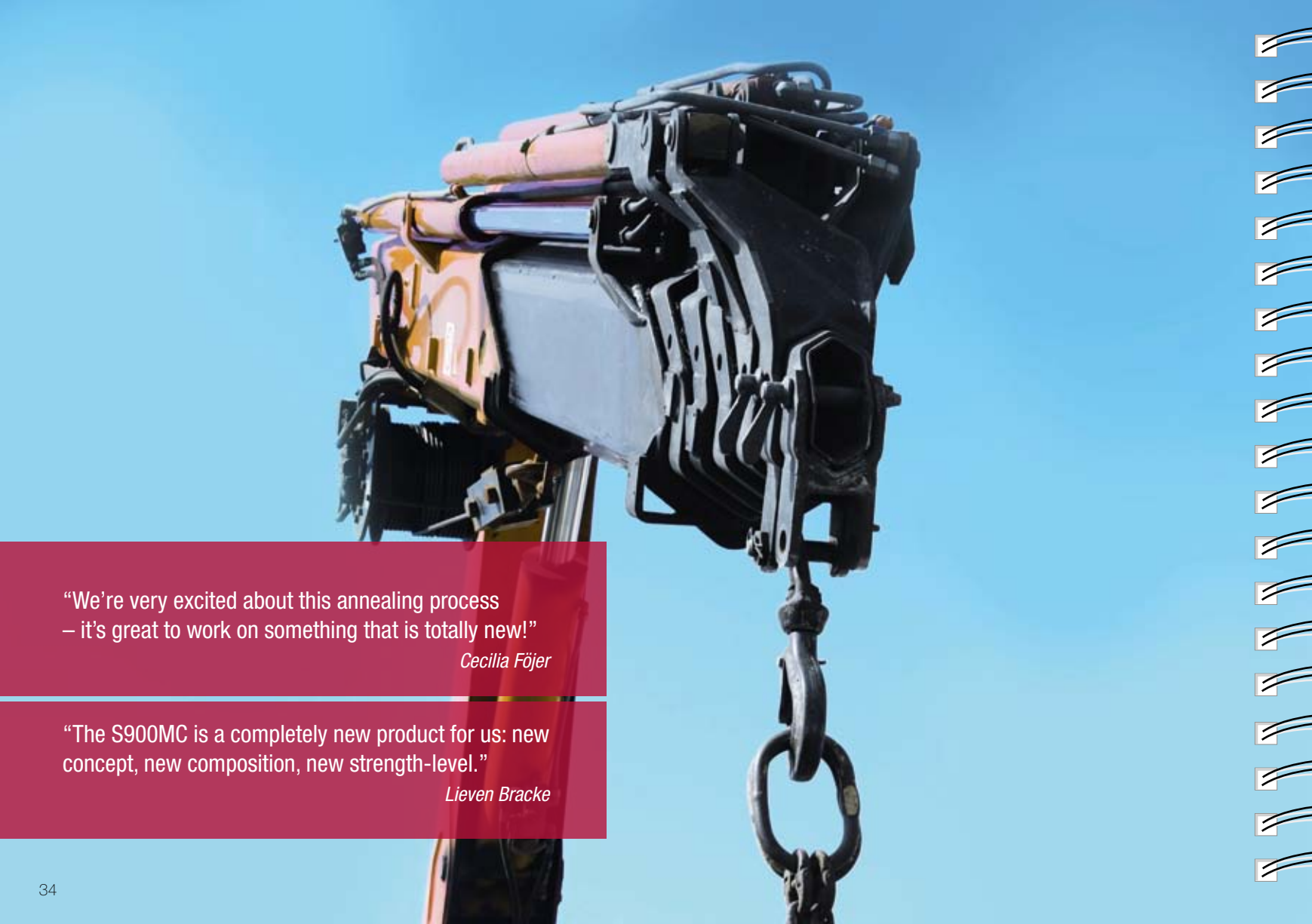
Durability is a key driver in the current economic environment – encompassing our customers' continuous quest to improve the performance of their products as well as increasing the life span of equipment and constructions.

Durability is important for OCAS and its customers in many ways. 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, weldability or dent resistance.

OCAS is deeply involved in the metallurgical development of a whole new generation of steels to answer these needs – searching for innovative microstructures that provide specific characteristics. 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.

Durability can also be translated into improved corrosion resistance, for which every environment has its specific requirements. Drawing on its extensive expertise in all kinds of organic and metallic coatings, OCAS has made important progress in improving the performance of thin organic coatings and temporary corrosion protection systems. As icing on the cake, Magnelis® – the new metallic coating that outperforms existing metallic coatings in many environments – is now available on the market.

As complex materials only reveal their full potential when applied correctly, OCAS is an expert competence centre for generating application guidelines and generic steel solutions. And as generic steel solutions open many doors, our co-engineering approach ensures that the new product offer is implemented successfully at the customer's site.



"We're very excited about this annealing process – it's great to work on something that is totally new!"

Cecilia Föjer

"The S900MC is a completely new product for us: new concept, new composition, new strength-level."

Lieven Bracke

Rolling out new high-strength steels

In both cold rolled and hot rolled high-strength steels, the mission is ever higher strengths – as well as optimising other properties – to reduce thickness and weight for heavy-duty industrial applications.

In 2010-2011, the *cold rolled* products team extended its offering by developing steel grades with higher strengths plus good ductility. In 2009, the highest yield strength ArcelorMittal offered for industry applications was 460 MPa.

Thanks to OCAS's developments, two years later ArcelorMittal was the only European steel company being able to produce the very specific Q&P (Quench & Partitioning) microstructure on industrial scale, outperforming by far all available cold rolled products with a yield stress over 1000 MPa, elongations of more than 10% and excellent in-use properties. As the processing in the ArcelorMittal Gent plant is not entirely straightforward yet, the next step is now to guarantee a robust non-stop production process.

Furthermore, the team started to fill the gap between 460 and 1000 MPa of yield stress.

At the end of 2011, they industrialised the new 500 MPa high-strength low-alloyed product (HC500LA) – which is perfectly suitable for metal forming, with better welding performance, and high strength in low thicknesses.

Stronger and tougher

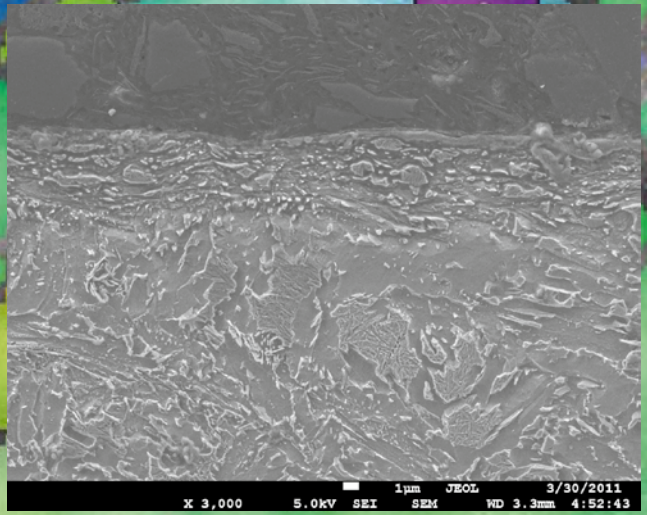
For the past two years, the *hot rolled* team has been focusing on yield strengths of 700 MPa and higher. The first project is to produce S700MC in heavy thicknesses. The team has succeeded in making this steel grade with a less expensive alloy and expanding the dimensions in which ArcelorMittal offers the material. Currently, this steel can be made up to 10 mm thick, with a toughness guarantee at a test temperature of -40°C and in 12 mm with a guarantee at -20°C. But there are market opportunities for thicknesses greater than 12 mm – so they are looking at 15 mm, with further improved properties, mainly toughness.

The second project is the S900MC – a different order of challenge, because it entails a different (highly alloyed) metallurgy, and a new strength-level. This product is now in guided industrial production up to 5 mm, and the team is waiting for customer feedback. Again, the next step is to go to higher thickness (8 mm) with guaranteed toughness.

Beyond S900, again another metallurgy is needed, especially challenging from the process perspective. So far, one industrial trial has already been carried out resulting in the strongest coil material ever produced on an ArcelorMittal strip mill. Some issues remain to be solved, but it looks very promising.

"A complex mix of multiple properties influences the in-use behaviour of wear-resistant grades. Taking all this into account – in combination with the limitations of hot rolling plant capabilities – makes this project a real R&D challenge."

Wei Xu



Durable steel grades wear well

Wear resistance extends the life of steel grades used by machinery and equipment manufacturers for applications in mining, construction, agriculture, etc. Consequently, the so-called yellow and green goods market is showing increasing interest in these durable steel solutions.

However, combining guaranteed hardness with superior cold formability and excellent welding properties is a formidable challenge. During 2010-2011, OCAS carried out successful lab tests to determine the best possible metallurgy. After up-scaling, an optimised HB400 grade was introduced into the market. Now, following the market trend, an even harder, more durable grade – HB450 – is well on its way to industrialisation.

Former developments provided OCAS researchers with the knowledge necessary to fully understand the favourable microstructure needed to obtain these wear-resistant grades. Today, the challenge is to produce these grades on existing industrial hot rolling installations at an affordable price.

