compact steel
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the thyssenkrupp steel magazine
thyssenkrupp-steel.com

Mission Emission

Carbon2Chem® is a project for using CO_2 in a sustainable manner. The key to this technology is the extraction of hydrogen.

engineering. tomorrow. together.

thyssenkrupp

Contents

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Page 02-03: thyssenkrupp Steel (2), Ritam Banerjee, Marco Rothbarth

Andreas Goss reflects on...

sustainability

We strive to offer innovative products, technologies, and services that help people live sustainably all over the world. That is why we take a holistic approach to managing our value and production chains and consider economic, ecological, and social issues when making business decisions.

Major projects for environmental protection, emission savings in steel production, and the inclusion of people with disabilities are just a few examples of our commitment to sustainability. This comprehensive and dedicated approach – from occupational safety to production – has earned thyssenkrupp the highest award from the World Steel Association.

Once a year, businesses across the world are honored as Steel Sustainability Champions for their forward-looking ideas and measurable achievements with regard to sustainability. It makes us proud to be part of this group of companies. We are also very pleased that thyssenkrupp has been included in the Climate A List for the second time by the international NGO CDP (Carbon Disclosure Project), making us one of the leading companies in global climate protection.

The cover story of this issue introduces readers to one of our most ambitious projects: Carbon2Chem. We built a dedicated technology center in Duisburg to prove that CO_2 can be utilized as a raw material. This broad initiative combines basic and applied research with hands-on industrial know-how from various sectors. Together we want to improve the ecological profile of the steel industry to ensure that steel will continue to play a central role as a sustainable material in the future.

Yours sincerely,
Andreas J. Goss
CEO thyssenkrupp
Steel Europe AG

View

Russia is getting ready...

...to roll. When the World Cup starts on June 14, Kazan will be at the epicenter of the sporting world for a few weeks. The metropolis by the Volga – and the capital of the Republic of Tatarstan – lies some 800 kilometers east of Moscow.

The Kazan Arena has been Rubin Kazan's new home stadium for four years now and can accommodate just over 45,000 spectators. The stadium's imposingly curved roof, which slopes gently from the center of the two main stands to the seats behind the goals, consists of a total of 12,000 tons of steel.

Steel plays an important role in the design and construction of sports arenas. For example, material from thyssenkrupp in Duisburg was used in the unusual roof construction of the Schalke Arena in Gelsenkirchen. Our steel also provides for cooling in the form of air ducts – a rather important feature given the often heated atmosphere in the stadium. Our material even serves the players in the shape of the lockers in the changing rooms. There, it acts as a 'steel witness' to many a trainer's pep talk.

This will certainly also be the case during the six World Cup matches in the Kazan Arena. France and Australia will be the first teams to face off against each other on June 16. On June 27, the German national team will be here for their last group match against South Korea.

Photo: Reinaldo Coddou H.

Efficient revolution

The Steel division of thyssenkrupp has added a 0.35-millimeter variant to its powercore® portfolio of fully finished PP (poly-purpose) products. The special feature of re-annealable PP grades: The negative influences on the magnetic properties that occur during processing are significantly reduced by annealing individual stamped parts or a complete package at the customer. The PP grades are ideal for use in electric motors thanks to their higher polarization levels, lower core losses, higher yield strength, and annealing-resistant paint with a defined surface resistance. They thus meet the increasing energy efficiency requirements of automotive drive systems and are also suitable for hydroelectric power stations, turbines, and wind turbines.

Product details: www.thyssenkrupp-steel.com/en/powercore-pp

Research facility for lightweight construction

At the Open Hybrid LabFactory (OHLF) in Wolfsburg, steel manufacturers, mechanical engineers, suppliers, plastics suppliers, and scientists have been jointly developing hybrid components for mass production, especially for automotive engineering, over the past one and a half years. thyssenkrupp is involved as a steel producer and participates in OHLF by contributing innovative materials. Steel-plastic hybrids can be tested here and made ready for volume production. The lightweight construction campus is funded by the Federal Ministry of Science and Research.

30 million

metric tons of thin sheet has been produced in the high-tech tandem mill in Duisburg-Beeckerwerth since 2001. The plant is known for its extremely wide and thin, high-strength multiphase steels that are essential to lightweight automotive construction.

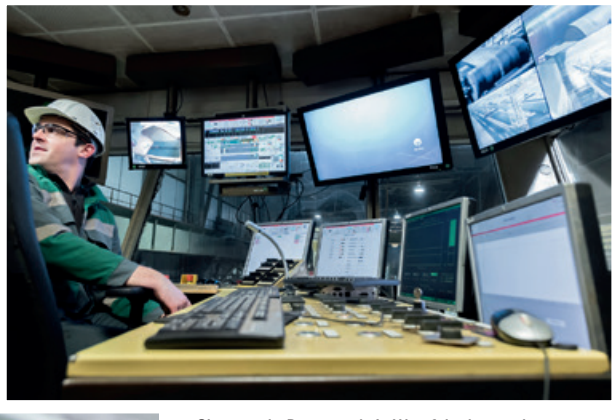
Cutting-edge pickling line

An investment of millions in Dortmund ensures higher quality and more flexibility. "Now we are back on the cutting edge in the pickling line," says team leader Björn Brüne. "Together with the conversion work we performed on the tandem mill, we can now pickle and roll a much wider range of materials."

Customers, too, benefit from this modernization as they get products with closer and more uniform tolerances. "The pickled surface is cleaner across the entire strip, despite reduced acid consumption and shorter cycle times." In short: Thanks to the new automation, customer requirements can be implemented quickly, cleanly, and individually.

But this investment wasn't just about quality. "Of course, as part of the

In cold rolling mill 3 at Westfalenhütte in Dortmund, the **pickling unit and tandem mill** have been modernized. The modern pickling and tandem line is now able to align its production of high-quality steel sheet even more closely to customer needs.