Pushing the limits

Because of their microstructure, wear-resistant hot-rolled coils are quite difficult to process and push the hot rolling mills to their limits. As customers expect these wear-resistant grades to become available in increasing thickness and extended width on coil, smart metallurgy is needed to answer market needs.

Developing new grades with strong emphasis on wear resistance and durability is more than a simple hardness guarantee. Customers benefit most from grades with excellent durability in combination with medium hardness – and thus, enhanced machinability.

In addition to wear-resistant grades, OCAS is also involved in the optimisation of boron grades, which are heat treatable and often used in agricultural parts such as plough shares, disks and tools. Boron grades can be hot- or cold-formed and provide cost-effective solutions for applications requiring resistance to abrasion.

"Reducing the customer's total cost of ownership by smart use of steel grades is motivating. Successful co-engineering projects like these illustrate the creative power of thinking out of the box."

John Vande Voorde

Co-engineering: how less can be more

Recent developments in high-strength and ultra-high-strength steel grades enable car manufacturers to make lighter cars and realise substantial energy-savings. The benefit for the customer is obvious. However, in more traditional industries – such as trailers, freight wagons and vehicles for agriculture – a little extra is required to swing the balance.

Rail is already the most environmentally friendly way to transport goods. Rail wagon dimensions are regulated by strict railway specifications and the wagons last 30 to 50 years, so there is no dynamic approach possible regarding design. Yet, cargo can easily damage wagons during loading and unloading. High-strength steel grades are more resistant to damage, thus lowering the cost for repairs.

In 2010-2011, other successful co-engineering projects resulted in lowering the total cost of ownership of agriculture vehicles and trailers. For trailers, as with cars, the advantage of energy-saving weight loss is clear – especially when you take an annual average of about 150,000 km per trailer into account.

Smart use of new steel grades lightens the workload

Manufacturers of tippers for harvesting are less affected by the fuel-saving solutions. However, introducing advanced high-strength steel grades to existing designs not only lowers the weight and overall material cost, the reduced thickness facilitates processing at the customer site. Easier sheet metal forming opens the door to design optimisation. So, smart use of these high-strength steels is translated into less welding or avoiding stiffeners. By reducing the number of welds, the potential risk of defects is equally reduced.

A generic solution has been proposed to reduce weight and cost and, at the same time, obtain a tipper with greater volume for harvesting. Customer feedback has been positive, and this solution also cross-fertilised other market segments for comparable optimisations.

"Being used to the former generation of metallic coatings, I'm impressed by the corrosion behaviour of this magnesium containing coating. Obtaining red rust during a salt spray test seems to have become mission impossible!"

Beril Corlu

Understand corrosion before it happens

Applying a metallic coating protects the underlying steel from rusting. Driven by the search for durable environmentally-friendly steel solutions as well as offering cost-effective alternatives, lately magnesium has been included in zinc alloyed coatings. This new development resulted in a metallic coating showing excellent corrosion resistance, both on its surface as on cut edges.

Once chemical composition and processing parameters were optimised on lab scale, the Magnelis® coating went into industrial production successfully. Outdoor exposure tests demonstrate that weight loss is many times lower than in case of pure zinc coatings. Thanks to its excellent corrosion resistance, the magnesium containing zinc alloy can be used as money saving alternative to batch galvanising. The possibility to reduce coating weight without compromising on corrosion behaviour also facilitates processing at the customer.

In 2010-2011 the major focus from OCAS was on customer support and corrosion behaviour assessment in various environments to enable a smooth transition to this new coating. E.g. to benefit from the improved corrosion behaviour around the weld seam, welding parameters need to be optimised. Another advantage of Magnelis® is its excellent resistance to very specific and harsh environments, widening its application to new markets. Promising results have already been obtained in buried applications.

Metallic coating on a diet

Although the introduction of magnesium in zinc alloy layers allows substantial reduction of the coating weight, current R&D projects aim for even thinner coatings. Other chemistries as well as other application techniques are investigated to make metallic coated steel even more environmentally-friendly at an affordable cost.

"We're at a very early stage in this project – the exploration phase – but we already have some very interesting results, especially for our iron-based alloy."

Nele Van Steenberge

Bulk metallic glasses: amorphous metals

‘Bulk metallic glasses’ are solid metallic alloys that have an amorphous structure, which means that the atoms are arranged more or less randomly. Most metals are crystalline in their solid state – their arrangement of atoms is highly ordered. Amorphous metals are non-crystalline, and so their structure is similar to that of a liquid or glass.

Bulk metallic glasses represent a new class of structural and functional materials with extraordinary properties including extreme strength and high elasticity, along with a number of superior chemical and physical properties.

In the past, this type of material was produced as a kind of foil, at around 20 µm in thickness. But the product had to be quenched to achieve its special liquid-like structure – so the shape you could obtain was limited. By the early 1990s, researchers modified the chemistry to reduce the speed of the crystallisation process, and so the extremely high cooling rates were not necessary anymore and the manufacture of bulk pieces (in the 1-10 mm range) was now possible.

In 2010-2011, the OCAS team focused on 4 discovery paths:

- finding a suitable and price-competitive alloy composition
- characterising the amorphous, magnetic and mechanical properties
- investigating near-net-shape casting and die casting processes
- exploring the markets: magnetic and near-net-shape casting

Simplifying casting

The goal is to provide a more suitable manufacturing process for small complex parts, because the piece is immediately cast without a lot of processing (machining or surface finishing). As the solid structure is very similar to the liquid structure, there is no shrinkage when going from liquid to solid, so very sharp edges and precise dimensions are obtained, plus a very nice surface finish.

3

Environment

Tom Waterschoot

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

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

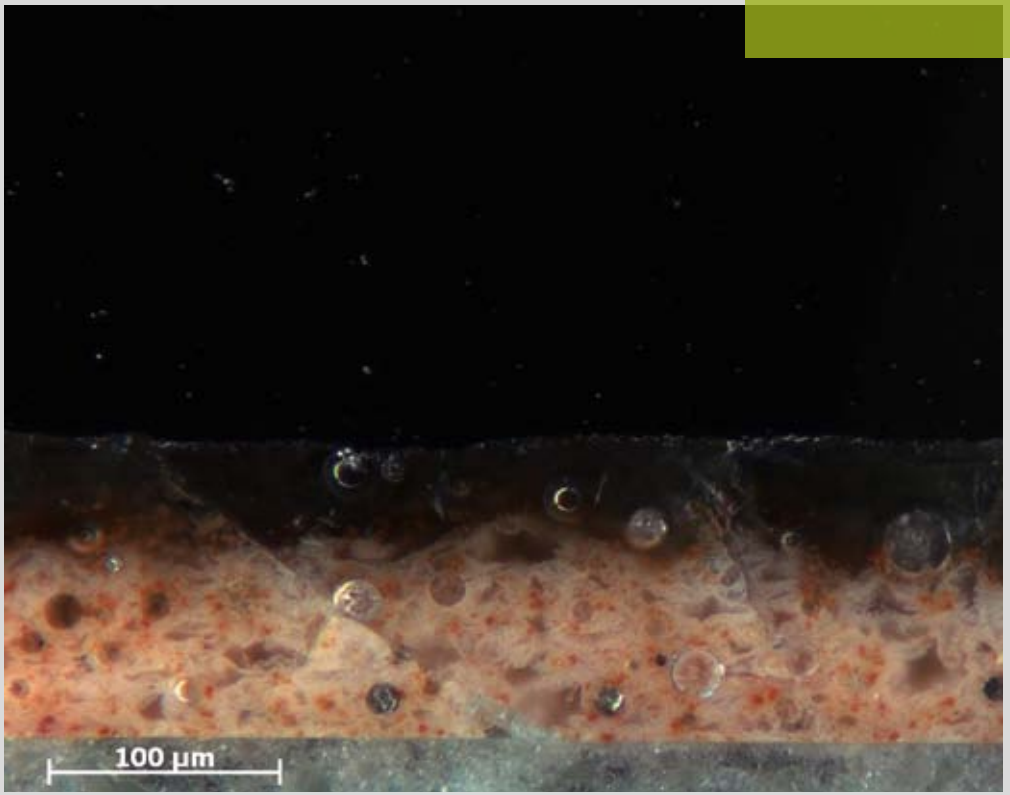
So, the climate around steel has been changing in recent years, and steel products have become more popular. Our industry does not view its environmental responsibilities merely as obligations but as strong drivers for material developments and innovations.

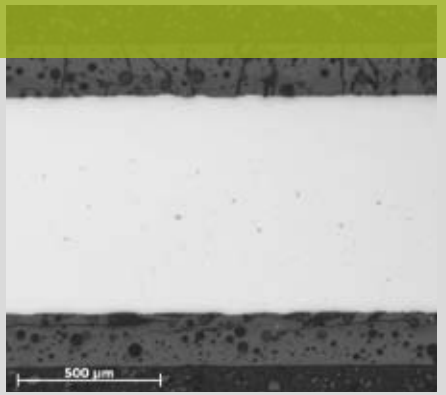
As a key player in the world's search for green products, OCAS develops and implements environmentally-friendly steel substrates and surface functionalisations. Our company has successfully developed effective alternatives for toxic hexavalent chromium passivation systems. Furthermore, OCAS has developed 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, lower the required firing temperature dramatically.

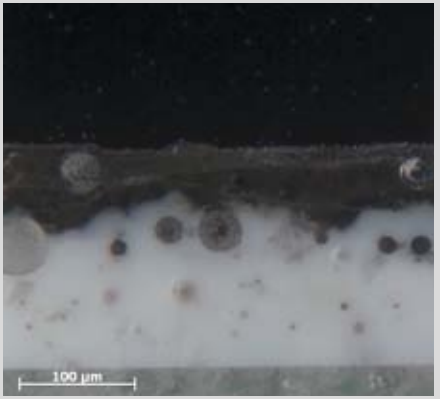
As we move forward into the 21st century, the pursuit of green products is accelerating, and OCAS is poised to perform a pioneering role.

"Enamelled steel is a perfect blend of tradition and high-tech environmentally-friendly innovation. A truly inspiring combination for a researcher!"

Marc Leveaux







Novel developments propel traditional enamelling into the 21st century

Enamelling is an ancient technique used to protect the underlying substrate and to give it an appealing look. Now, environmentally-friendly alternatives not only reduce enamelling's carbon footprint, they also reduce the cost of the customer's process.

In the past few years, OCAS has developed a post-treatment for steel coil that allows to skip oiling and thus degreasing at the customer site. Furthermore, this patented Ready-to-Enamel® steel solution facilitates the enamelling process so that the customer can reduce the firing time and temperature. Customers have successfully tested this cost-effective treatment for household appliances, and it looks promising for sanitary ware applications as well.

The Ready-to-Enamel® product inspired our research team to develop a universal primer on steel coil, replacing the ground coat. This primer ensures a perfect adhesion of the top coat enamel, reducing the traditional two-coat system to a simple mono-layer. This application provides an ecological solution for the direct white enamelling market, and it can also be used in the construction industry (e.g. for architectural panels). Potential health & safety issues during firing have been successfully assessed by our in-house toxicology team.

Continuous progress

Another challenge related to steel grades for enamelling is to combine good formability with a perfect surface and reduced fish-scale sensitivity. Recently, a novel approach has led to a new steel grade processed by continuous annealing. Customers from various market segments have already made prototypes using this new grade, and their feedback is positive.

OCAS has developed a new cold-rolled enamelling grade specifically for water boilers – reducing the wall thickness by 0.2 mm, whilst keeping the strength level well above 300 MPa after firing the enamel. Yet another example of how traditional techniques can still be sources of innovation.

The outlook for enamel-based technology is very promising indeed. Encouraged by enamel's excellent durability, appearance and recyclability, OCAS's researchers are currently working on a new enamel concept. This future product would be durable, ecological, light-weight and easy to shape – at an affordable price.

"Although bringing this new surface treatment into industrialisation has not been easy, receiving positive feedback from customer trials is very rewarding. The OCAS team is motivated to further improve the product's properties."

David López Granados

Cold-rolled steel surface is now Ready-to-Paint®

Surface treatment is widely used on hot dip galvanised steel grades to provide temporary corrosion protection whilst adding extra functionalities to the surface. The success with hot-dip galvanised steel inspired OCAS to develop a comparable coating for cold-rolled steel.

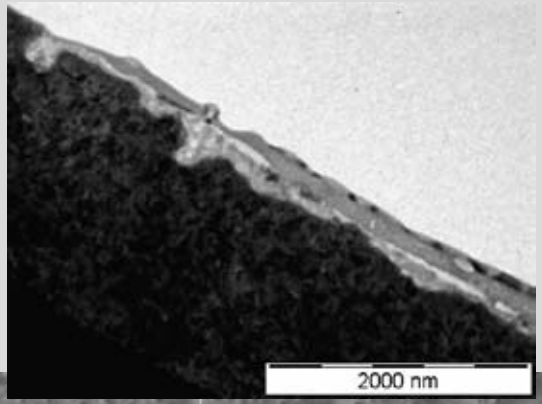
Using Ready-to-Paint® cold-rolled steel avoids oiling, degreasing and the application of a phosphate or passivation layer. So, customers producing steel furniture, drums or household appliances are eager to switch to this green alternative. Not only can you paint directly onto the treated surface, the treatment also greatly contributes to surface cleanliness. Moreover, Ready-to-Paint® is compatible with many other operations such as cutting, slitting, bending, profiling, light stamping, welding and clinching.

Corrosion tests on painted samples have shown that this new coating clearly out-performs Fe-phosphated cold-rolled steel. Moreover, it performs equivalently to tri-cation phosphated electrogalvanised steel (2.5 µm zinc per side). Therefore, it's quite likely that other market segments will soon be interested in joining the switch to Ready-to-Paint® cold-rolled steel.

Reducing the carbon footprint without compromising quality

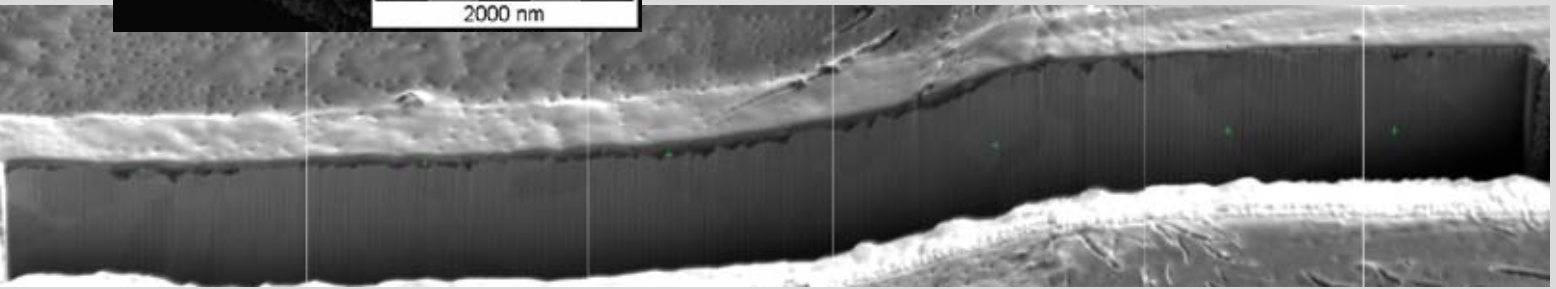
Although this development was primarily driven by environmental issues such as reducing waste water and eliminating toxic adhesion promoters, this green alternative provides customers with a highly durable product of superior quality.

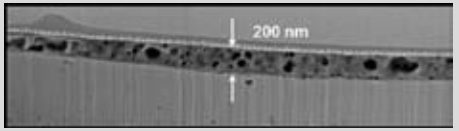
In 2010-2011, the OCAS team put a lot of effort into optimising the application parameters and determining and guaranteeing a stable process window for the processing lines industrialising this new nano-scale product at high speed (about 200 m/min). Today, OCAS researchers are focusing on improving the additional functionalities of the surface treatment. For example, Ready-to-Paint® suitable for deep-drawing operations is expected to be available in the coming years.



"While in the past we looked for a green alternative to Cr(VI), the new challenge is to outperform that toxic compound and reduce the ecological footprint even further. It feels good to move on to this next step!"

Nathalie Van den Bossche





Improving the performance of passivation products

Environmental and health issues with the corrosion inhibitor hexavalent chromium compelled Western Europe to switch to alternative solutions for preventing steel products from rusting during transport and storage. A lot of R&D effort was applied to help production lines change to alternative products. During 2010-2011, OCAS was able to focus on improving the performance of these green products.

Over the past eight years, OCAS has helped more than 25 production lines make this technology transfer. The switch to non-carcinogenic alternatives meant that the process window for all these lines had to be revised.

Identifying and understanding all of the parameters that influence the application of passivation products on our wide range of metallic coated steel substrates, as well as insuring stable bath conditions on all lines, took a great deal of effort – but the knowledge we acquired is invaluable. In addition, the product range for green passivation has been completed with environmentally-friendly solutions for thin organic coatings and paint systems as well.

Today, customers are convinced of the advantages and rely on these green alternatives. We're now fully prepared to push the limits even further and explore more opportunities with regard to optimising product performance.

Green feels good

European legislation is no longer the driving force for developing green alternatives. Instead, the challenge is to use our knowledge to improve the properties of the products used by our customers. And as these 'in-use' properties are of high interest to our customers, they give us their full support. First industrial trials based on lab results look promising – and, although a lot of work still needs to be done, customer feedback is positive.

It is reassuring to know that we are now able to reproduce performance indicators on a laboratory scale. Customers are eager to use these green solutions as a competitive advantage. The fact that improved performance could lead to cost-reduction on packaging is a bonus.