Changes in Dortmund: At Westfalenhütte, the pickling tanks are now made of plastic, and the water extinguishing system has been replaced. Furthermore, the entire plant technology has been upgraded.

conversion of the 130-meter long line, we also made sure that the units meet the latest safety requirements," says Brüne. As a result, the process design was fundamentally changed, and the five pickling tanks were made entirely of plastic. In addition, the steel substructure and the stacking containers as well as the pumps and heat exchangers were replaced. The plant was further equipped with new electrical and automation technology, and the welding machine, the coil transport, and the acid protection in the looping tower were refurbished.

In the course of modernizing the facility, the water extinguishing system also had to be renewed. "The modification of our pickling and tandem line allows more flexible operation of the unit and significantly enhances the quality of the products," says Dr. Andreas Igelbüscher, team coordinator in the cold rolling mill. "This represents clear added value for our customers." The plant mainly produces flat steel for car manufacturers and automotive suppliers.

This modernization helps to secure the future of the 45-year-old facility for the production of high-quality steel sheet. A similar unit - the hot strip pickling line at thyssenkrupp's Duisburg-South plant - was already modernized in early 2017.

For information on the automotive sector and innovations, visit this page: https://www.thyssenkrupp-steel.com/en/industries/automotivetrucks/automotivetrucks.html

thyssenkrupp Steel – I like it!

You can now stay up to date on what's happening in the steel sector on social media: thyssenkrupp's Steel division now has its own Facebook page. Enjoy the fun facts and interesting news, video clips, quiz questions, and many more things presented there.

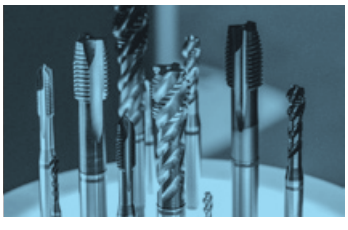
Friend us on
www.facebook.com/thyssenkruppSteel

Dates

June

Coilwinding/CWIEME 2018
19–21 June, Berlin

thyssenkrupp's Automotive and Electrical Steel business units will be showcasing products for the energy sector at the world's largest industry event for coil winding, insulation, and electronics assembly. The steel experts and more than 500 exhibitors from 40 countries will present electrical equipment, insulation systems and materials, the latest machines, products, and services for the coil winding sector.



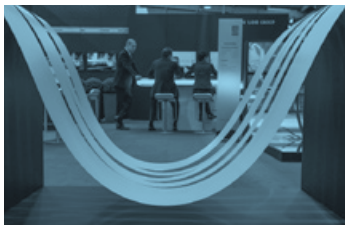
September

ALIHANKINTA 2018
25–27 September, Tampere/Finland

Key suppliers serving the electrical engineering, plastics technology, and metalworking sectors are getting ready to meet yet again in Tampere. The heavy plate segment of thyssenkrupp will be presenting high-strength and wear-resistant steels at the booth of its trading partner Flinkenberg.

Coiltech 2018
27–28 September, Pordenone/Italy

The trade fair for coils and windings is all about the production of electric motors, generators, transformers, and coil systems. thyssenkrupp's Steel division will be there to present its portfolio.



October

EuroBLECH 2018
23–26 October, Hanover

thyssenkrupp Steel will once again enrich Europe's largest sheet metal exhibition EuroBLECH with innovative solutions for industrial sheet metal processing. The focus is on production optimization, energy efficiency, innovation, sustainability, and the expansion of research and development.

Photos: thyssenkrupp Steel (3), PR (3)

Mission Emission

The **Carbon2Chem®** initiative aims to prove that CO_2 can be used as a raw material. Practical research is starting at a unique **technical center** at the thyssenkrupp Steel site in Duisburg.

Text Judy Born
Photos: Rainer Schroeer

Imagine if you could not only permanently reduce carbon dioxide emissions, but also make economic use of the carbon, oxygen, hydrogen, and nitrogen contained within them. Does that sound unrealistic to you? It doesn't to thyssenkrupp and 16 other partners from the fields of industry and research (including Siemens, Evonik, Linde, and the Fraunhofer Institute). Together, they have launched a large-scale research project, Carbon2Chem®, with the aim of converting gases released during the steelmaking process into base chemicals.

To test how this works in reality thyssenkrupp Steel has built a technical center at its Duisburg site that is directly connected to the gas pipelines of the integrated steel mill. It opened in April 2018, and the combination of basic research and industrial expertise is expected to produce initial results in September. Cleaning the steel mill gases is a key element of Carbon2Chem®. This task is being carried out by Linde AG, one of the world's leading firms in the field of plant engineering, and plant specialists from thyssenkrupp Industrial Solutions.

At the opening of the technology center we spoke with Dr. Andreas Frey, a development and process engineer at Linde, and Dr. Wiebke Lüke, Carbon2Chem® Project Leader at thyssenkrupp AG. As the Project Coordinator, Frey is responsible for the wide-ranging topic of gas treatment, while Lüke manages all related work carried out throughout the thyssenkrupp Group.

How would you explain what Carbon2Chem® is to a layperson?

Lüke: Essentially, Carbon2Chem® involves using steel mill gases from the melt shop, coking plant, and blast furnace to manufacture chemical products. We focus on using the CO_2 contained in these gases as a raw material.

> In the future, CO_2 should be seen as a raw material instead of a pollutant.

Dr. Wiebke Lüke, thyssenkrupp AG

Frey: Normally, you'd use the majority of these gases to produce energy and then release them into the atmosphere. We want to stop that with Carbon2Chem®; instead of releasing these gases, we want to convert them into chemical products.

Are these 'chemical products' more environmentally friendly than CO_2 emissions?

Frey: The key concept here is substitution. We can't do without chemical products if we want to continue using plastics in clothing, cleaning products, and other everyday items. But whether you choose to manufacture the chemicals for these plastics from oil or, as we're aiming to do, from components of steel mill gases, ultimately makes no difference in terms of the end product.

What kinds of chemical products are you talking about?

Lüke: Base chemicals that are all further processed after they're extracted. Here at the technical center, we're starting by using steel mill gases to produce methanol and ammonia. Methanol is contained in some cleaning products and can also be used as a fuel. Ammonia is further processed into substances such as urea, which is processed in turn to make mineral fertilizer.

Will Carbon2Chem® reduce our dependency on oil?

Lüke: You could say so, yes. We reuse the carbon that we inject into the blast furnace several times, which uses up fewer scarce fuel resources. Moreover, the chemical products that we produce are far more environmentally friendly than the ones made in the past. For example, we can manufacture oxymethylene ether, a diesel substitute that burns with less soot than conventional diesel does. However, switching to CO_2 only makes sense if the lifecycle analysis shows that this option is less expensive on the whole. That factor always needs to be taken into account.

Why is the Carbon2Chem® process so complicated?

Frey: The biggest problem lies in the fact that the steel mill gases we use contain not only the hydrogen (H_2), nitrogen (NH_2), carbon monoxide (CO), and CO_2 that we need for our chemical synthesis, but also a large amount of other components that damage highly sensitive catalyzers. On top of that, we work with three different types of gases: converter, blast furnace, and coke oven gas.

And that's where Linde comes in.

Frey: Yes. Gas scrubbing is central to the Carbon2Chem® initiative. If we don't manage to purify metallurgical gases

Inspecting the construction site: Andreas Frey and Wiebke Lüke check the gas supply lines in one of six lab rooms.

Supplementary measure: Water electrolysis is used to produce the additional hydrogen required for chemical syntheses (above).

Pneumatic post: The purified gas is transported in the research partner's lab rooms inside the technical center via numerous pipelines (below).

> “Gas scrubbing is crucial to the success of Carbon2Chem®.
>
> Dr. Andreas Frey, Linde AG

to such an extent that we get a pure synthesis gas at the end of the process, then the concept behind Carbon2Chem® will have failed.

That must pose an enormous challenge.
Frey: True. But ultimately, it's also why Linde is taking part in the project. This represents a unique opportunity to carry out trials with a complex real gas. From a technical standpoint, that would be virtually impossible to set up synthetically in the lab. When it comes to gas scrubbing, we often need to purify a synthetic gas with far fewer components to obtain pure hydrogen. When we work with a complex steel mill gas, though, we need to contend with 400 components or more.

And have you identified all of these components?
Frey: No, that figure was just an estimate. However, we do have experience with the key components and their behavior. As part of the Carbon2Chem® project, we apply this knowledge to gas purification in keeping with the 'best guess' principle. We want to demonstrate that we can purify steel mill gases despite their many trace components. Carbon2Chem® is a very large-scale experimental project, and everyone involved is contributing their experience. If we succeed, we can transfer this experience and expertise to other projects and therefore to other gas mixtures as well – since steel mill gases basically represent the most difficult kinds of gases to purify.

The steel mill gases you use come from three different sources. How do you divide up the purification tasks for these in the technical center?
Lüke: Coke oven gas purification is carried out by Linde, while thyssenkrupp Industrial Solutions purifies blast furnace and converter gases.

Are some of these tasks more important than the others?
Lüke: No, everything we do is of equal importance. Incidentally, hydrogen represents a key component. That's the substance we need the most of, but it's also the one that's the least available.

Exterior view: The gas scrubbing system lies at the core of the technical center (foreground). Water electrolysis is carried out in the reflections Pearl-coated shop behind the center.

People

Dr. Wiebke Lüke
studied chemistry in Oldenburg majoring in electrochemistry, then earned her daoctorate in fuel cell development from RWTH Aachen University. Afterwards, she headed the water electrolysis development department at the Jülich research center. Lüke has been responsible for managing the Carbon2Chem® project at thyssenkrupp since 2016.

Dr. Andreas Frey
studied chemical and biological engineering in Erlangen, then completed a doctorate in thermal process technology. He now works as a process engineer for adsorption systems at Linde AG. Within the scope of Carbon2Chem®, Frey is in charge of the entire gas scrubbing subproject, focusing in particular on the coke oven gas purification carried out by Linde AG.

How do you tackle that problem?
Lüke: In order to make use of the accrued CO_2 at the steel mill, we need more hydrogen than we're able to extract from the steel mill gases. That's why we generate additional H_2 using the water electrolysis process developed by thyssenkrupp Uhde Chlorine Engineers. This involves splitting water into hydrogen and oxygen using electricity. We use renewable energies to carry out water electrolysis.

Do you also use the steel mill gases to generate power?
Lüke: Yes, we do. As an integrated steel mill, we use the gases to supply ourselves and others with power and heat. Since we need to be able to guarantee this going forward, we've divided our systems into obligatory and optional consumers. At present, we're only using the portion of the steel mill gases that go into the power plant – where less effort is required to also generate energy from other sources.

And how do you do that?
Lüke: Using renewable energies. If, for example, we used lignite here, the concept underlying Carbon2Chem® would only be environmentally friendly to a limited extent. However, the problem that we have with wind and solar energy is that they are not constantly available. That being said, in our system we have good control of when and where energy will be used over the short term, and we're capable of relieving the load on the grid by always generating hydrogen when a lot of renewable energy is available. That way, we can help balance out the current profiles.

What quantities of electricity and steel mill gases are we talking about here?
Lüke: The Duisburg site needs about as much electricity each day as the city of Berlin. Here, we generate around two million cubic meters of steel mill gases per hour. That's enough to fill up the Gasometer in Oberhausen 150 times each day.