4

Technical Support & Entrepreneurial R&D

Sofie Vanrostenberghe

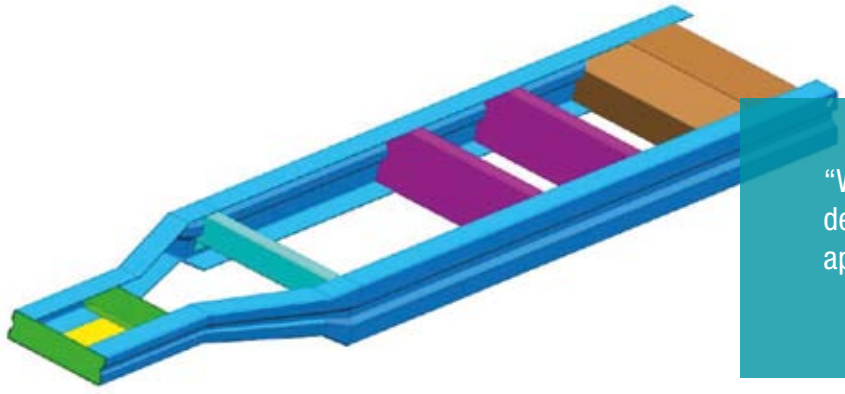
In a climate of ever-increasing globalisation and fierce competition, innovation and the creation of value for our customers will continue to be of utmost importance. Reducing costs without product innovation will inevitably result in diminishing returns. So, for most of our customers, the best approach is to trim costs and upgrade the diversity and quality of their product offer. And that's where co-development projects and state-of-the-art technical support available at OCAS open unexpected opportunities.

A wide spectrum of technical issues – ranging from cracking during forming to coating issues to premature fatigue failure – can be addressed to assist our customers active in a variety of sectors. We encourage early involvement in each study in order to move from a cost-saving to a value-

creation mindset. Our customer-oriented approach leads to advanced research for value creation and cost reduction through innovative solutions. By combining experimental work and finite element analysis in multi-disciplinary teams, we assist customers from product design to the optimisation phase.

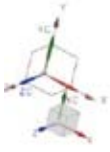
And we go even further than that: entrepreneurship is stimulated at OCAS, where we are constantly looking for new opportunities as well as improvements to often well-established processes with the aim of creating new economic value. Assisted by the Finindus investment fund, OCAS creates spin-offs and joint-ventures to valorise its know-how and expertise. Several of these initiatives have drawn international attention and are building solid customer portfolios – so the outlook for growth is quite promising.

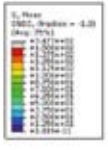
At OCAS, we look forward to continuing to provide technical support and innovative solutions for our customers' challenging issues!

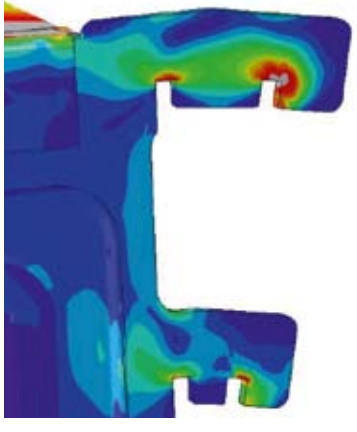


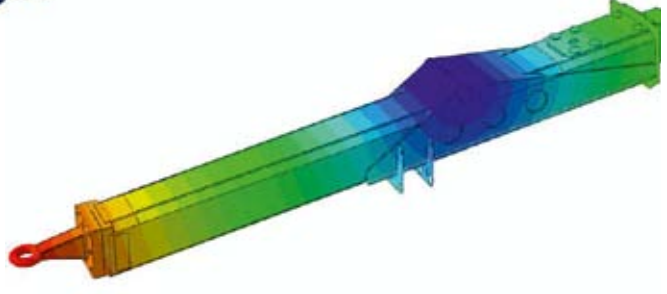
"We apply advanced steels to help customers solve design and engineering problems in a wide variety of applications."

Sofie Vanrostenberghe









Helping customers reach their goals

OCAS is collaborating closely with AMDS (ArcelorMittal Distribution Solutions) – and, more specifically, the Products and Solutions Development team – to meet customer needs.

The OCAS-AMDS partners set up co-development projects with AMDS customers to solve the customers' design and engineering challenges. The objective is to position ArcelorMittal as a competent supplier and to support the implementation and marketing of new products, such as the S700MC and S900MC high-strength hot-rolled grades or Magnelis® coated steel grades.

In 2010-2011, the team conducted co-engineering projects with customers in a wide variety of market segments, including agricultural machinery, transportation, heating ventilation and air conditioning, and more. The key drivers are most often cost- and weight-reduction and energy-savings.

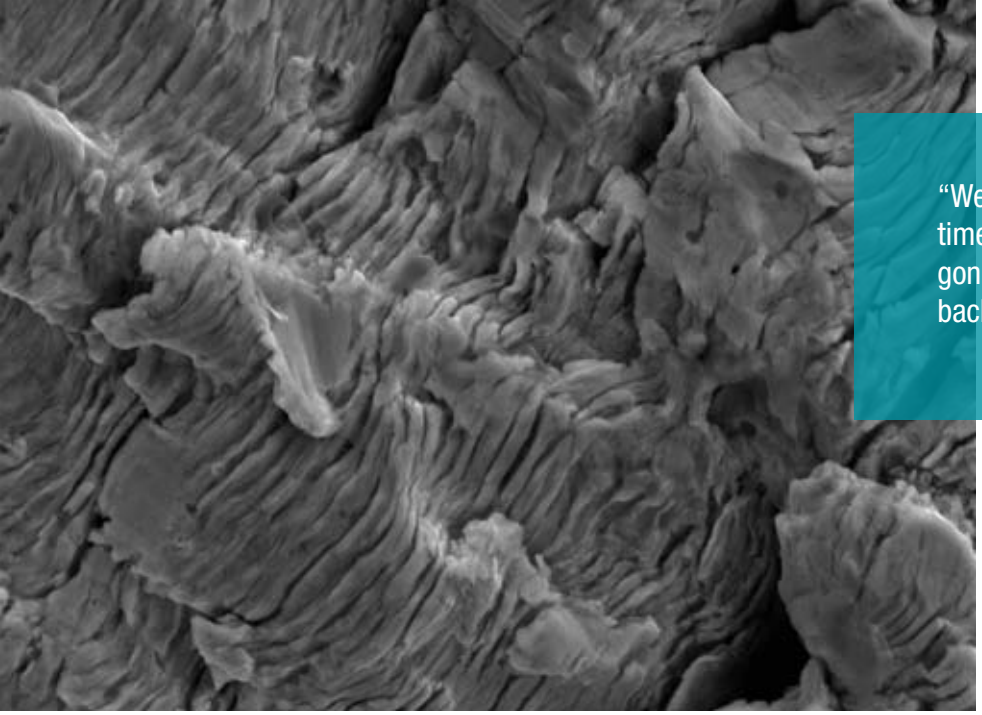
An example of a recent project: a trailer manufacturer had been making trailers out of commodity steels; but, due to rising costs, he wanted to optimise the steel consumption while keeping the same performance. The team proposed a design based on high-strength steel, which is currently implemented by the customer.

From needs analysis to final design

In the first stage, the team works with the customer to identify the customer's needs. For example, the customer's objective might be to reduce costs by 10% to be more competitive in the market. They also discuss the technical specifications and the requirements and constraints of the application. Using this input, they then make a first analysis and offer some suggestions for improvement – e.g. switch to other steel grades or to lower thickness, use another production technique, or even make a design change.

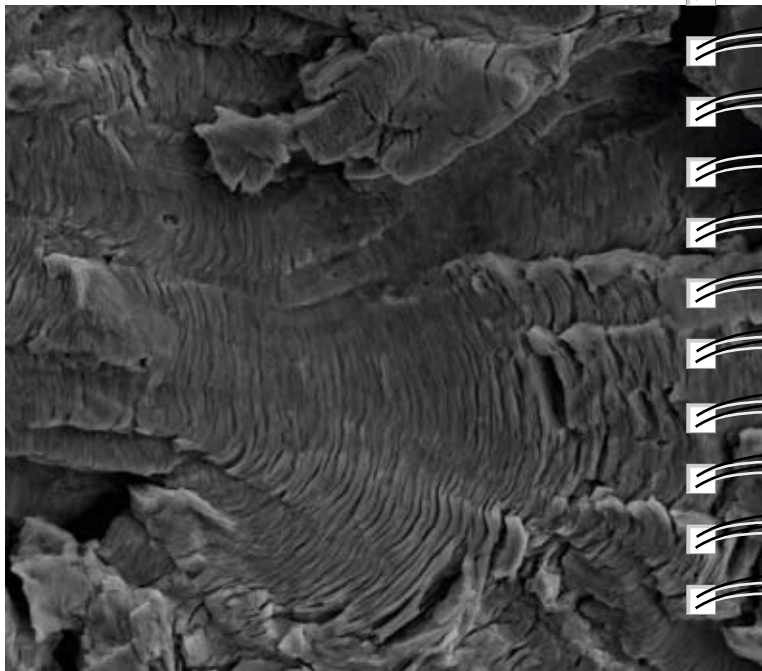
The customer considers the recommendations, along with the cost impacts, and then the team can assist further with experimental testing as required (e.g. how to bend or weld a certain high-strength steel). In a final stage, the team can assist in prototyping and, ultimately, in testing the final design.