And what proportion of those gases goes to the technical center?
Lüke: Industrial Solutions purifies around 140 cubic meters of gases per hour from the

Adsorption system: Highly purified hydrogen is extracted from the coke oven gas.

converter and blast furnace, while Linde purifies around 100 cubic meters per hour from the coke oven. That's a tiny amount of the total volume, but it's a good amount for the pilot program to work with.

If Carbon2Chem® succeeds, will thyssenkrupp become a resource supplier?

Lüke: Yes, that's actually one of the main aspirations behind the program: In the future, CO_2 should no longer be seen as a pollutant, but rather as a raw material.

Frey: And beyond that, Carbon2Chem® has the potential to become a key technology for global climate protection. It can be used in steel production as well as in other emissions-intensive sectors.

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Figures for Carbon2Chem®

0.4
parts per thousand

is the amount of CO_2 in the air. Since it absorbs and re-emits some of the heat released from the Earth into space, it nonetheless plays a decisive role in influencing the planet's climate.

50
steel sites

as well as numerous related emissions-intensive sectors worldwide can use Carbon2Chem® technology and thereby make a significant contribution to climate protection.

44
percent

nitrogen, 23 percent carbon monoxide, 21 percent carbon dioxide, ten percent hydrogen, and two percent methane are contained in steel mill gas.

15
years

is how long it will take, according to experts' estimates, until the Carbon2Chem® technology can be applied in industrial practice.

16
partners

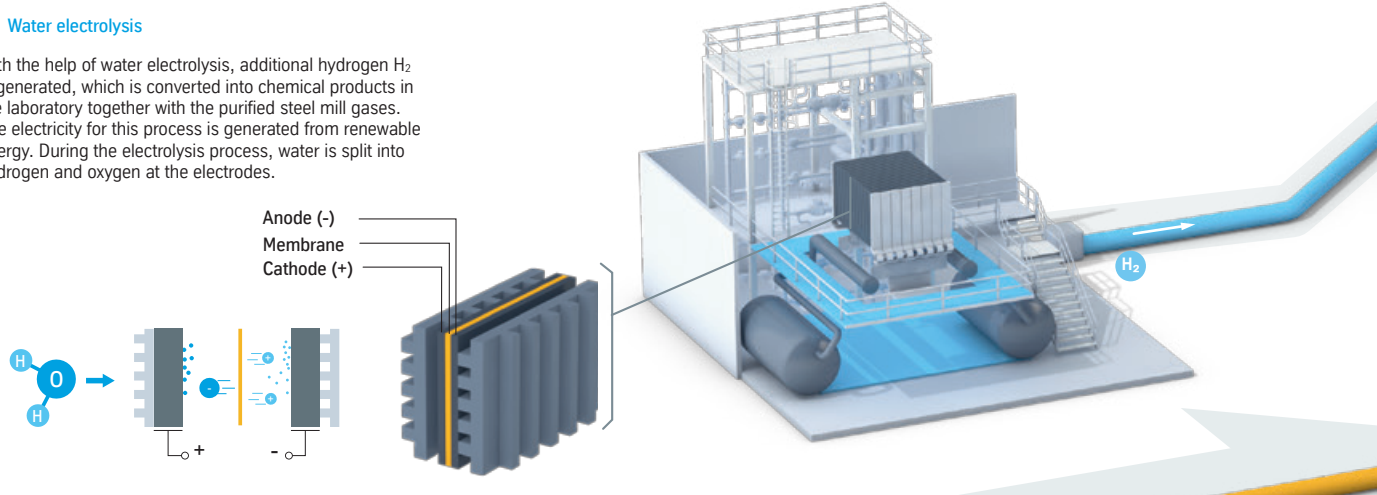
from the fields of industry, business, and science joined forces for the project, under the leadership of thyssenkrupp.

Launching the technical center

The **Carbon2Chem®** research project is pursuing the goal of utilizing the CO_2 contained in the gases released during steel production as a raw material for base chemicals. The first step is to clean the metallurgical gas.

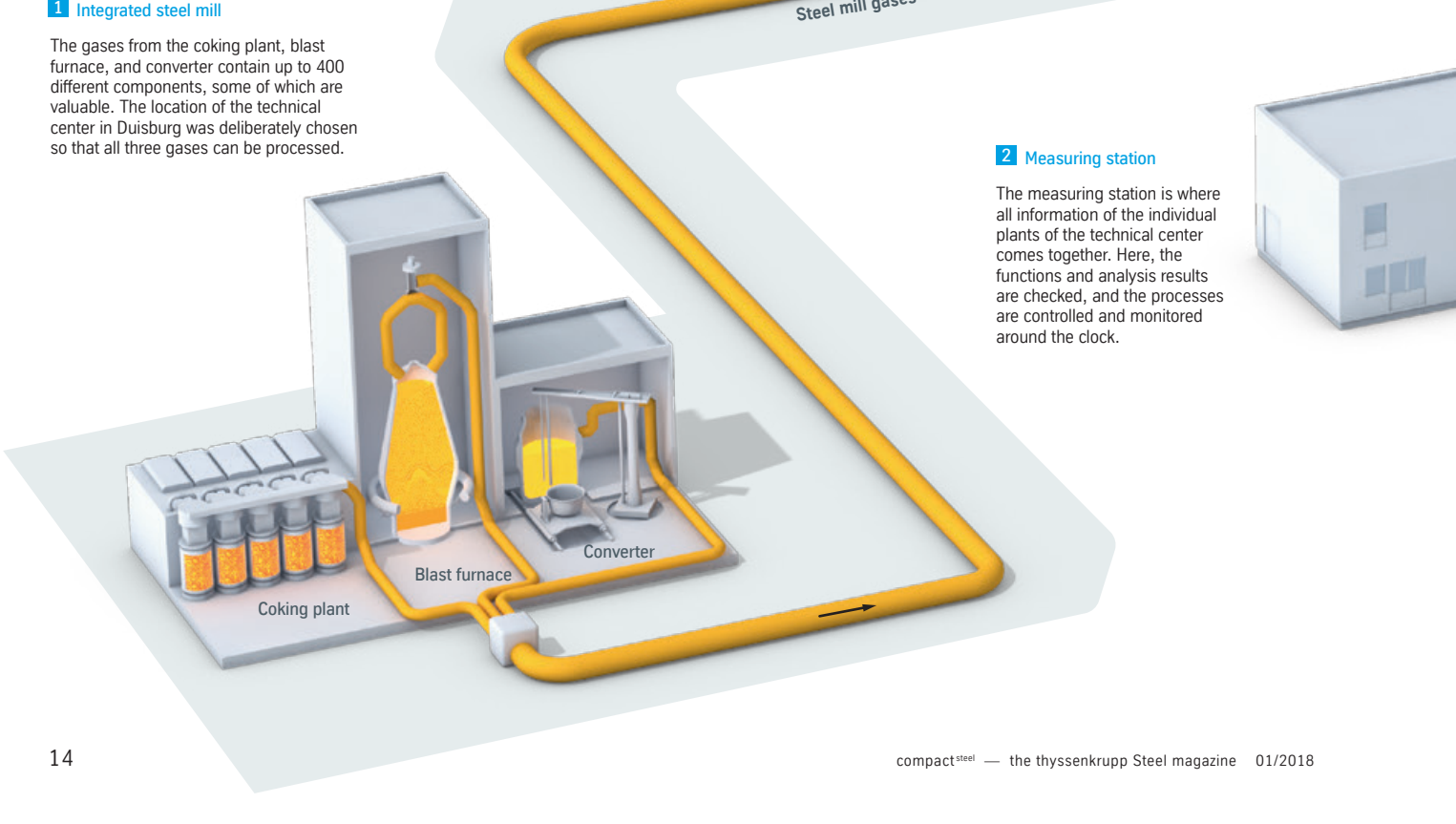
3 Water electrolysis

With the help of water electrolysis, additional hydrogen H_2 is generated, which is converted into chemical products in the laboratory together with the purified steel mill gases. The electricity for this process is generated from renewable energy. During the electrolysis process, water is split into hydrogen and oxygen at the electrodes.



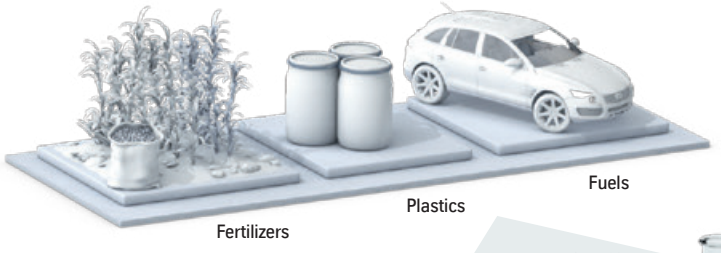
1 Integrated steel mill

The gases from the coking plant, blast furnace, and converter contain up to 400 different components, some of which are valuable. The location of the technical center in Duisburg was deliberately chosen so that all three gases can be processed.



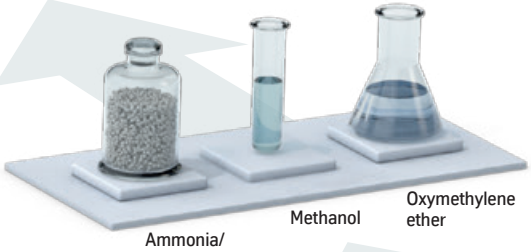
2 Measuring station

The measuring station is where all information of the individual plants of the technical center comes together. Here, the functions and analysis results are checked, and the processes are controlled and monitored around the clock.



6 Final products

The chemical products gained through Carbon2Chem are key ingredients in the production of items in strong demand across the globe.