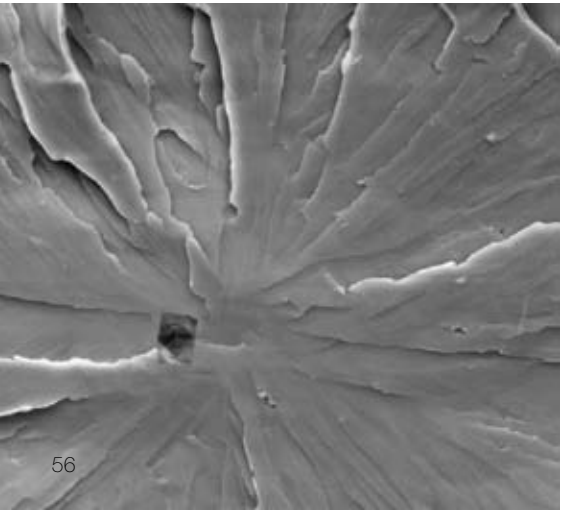
The OCAS team and AMDS have been working together like this for 3 years now – the outlook is a fruitful, long-term partnership.

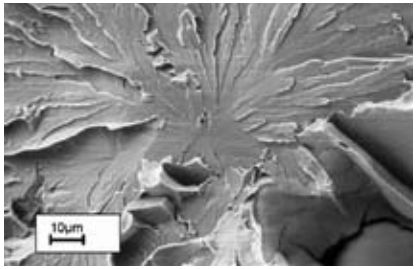


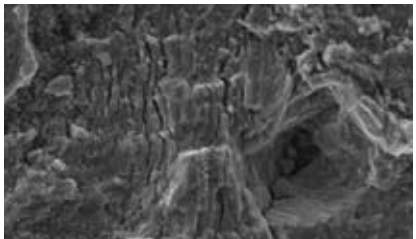
"We try to be very responsive – because most of the time, when somebody comes to us, something has gone wrong and they need help fast to get production back up and running."

Nico De Wispelaere









TS&S - to the rescue

In January 2011, a new department was created in OCAS: Technical Support & Services (TS&S). In operation for a little over a year now, TS&S has successfully formalised and centralised important tasks that had been handled ad hoc in the past.

The TS&S department is in charge of 3 main spheres of activity:

- *Direct technical support for the ArcelorMittal Gent plant* - No matter what the problem might be – a material breaks or corrodes, or they need an advanced test or characterisation – TS&S stands ready to provide a solution to OCAS's neighbouring ArcelorMittal plant.
- *Customer technical assistance in Europe for the industrial market* - If an ArcelorMittal customer in Europe has a problem– with an ArcelorMittal steel, TS&S will delve to the bottom of the issue to provide help or an explanation and to solve the problem.
- *Sales to external companies* - OCAS sells spare resource capacity to external companies. As the ultra-expensive high-tech testing equipment that OCAS has in-house is not always used 100% of the time for product application development within the project portfolio, TS&S uses the machines during these idle periods to carry out tasks for external companies. This way, the external companies need not invest in the cutting-edge technologies – and the specialised competence – themselves. They call on OCAS!

With regard to the sales to external customers, one rule of thumb applies to keep these services profitable: TS&S only handles assignments for which they already have the equipment and expertise (this way, they don't incur the costs of new equipment or of bringing in outside expertise for a particular assignment).

With the creation of TS&S, a dedicated team handles these assignments in the most efficient way and with short response time. Such assignments are almost always urgent, so they are well-placed to take care of matters with minimal disruption to OCAS's normal activities.

"One of the nice things about this project is that there is strong market pull. The imitation of brushed stainless steel by low-carbon steel is in high demand, while the current solutions are based on laminated films. Our xcellook solution is a full steel solution."

Marijke De Meyer

"We're excited about validating the xcelcool technology and winning acceptance of our solution by some of the world's largest teletronics manufacturers."

Vincent Stone

xcelcoat the coolest look

The xcelcoat project accomplishes the industrialisation and commercialisation of new coated products on low-carbon steel.

Two generations of xcelcoat products are well on their way to their respective markets.

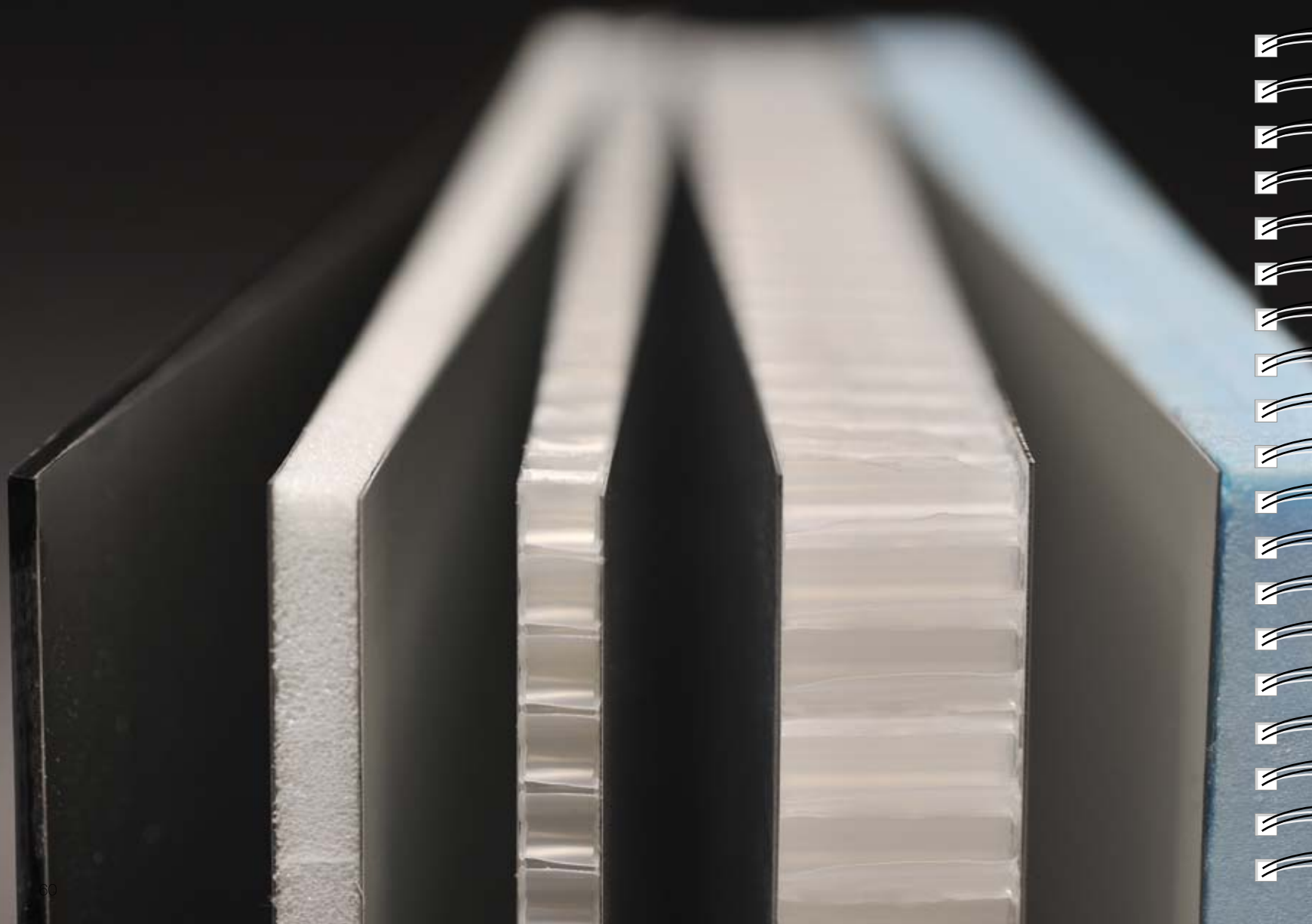
The first generation are three aesthetic products for indoor applications: xceldesign, xcelcolour and xcellook. The most promising development concerns the **xcellook** product. This product is based on galvanised steel that is brushed to imitate brushed stainless steel. In 2010-2011 trials were conducted on a prototype installation to finalise the design of the industrial machinery. Last year, a brushing installation was set up to begin production.

The domestic appliances and the elevator markets are highly interested in xcellook. As of 2012 industrial samples of these products are being sent to potential customers, and commercial production is expected to start before the end of the year.

Solving thermal management issues

A second generation of products, is about to be launched for industrial trials in 2012. This generation broadens the aesthetic range towards outdoor applications, and functional coatings. For the latter the main development is related to the product **xcelcool**, a steel sheet with improved heat-releasing properties for electric/electronic appliances such as printers and LCD displays.

Providing a cost-effective, space-saving way to increase the release of heat from metal enclosures, the xcelcool product reduces device failures, increases component efficiency and lifetime, and helps to meet safety requirements. The xcelcool product is currently undergoing fit-for-use assessments by end-user market leaders.