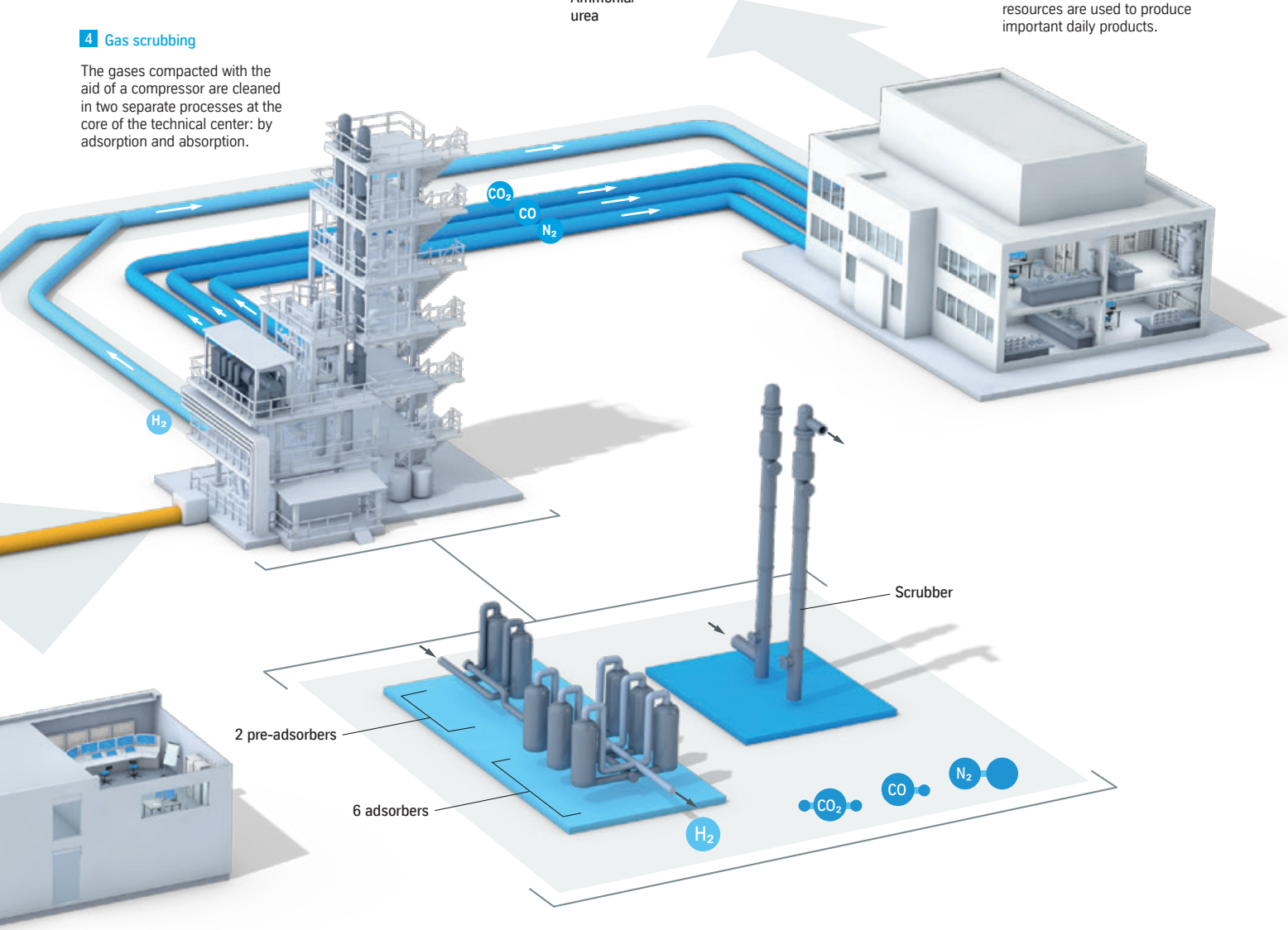


5 Lab

After gas scrubbing, the pure chemical elements H_2, CO, CO_2, and N_2 are fed into the laboratory and turned into ammonia/urea, methanol, and oxymethylene ether. These resources are used to produce important daily products.

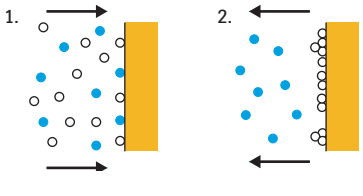
4 Gas scrubbing

The gases compacted with the aid of a compressor are cleaned in two separate processes at the core of the technical center: by adsorption and absorption.



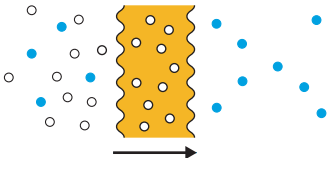
Adsorption

This task is completed by **Linde.** A pressure swing adsorption process is used to extract hydrogen from coke plant waste gases and process it to the highest purity. This is used in the technology center for the production of resources.



Absorption

This is the task of **thyssenkrupp Industrial Solutions.** The washing process removes undesired substances from blast furnace and converter gases. The remaining CO_2 is then turned into usable resources in the laboratory.



Graphics: C3 Visual Lab

Smart men, smart product: Dr. Thomas Flehmig (left) and Martin Kibben made significant contributions to the development of the new technology.

A smart innovation

Wouldn't it be fantastic to be able to reliably process **dimensionally accurate components** made from ultra-high-strength steel grades? The innovative **smartform®** method now makes that possible.

Text: Judy Born
Photos: Rainer Kaysers

According to statistics, 50 safety-relevant structural components are made each second, churning off the presses of European automotive manufacturers. Highly complex production steps that entail a host of challenges are carried out in the press plant, a crucial point in the automotive manufacturing process. To name one such challenge, the higher the strength of the material used, the greater the process-related springback. In the past, compensating for this effect required a great deal of effort.

But what if manufacturers could use a single tool for steel grades of strength classes ranging from 600 to 1,200 MPa to produce a dimensionally accurate components – without having to make any changes to the parameters or the tool itself? "Up until now, that's been impossible in the field of forming technology," says Martin Kibben, a development engineer at thyssenkrupp Steel's Duisburg location. Now, it's possible – Kibben and his colleagues in Applications Technology have succeeded in cold forming high-strength steels in a reliable, dimensionally accurate process. The patented technology that enables this is called smartform®.

This innovative method particularly solves the issue of springback. "High-strength steels generally act like springs," says Dr. Thomas Flehmig, head of the development team. "They can be formed, but sometimes they spring back significantly as soon as they leave the tool." This is an important effect to consider because even minimal changes to component geometry have an impact on further processing: "For example, in a car, each component is combined with other components, so the areas where they adjoin have to fit together precisely."

> "The smartform® method is highly robust, which is a big plus."
>
> Martin Kibben, Technology and Innovation, thyssenkrupp Steel

smartform® makes it possible to precisely produce even highly complex geometries from high-strength materials. "The goal of development was to support the automotive industry in reliably processing our newest materials," says Flehmig. "However, this technology can also be applied in other sectors." It essentially consists of two stages: manufacturing the preform and sizing to the final geometry. During the first stage, the steel sheet receives a component geometry that is as close to the final contour as possible, whereby the springback effect is fully tolerated. During the second stage, the preform receives its final contour. Inside the sizing tool, the future component is compressed in a targeted way, which compensates for any undesired springback. The tools for the smartform® method are compatible with all standard systems, and do not differ drastically from conventional equipment in terms of cost.

This technology, which is ready for volume production, also provides other advantages. "The process is highly robust, which is a big plus," says Kibben. "During conventional manufacturing processes, the system sometimes needs to be readjusted after a coil change, which can take a lot of time. smartform®, however, greatly reduces the influence of friction or material properties." Despite varying input and process variables, the result always remains constant. Moreover, smartform® not only saves customers time and money, but also material - in two ways. During the manufacturing process, the exact amount of sheet required for forming is used. Since, unlike with conventional deep drawing, the edge trim is eliminated to a very large extent, material consumption can be reduced by 15 percent on average, depending on the component's complexity.