Elytra

Elytra is an OCAS spin-off company that specialises in innovative light-weight sandwich panel solutions. In 2010-2011 Elytra refocused its activities on 4 applications, each with a specific product solution:

This strategic re-orientation resulted in 4 market segments and their corresponding products:

- *Visual communication boards - white boards for writing and projection.*
  The team developed a light-weight version and a new matte organic coating (to minimise reflection)
- *Flooring*
  These heavy-duty sandwich panels, with steel skins, are designed as a light-weight product for both indoor and outdoor stages and temporary elevated floor solutions. A solution was found to the challenge of applying an anti-skid layer on the steel surface by using a thermo-plastic adhesive, allowing to produce the panels in one instead of multiple lamination steps.
- *Point-of-sale panels*
  Light-weight panels with steel skins that are used for all kinds of POS exhibition boards and displays for new products. The magnetic properties of the steel skin are particularly handy for this purpose.
- *Super-light all-polymer sandwich structures*
  Lightweight panels with Curv and Twintex skins for use in flight cases and airfreight cargo solutions.

In 2010-2011, OCAS undertook the product development and co-engineering with customers for these four product groups. The team optimised the features and performance of the products as well as the lamination production process parameters (heating and cooling cycle, speed, pressure, etc.).

At the end of 2011 it became clear that Elytra would not succeed in developing a level of profitability allowing a continuation of the business on a stand-alone basis. Therefore it was decided to transfer the business to another panel manufacturer and close down the operations in Geel.

"We look forward to further supporting borit as their business further develops and they are confronted with new technical challenges."

Sofie Vanrostenberghe

Borit – growing with the clean energy market

Borit nv is a joint-venture between OCAS and borit Leichtbau-Technik GmbH established in 2010 and located in Geel (Belgium). In 2010-2011, OCAS and borit worked together to support borit's business activities.

Borit supplies high precision, thin metal sheet components and sub-assemblies to growth markets such as heat management solutions, fuel cells, electrolysers and micro-reactors.

Using its proprietary metal forming technology, borit enables its customers to enhance product performance, reduce post processing costs, speed up and de-risk their product development, and realize a flawless transition from concept to prototyping and large series production.

Providing borit with specialised support

OCAS is supporting borit in its business activities for bipolar plates and interconnects for fuel cells and electrolysers and flow plates for heat exchangers. OCAS is regularly consulted to provide quality checks on the mechanical properties of incoming material.

The two main projects that OCAS and borit have worked on in 2010-2011 were:

- Development of a methodology for *corrosion testing* of metal bipolar plates for use in fuel cells.
- Study on the *forming behaviour* of thin metal sheets by means of hydro-forming, and benchmark with conventional forming techniques (e.g. deep-drawing).

Borit works with very thin material (0.05 – 0.5 mm), different coating systems and metals (including stainless steel, titanium and nickel-based alloys). This new methodology for corrosion testing helps borit to better analyse and rank different coated and uncoated substrates in terms of corrosion behaviour in these applications.

With regard to the forming behaviour of thin metal sheets, OCAS developed a technique that allows to verify the dimensional tolerances and assess the quality of a formed component. Borit uses this technique in its quality control processes in series production.

"We are working on the integration of the Lancas FA-CVD technology in the manufacturing processes of some customers – it is always quite a challenge to introduce new technology to existing production environments."

Tom Ceulemans

Lancas - spearheading a new coating technology

Since 2004, OCAS has been conducting research on CVD (Chemical Vapour Deposition). The project has reached a stage in which the potential to use this technology to apply nano-coatings with particular functionalities on steel, but also on other materials, is demonstrated.

For the past two years, the OCAS team has been focusing on easy-clean functionalities, where the dirt pick-up of a surface is reduced and where dirt can easily be removed by natural rainfall without the need of wiping the surface. But, the technology can also be used to obtain anti-reflection, anti-fog, anti-bacteria properties, and more.

The technology used is Flame Assisted CVD (FA-CVD), a relatively inexpensive method, whereby a precursor and a flame are used to deposit a transparent nano layer under atmospheric conditions on a substrate.

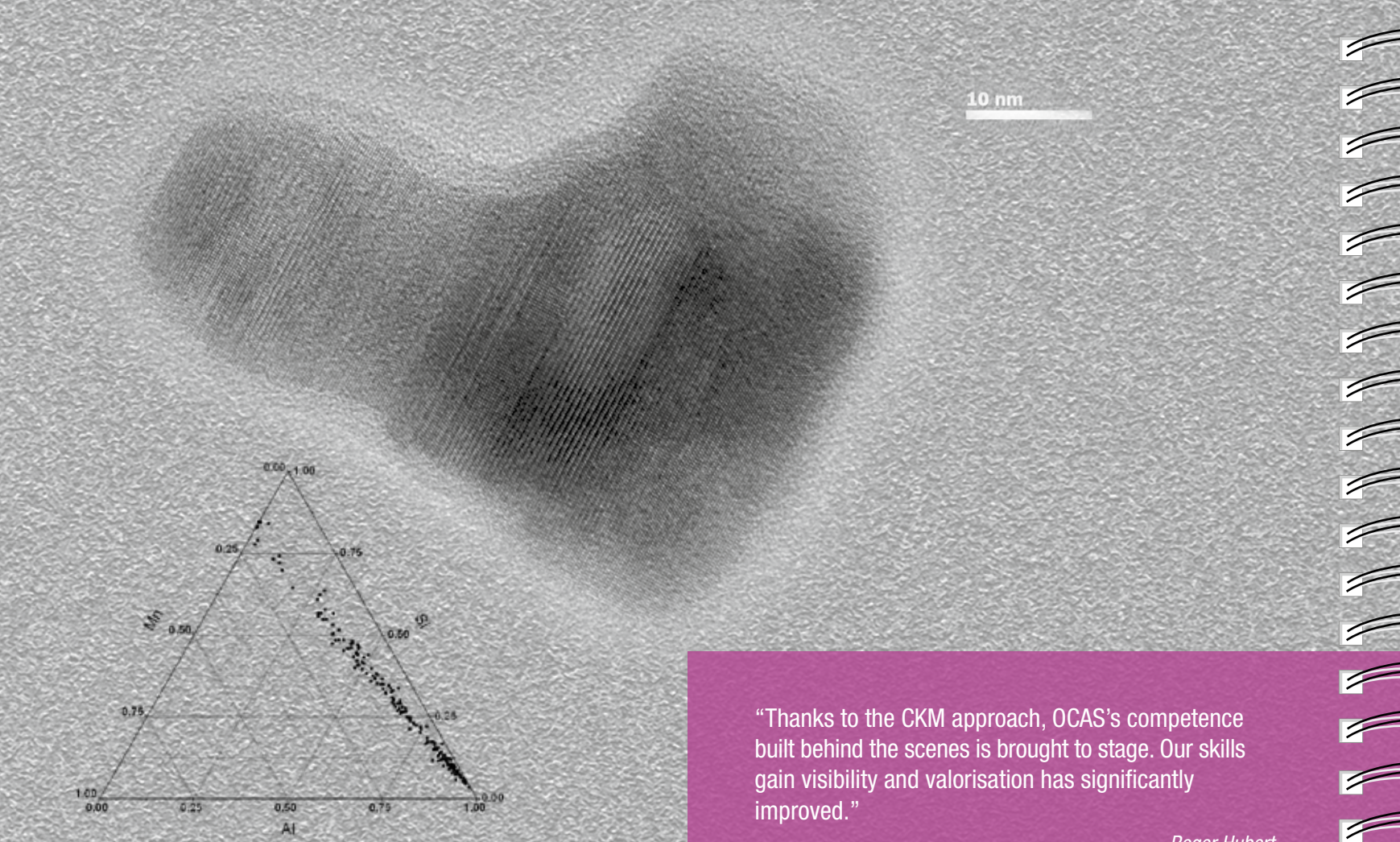
The R&D activity follows two tracks: a track on applying the technology on steel and a track on other materials. The project name for the non-steel track is called LANCAS – **L**arge **A**rea **N**ano **C**oatings developed by OC**AS**.

A key element of the project is that the team succeeded to obtain high quality layers at high speed (compatible with steel manufacturing processes and temperature sensitive substrates). These findings are the basis of a patent application.

A wide range of applications

OCAS is seeking to valorise the technology as well inside as outside the steel business. As they are now quite successfully applying the easy-clean coating to a variety of substrates – especially (transparent) polymers – the way is open to valorisation on a broader scope. The proof-of-concept phase has been completed, and OCAS is now starting pilot projects with several companies that are interested in implementing this technology in their production environments. When this has been accomplished with these first key players, the technology will be rolled out to a larger market.

For many industries, this is a very new technology to add functionality to their products and differentiate themselves from competition.



"Thanks to the CKM approach, OCAS's competence built behind the scenes is brought to stage. Our skills gain visibility and valorisation has significantly improved."

Roger Hubert

CKM - building competence behind the scenes

The value of a research centre, of course, lies in its competence. In 2010-2011, CKM – Competence, Knowledge and Methodology – was launched as a transversal activity programme within OCAS.

In the past, when a team worked on a project and needed a new tool or methodology, they went about developing it. However, at the end of the project, the development of the tool or methodology stopped too. Thus, its value was lost before OCAS had the chance to valorise it.

So, two years ago, as a result of the centre-wide strategic exercise, OCAS decided to introduce the CKM approach to attend specifically to these fundamental R&D activities. The development of competence, knowledge and methodologies was formalised and made visible and available to everyone in OCAS.

Supporting all projects

The first step was to identify OCAS's key expertise: that is, the domains that OCAS wants to develop further and that will continue even if certain projects are terminated. The company selected 7 domains of activity: precipitation; microstructure & phase transformation; mechanics of materials; surfaces & corrosion; measurement methodology & quality; modelling & simulations; process methodology. A committee approves the topics to be developed, and then each topic is assigned to the people in the company who are best placed to work on it. One example is the investigation of precipitates in steel, which serves all of the projects dealing with high-strength steels.

The search for solutions is conducted inside and outside OCAS: researchers study the things competitors are doing and review the academic literature. CKM also promotes benchmarking and round-robin tests (for example, participating in the analysis and validation of reference steel specimens).

Although two years is a short time to get a new activity up to full speed, the team already has some very good results. Most of the activities are not yet finalised, but they are on track, and the value they will add is already apparent. For example, one of the major achievements of this year will be the creation of an OCAS microstructure catalogue.

Another notable achievement: the European Synchrotron Radiation Facility in Grenoble, France, has selected CKM's proposal to conduct an analysis of the interface reactions between a steel substrate and a metallic coating. This project was chosen among submissions from all over Europe.

List of publications 2010/11

Papers published in Scientific Journals

Authors	Title	Journal	Reference
P. Gobernado, R. Petrov, **D. Ruiz, E. Leunis**, and L.A.I. Kestens	Microstructure and Texture Optimization in Fe-Si Ferritic Steels	Materials Science Forum	Vol. 638-642 (2010) pp. 2829-2834
J. Gautam, R. Petrov, LA.I. Kestens and **E. Leunis**	Surface Microstructure and Texture Evolution during Interrupted annealing in Ultra Low Carbon Steels	Advanced Materials Research	Vol. 89-91 (2010) pp. 202-207
P. Yan, **Ö. E. Güngör, P. Thibaux**, H. K. D. H. Bhadeshia	Crystallographic Texture of Induction-welded and Heat-treated Pipeline Steel	Advanced Materials Research	Vol. 89-91 (2010) pp. 651-656
P. Yan, **O. E. Gungor, P. Thibaux** and H. K. D. H. Bhadeshia	Induction welding and heat treatment of steel pipes: evolution of crystallographic texture detrimental to toughness	Science And Technology of Welding And Joining	Vol. 15 (2010) pp. 137-141
J. Gautam, R. Petrov , **E. Leunis** and L.A.I. Kestens	Surface Microstructure Evolution During Phase Transformation on Mn,Al and Si Alloyed Ultra Low Carbon Steel	Defect and Diffusion Forum	Vol. 297-301 (2010) pp. 757-763
L.A.I. Kestens, R. Petrov , P. Gobernado and **E. Leunis**	Texture Control in Non-Oriented Electrical Steels by Severe Plastic Deformation	Solid State Phenomena	Vol. 160 (2010) pp. 23-29
J. Gautam, R. Petrov, LA.I. Kestens and **E. Leunis**	Surface Microstructure and Texture Evolution during Interrupted annealing in Ultra Low Carbon Steels	Advanced Materials Research	Vol. 89-01 (2010) pp. 202-207
E. De Moor, **C. Föjer**, J. Penning, A. J. Clarke, and J. G. Speer	Calorimetric study of carbon partitioning from martensite into austenite	Physical Review B	Vol. 82 (2010)
F. Van den Abeele and T. Skocovsky	Enhanced Failure Criteria for Composite Crack Arrestors	Journal of Pipeline Engineering	Vol. Q1 (2011) pp. 57-69
K. Lejaeghere, S. Cottenier, **S. Claessens**, M. Waroquier and V. van Speybroeck	Assessment of a low-cost protocol for an ab initio based prediction of the mixing enthalpy at elevated temperatures: The Fe-Mo system	Physical Review B	Vol. 83 (2011)
D. Soccol, J. Martens, **S. Claessens** and J. Fransaer	Effect of Carbon Modification of Particles on Their Incorporation Rate during Electrodeposition	Journal of Electrochemical Society	Vol. 158 (2011) pp. 515-523
R. Shabadi, R. Taillard, B. Radiguet, J. de Baerdemaeker and **E. Leunis**	Effect of Mn on the Nanoprecipitation in Binary Fe-Cu alloys	Solid State Phenomena	Vol. 172-174 (2011) pp. 297-302
P. Yan, **Ö.E. Güngör, P. Thibaux, M. Liebeherr** and H.K.D.H. Bhadeshia	Tackling the toughness of steel pipes produced by high frequency induction welding and heat-treatment	Materials Science And Engineering - A - Structural Materials	Vol. 528 (2011) pp. 8492-8499

L. Bracke, N. De Wispelaere, H. Ahmed and Ö. E. Güngör	S700MC/Grade 100 in heavy gauges: Industrialisation at ArcelorMittal Europe	Revue De Métallurgie	Vol. 108 (2011) pp. 323–330
D. Kowal, L. Dupré, P. Sergeant, **L. Vandenbossche and M. De Wulf**	Influence of the electrical steel grade on the performance of the direct-drive and single stage gearbox permanent-magnet machine for wind energy generation, based on an analytical model	IEEE Transactions On Magnetics	Vol. 47(12) (2011) pp. 4781-4790
C.H.J. Gerritsen, S. Daneshpour, M. Koçak and S. Riekehr	Weerstands- versus laserpuntlassen	Lastechniek	(2011) pp. 18-22
Ö.E. Güngör, C.H.J. Gerritsen and J. Goudemez	Laserlassen S700MC. Invloed van voor- en nawarmen met inductie	Lastechniek	(2011) pp. 14-17
D. Soccol, C. N. Ngoy, **S. Claessens** and J. Fransaer	Influence of particle surface potential on electrocodeposition of BaSO4: a ζ-potential study	Electrochemistry Communications	Vol. 25 (2010) pp. 69-79
S. Coppieters, **S. Cooreman**, H. Sol, P. Van Houtte and D. Debruyne	Identification of the post-necking hardening behaviour of sheet metal by comparison of the internal and external work in the necking zone	Journal of Materials Processing Technology	Vol. 211 (3) (2011) pp. 545-552
S. Coppieters, **S. Cooreman**, P. Lava, H. Sol, P. Van Houtte and D. Debruyne	Reproducing the experimental pull-out and shear strength of clinched sheet metal connections using FEA	International Journal of Material Forming	Vol. 4 (4) (2011) pp. 429-440

Papers published in Conference Proceedings

Authors	Title	Conference
F. Van den Abeele and **P. Thibaux**	A Simulation Strategy to Ensure Pipeline Integrity	2010/04/19 - Hannover, Germany - Pipeline Technology Conference
E. Leunis and **L. Duprez**	Selecting hydrogen embrittlement resistant materials by means of the disc rupture test	2010/05/16 - Essen, Germany - WHEC 2010 - 18th World Hydrogen Energy Conference
S. Jacobs, **L. Vandenbossche**, T. Waeckerlé, F. Pottier, E. Attrazic, S. Paolinelli and D. Kajfos	Magnetic material optimisation for high frequency transformers: FeCo vs. FeSi alloys	2010/06/22 - Berlin, Germany - Coil Winding Expo + Inductica
Güngör Ö. E. and Goudemez J.	Characterisation of DP600 steel in terms of heat-affected zone (HAZ) softening	2010/07/11 - Istanbul, Turkey - International Institute of Welding - 63rd Annual Assembly and Conference
Gerritsen C.H.J., Güngör Ö. E. and Goudemez J.	The effect of in-line induction pre- or post-heating during laser butt welding on the mechanical properties of S700MC high-strength steel	
F. Van den Abeele, L. Amlung, M. Di Biagio and S. Zimmermann	Towards a Numerical Design Tool for Composite Crack Arrestors on High Pressure Gas Pipelines	2010/09/27 - Calgary, Canada - IPC 2010 (International Pipeline conference)
F. Van den Abeele, J. Bar and **S. Jakani**	Buckling and Unstable Collapse of Seamless Pipes and Tubes	
P. Thibaux and **F. Van den Abeele**	Influence of the Forming Operations on the Yield Stress Measured on Pipe	