Last but not least, this method even offers potential for lightweight design. The material benefits of high-strength steel grades are particularly important for the automotive industry; for instance, in the production of crash-relevant components. Up until now, these types of steels were not used in large quantities for complex geometries during cold forming, since the requisite process reliability could not be ensured. Flehmig says: "Thanks to smartform®, these components can now be produced from steels of the next-highest strength class and with a lower thickness."

smartform® technology stabilizes the manufacturing process, shortens system downtimes caused by disruptions, reduces material usage, and protects tools. It makes the impossible possible; namely, manufacturing dimensionally accurate components in various strengths with just a single set of tools.

Smarter manufacturing: smartform® is suitable for geometrically complex components.

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A breath of fresh air for electricity

Patented **TetraFlex®** technology can be used to build wind towers that are taller and more lightweight than their predecessors, and made **entirely of high-quality flat steel**.

Text: Judy Born
Photos: Rainer Kaysers

New tower design: The base made of spiral welded tubes enables the construction of taller wind turbines. The higher the tower, the larger the rotors that can be used, which in turn increases capacity.

Wind power can be generated in many places around the world; it represents a virtually unlimited and thereby sustainable, ideally renewable source of energy.

On average, most wind towers currently in place are between 70 and 100 meters tall. thyssenkrupp Steel has now developed a steel design, TetraFlex®, that can be used to erect wind turbines with heights of over 150 meters. Scaling the tower, rotor, and turbine allows for a significantly higher energy yield to be realized.

This new design replaces conventional wind tower design with a modern, reduced-weight lattice structure, and consists of spiral welded tubes that can be used to construct wind towers entirely from high-quality flat steel. Three pylons with a diameter of approximately 1.5 meters each constitute the load-bearing elements. In the center of the structure, a pylon approximately 2.5 meters in diameter enables maintenance access to the nacelle with the generator. “This intricate design makes the tower around 20 percent lighter and therefore less expensive than previous structures,” says Dr. Lothar Patberg, Head of Innovation at thyssenkrupp Steel.

Another advantage is that the tower can be created in individual segments and easily transported, independently of its final overall height. “The structure is designed in such a way that as much of it as possible can be pre-manufactured

in assemblies," says Stefan Mayer, who has overseen the development of TetraFlex® in the Innovation department from the outset. "At the construction site, you just need to bolt the segments together." The structure is also fully recyclable, in case dismantling is required.

Chinese steel manufacturer Ansteel has served as the ideal partner for constructing the prototype. Together with this state-owned company, thyssenkrupp Steel has been running the joint venture Tagal for 15 years, which supplies the Chinese automotive industry from its hot-dip galvanizing lines. At its Ba Yuquan location in the northeast of the China, Ansteel generates electricity using its own wind turbines, among other sources. "When they were planning a new expansion and learned about our TetraFlex® concept, they were immediately interested," says Klaus Kottkamp, Application Consultant at thyssenkrupp and Project Manager for the prototype. "That was really serendipitous, since we'd been working together with them for years, and mutual trust was already in place. At their site, we can produce and assemble the segments and then provide the proof of concept."

China is not only the world leader in generating wind power, but also in expanding capacities for generating renewable energy. What's more, the nation also wants to increase its future production by 25 gigawatts each year. "As a result, over the next few years, China will install around 12,000 new wind turbines per year," says Dr. Yu Sun, Head of Regional Business Development. In order to improve cost-efficiency in this area, the market demands structures that use as little material as possible. At the same time, the towers need to be higher yet easy to transport. "The higher you go, the greater the wind speeds," says Sun. "Moreover, higher up, the wind is more constant, which allows more electricity to be continuously generated."

thyssenkrupp partner Ansteel plans to exchange a 70-meter tower at its facilities with a 150-meter TetraFlex® model. Kottkamp says, "Building this TetraFlex® prototype enables us to make direct comparisons with existing systems so that we can gain valuable findings about the energy output this technology yields." In addition to providing information about efficiency, the prototype will also provide data on manufacturing, assembly, and maintenance.

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Flying high (from left): Stefan Mayer, Dr. Lothar Patberg, Klaus Kottkamp, Jia-Uei Chan, and Dr. Yu Sun are ensuring greater energy output with TetraFlex®.

Graphics: C3 Visual Lab

Shedding weight

Vehicle body panels can now be manufactured as thin as 0.55 millimeters thanks to a **new dual-phase steel**.

Every gram counts. The weight saved in a car has a real impact – no matter how small. It affects fuel consumption, pollutant emissions, and production costs. Lightweight construction is therefore one of the most important topics for manufacturers and their suppliers.

The task has not become any simpler for them over time: "Initially, innovations from one generation to the next made it possible to save several kilograms, but modern car bodies are usually at such a high level that the research that goes into shaving off a single kilogram has become much more complex," says Dr. Volker Smukala, who works in product management for coated products at thyssenkrupp Steel. It is therefore no exaggeration to speak of a major achievement when suddenly one kilogram of material is saved in one part alone – and there are potentially four such parts in each car: the doors. This radical saving is made possible by a new product from thyssenkrupp Steel: DP-K® 290Y490T dual-phase steel.

Thanks to this product, the panel can be made in a thickness of only 0.55 millimeters – and this even includes a hot-dip galvanized or zinc-magnesium protective coating. Importantly, the lower thickness does not result in a loss of stability. "We have succeeded in increasing the strength, i.e. the stability of the material," says Smukala. "This means that our customers can achieve the same component stability with lower sheet thicknesses and thus lower weight."