Ö. E. Güngör, P. Yan, **P. Thibaux, M. Liebeherr**, H. K. D. H. Bhadeshia and D. Quidort	Investigations into the Microstructure Toughness Relation in High Frequency Induction Welded Pipes	2010/09/27 - Calgary, Canada - IPC 2010 (International Pipeline conference)
D. Ruiz Romera, M. Liebeherr, Ö. E. Güngör, D. Quidort and S. Ehlers	Development of X100 on coil and first weldability assessment	
Ö. E. Güngör, M. Liebeherr, D. Quidort	Welding Evaluation of 21.6 mm X80 Linepipe Steel from Coil	2010/10/21 - Sofia, Bulgaria - The 2nd South East European IIW International Congress
L. Vandenbossche, S. Jacobs, F. Henrotte and K. Hameyer	impact of cut edges on magnetization curves and iron losses in e-machines for automotive traction	2010/11/05 - Shenzhen, China - EVS25 Electrical Vehicule Symposium
F. Van den Abeele, J. R. De Oliveira Jr. and **F. J. Huertos**	Identification of the Complex Moduli of Orthotropic Materals using Modal Analysis	2010/11/17 - Paris, France - COMSOL Conference
F. Van den Abeele and **J. Vande Voorde**	Flow Induced Oscillations of Marine Risers with Wake Interference	
P. Goes and **F. Van den Abeele**	Electromagnetic Non Destructive Testing Techniques for Defect Sizing of Underwater Welds	
P. Legros	Improving the value of steel through UV curable coatings	2011/01/16 - Zelzate, Belgium - RTE Metal Coatings Seminar 2011 (OCAS)
F. Van den Abeele and M. Di Biagio	Design of Crack Arrestors for Ultra High Grade Gas Transmission Pipelines: Material Selection, Testing and Modelling	2011/02/16 - Gent, Belgium - Conference on Sustainable Construction and Design
F. Van den Abeele, M. Di Biago and L. Amlung	Design of Crack Arrestors for Ultra High Grade Gas Transmission Pipelines: Simulation of Crack Initiation, Propagation and Arrest	
F. Van den Abeele and J. Vande Voorde	Stability of Offshore Structures in Shallow Water Depths	
F. Van den Abeele and P. Goes	Non Destructive Testing Techniques for Risk Based Inspection	
T. Galle, W. De Waele, P. De Baets, **J. Van Wittenberghe, F. Van den Abeele and S. Jakani**	Influence of Design Features on the Structural Integrity of Threaded Pipe Connections	
F. Van den Abeele and J. Vande Voorde	Stability of Offshore Pipelines in Close Proximity to the Seabed	2011/04/04 - Hannover, Germany - Pipeline Technology Conference
D. Kowal, P. Sergeant, L. Dupré and **L. Vandenbossche**	Relation between electrical steel grade, active mass and efficiency in direct-drive permanent magnet synchronous generator for large scale wind energy application	2011/04/25 - Taipei, Taiwan, Province Of China - IEEE International Magnetics Conference-Intermag 2011
C.H.J. Gerritsen and T. Baaten	An evaluation of novel MIG/MAG and TIG variants for welding of thin section steels	2011/05/10 - Tisvildeleje, Denmark - Joining of Materials, JOM-16
D. van Hoecke, S. Jacobs, B. Weber and E. Attrazic	Advanced electrical steel characterisation of electrical machines subjected to high levels of mechanical stress: automotive traction	2011/05/17 - Berlin, Germany - Inductica 2011

M. Madani	XRF versus GDOES in steel industry applications	2011/05/17 - Luxembourg - CETAS 2011 - 8th Int. Workshop on Progress in Analytical Chemistry & Materials Characterisation in the Steel and Metal Industries
F. Van den Abeele and J. Vande Voorde	Coupled Eulerian Lagrangian Approach to Model Offshore Platform Movements in Strong Tidal Flows	2011/06/19 - Rotterdam, Netherlands - OMAE 2011 30th Int. Conf. on Ocean, Offshore and Arctic Engineering
P. Thibaux and **F. Van den Abeele**	Relationship between Charpy V-notch impact value and fracture mechanics toughness	
L. Moli-Sanchez, F. Martin, **E. Leunis** and J. Chêne	Hydrogen Transport in 34CrMo4 Martensitic Steels: Influence of Microstructural Defects on H Diffusion	2011/07/03 - Dijon, France - DIMAT2011 - Int. Conf. on Diffusion in Materials
L. Moli-Sanchez, J. Chêne, **E. Leunis**, F. Martin, L. Marchetti and M. Wery	Etude par thermodésorption (TDS) du piégeage de l'hydrogène dans des aciers martensitiques revenus	2011/07/11 - Lyon, France - Journées <Jeunes Chercheurs 2011>
S. Ng, M-L Abel, J.F. Watts and **J. Wielant**	The Surface Chemical Characteristics of Galvanised Steel Substrates	2011/09/04 - Cardiff, United Kingdom - ECASIA 2011
L. Moli-Sanchez, F. Martin, **E. Leunis**, J. Chêne and M. Wery	Hydrogen Behaviour In 34CrMo4 Martensitic Steels: Influence of Microstructural Defects on H Trapping and Embrittlement	2011/09/14 - Glasgow, United Kingdom - WHTC2011 - 4th World Hydrogen Technologies Convention
D. Kowal, P. Sergeant, L. Dupré and **L. Vandenbossche**	Temperature distribution for several material grades in direct-drive PM synchronous generators for 5 MW wind turbines	2011/09/18 - Kos, Greece - 20th Soft Magnetic Materials Conference
D. Pérez Escobar, M. Verhaege, **L. Duprez** and K. Verbeken	Study of the hydrogen traps in a high strength TRIP steel by Thermal Desorption Spectroscopy, X-ray Diffraction and Differential Scanning Calorimetry	2011/09/28 - Gent, Belgium - Steely Hydrogen Conference
L. Moli-Sanchez, J. Chêne, F. Martin and **E. Leunis**	H-embrittlement mechanisms in 34CrMo4 martensitic steels	
L. Duprez, M. Arafin, F. Van den Abeele, N. Bernier, D. B. Rosado, J. De Mey and V. Van Speybroeck	Constant Load Testing with In-Situ hydrogen Charging on Martensitic Ultra High Strength Steel	
T. Depover, D. Pérez Escobar, E. Wallaert, M. Verhaege, **L. Duprez** and K. Verbeken	In-situ mechanical evaluation of hydrogen embrittlement for TRIP, FB, DP and HSLA steels	
Ö. E. Güngör, M. Liebeherr and D. Quidort	Factors Affecting the Toughness of High Frequency Induction Welded Pipes	2011/10/12 - Antalya, Turkey - AWST 2011 - IIW International Congress on Advances in Welding Science & Technology
L. Vandenbossche, S. Jacobs, **D. van Hoecke,** B. Weber and E. Attrazic	New Electrical Steels for high performance traction motors	2011/10/26 - Brussels, Belgium - EEVC
H. Ahmed, C.H.J. Gerritsen and T. Baaten	Investigation of fatigue improvement techniques for welds	2011/11/21 - Gent, Belgium - BIL/NIL welding symposium
M. Liebeherr, Ö. E. Güngör, D. Quidort, D. Lèbre and N. Ilić	Development and Weldability Assessment of Heavy Gauge X80 Linepipe Steel for Spiral Welded Pipe	2011/11/28 - Araxa, Brazil - CBMM Welding of High Strength Pipeline Steels, International Seminar

OCAS team at the start of the 20th anniversary celebration

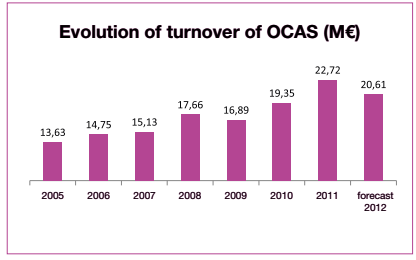
Fact Sheet

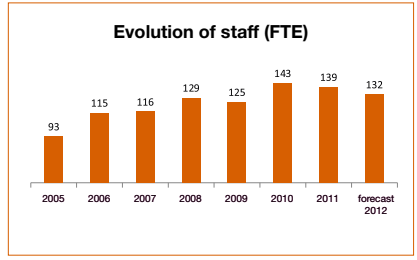
The graphs show the evolution of OCAS during the past years and forecast for 2012.

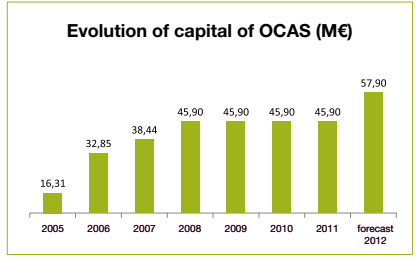
In 2011, OCAS celebrated its 20th anniversary and inaugurated the Metal Structures Centre at its Zwijnaarde facilities. Further synergies led to the kick-off of the collaboration agreement of the Materials Research Cluster. Today, the Materials Research Cluster is a partnership of OCAS, Belgian Welding Institute, CRM, Sirris, Strategic Initiative Materials Flanders, Flamac, Clusta and Ghent University.

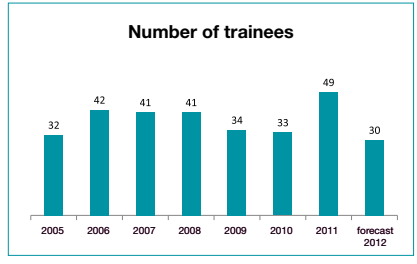
In addition, OCAS maintains and broadens its collaboration with numerous universities and institutes worldwide. In 2011, OCAS sponsored 18 PhD students in fields of metallurgy, coating and steel application research.

In September 2011, OCAS successfully organised the first edition of “Steely Hydrogen” at its Zwijnaarde facilities, the first ever European conference on the behaviour of hydrogen in steel. More than 120 participants from Europe and abroad attended the conference, all major steel producers and various end-users being present.









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OCAS is a joint venture between ArcelorMittal and the Flemish Region