Slim line production

In the past, dual-phase steels were generally not suitable for use in vehicle panels. But thanks to the new, slim line and innovative coating options, it has now also become an attractive option for the automotive industry. Recently, DP-K® 290Y490T with a hot-dip galvanized coating has become ready for volume production. The material is thus now being produced and offered as a standard product.

Several manufacturers have started to test the product, which is not only suitable for doors, but can be used for the entire outer paneling, including hood, roof, tailgate, and fenders. Besides its low thickness, the second major advantage of dual-phase steel is its coating. For the first time, it is now possible to produce this steel with a hot-dip galvanized or zinc-magnesium coating. Together with electrolytic galvanizing, the weight-saving, ultra-thin sheets can now be integrated into any corrosion protection concept without putting a blemish on the overall appearance. Zinc-magnesium coatings offer particularly big advantages. "Our ZM Ecoprotect® quality level offers significantly improved corrosion protection, especially for the very sensitive cutting edges, and reduces abrasion during component manufacture in the press plant," says Smukala.

It also helps conserve resources and thus goes easy on the environment, as it requires about 30 percent less zinc than a traditional zinc coating. Therefore, DP-K® 290Y490T meets the objectives of lightweight construction both for the steel itself as well as for the coating.

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A new twist

The Packaging Steel business unit has developed a new, high-quality, **low-earing packaging steel** for the production of particularly thin-walled screw caps.

There are some things that we believe will never change. Lug caps, for example, as are commonly used for juice bottles or cucumber jars. However, the Packaging Steel business unit is never satisfied with the status quo. As a technology leader for packaging steel, the Andernach-based company is constantly researching new material properties and production processes.

The latest innovation from the thyssenkrupp tinplate experts is rasselstein® Ultra-Low-Earing Steel, which is particularly well suited for the production of such lug caps. rasselstein® Ultra-Low-Earing Steel is an exceptionally homogeneous and isotropic steel. This means that the tinplate always reacts in the same way to the most varied loads from different directions when being processed into a lug cap. This avoids unwanted earing and uneven wall thicknesses. But what exactly does 'earing' mean? Earing is a distortion effect that occurs during deep drawing, i.e. the process used to turn packaging steel into the specific shape of a lug cap. It creates a wavy edge at end of the deep-drawn part. However, a straight closure is essential for downstream processing:

> "Packaging steel will expand its role as an environmentally friendly product.
>
> Stephan Schiester, Development Engineer at Materials Technology, Packaging Steel

"Caps with earing will always get stuck somewhere: for example on the tools or later during transport," says Stephan Schiester, development engineer in the Materials Technology department at Packaging Steel. "A low earing level is therefore much more efficient, as it ultimately saves material and thus valuable resources." Another benefit of rasselstein® Ultra-Low-Earing Steel is that is allows for producing thinner-walled caps. "When trying to attain the same low thickness with conventional material, this will result in a noticeably poorer lug cap quality and thus a higher reject ratio," explains Schiester. There are even certain caps that cannot be produced without low-earing steel, in particular lug caps with small diameters and high cup walls. "You simply need a material that delivers a high degree of homogeneity and isotropy." rasselstein® Ultra-Low-Earing Steel has yet another advantage: The innovative steel also improves the quality of tensile pressure on deep-drawn cans. The new product is very popular with customers.

The new material is also successful within the company: rasselstein® Ultra-Low-Earing Steel took second place in the Steel Tomorrow award, with which thyssenkrupp annually honors the steel innovations of its employees. "Of course, it helps to have the entire production chain in front of our eyes and to collaborate with our colleagues at thyssenkrupp Steel in Duisburg in the area of research and development," says Schiester. "These and many other innovations will of course contribute to further expanding the role of packaging steel as an environmentally friendly and efficient product in the future. A development that also benefits the environment and thus all of us.

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Precision all the way

The Precision Steel business unit is highly specialized in the production of **hot-rolled steel strip.** It has received numerous awards in recognition of its **Industry 4.0** solutions.

Text: Judy Born
Photos: Rainer Schroeer

The way to Hohenlimburg leads along the Lenne, a tributary of the Ruhr. To the left and right rises a densely wooded, hilly landscape, which rests on a foundation of natural limestone rocks. Here, where the Ruhr Region and the Sauerland meet, space is scarce, especially for commercial premises. And yet numerous companies – including thyssenkrupp Steel's precision strip specialists – are headquartered in the Hagen district.

Hohenlimburg precision strip is produced in widths of up to 720 millimeters and thicknesses from 1.5 to 16 millimeters. It can be supplied in coil sizes of up to 20.5 kilograms per millimeter of strip width, down to batch sizes of a single coil as required. "For us, the focus is clearly on single coil production," says Matthias Gruß, technical customer consultant at the Precision Steel business unit. "Because we produce a narrower product, the rolling stands can exert greater pressure, allowing us to roll even high-strength materials with extremely close tolerances and very homogeneous material properties. Customers can choose between pickled, unpickled, or annealed materials, which is slit or cut to length in line with customer requirements or supplied with mill edges free of work hardening.

Most of the grades produced in Hohenlimburg are sold to the cold rolling industry or directly to automotive suppliers. Gruß continues: "According to our estimates, around 85 percent of our material ends up in cars." The application range includes shift forks for transmissions, clutch springs, brake pistons, vibration dampers, airbag components, axle

Along the precision strip line: The cooling section (top left) ensures, among other things, the mechanical properties. The finishing train (top right) consists of two two-high and seven four-high stands.

Talking shop with colleagues: Matthias Gruß and Dr. Anastasia Höhne in the Hohenlimburg showroom.

> “According to our estimates, 85 percent of our precision strip is used in cars. It’s everywhere, except for the car body.”
>
> Matthias Gruß, Precision Steel business unit, thyssenkrupp Steel

tubes, and backrest adjusters for car seats. “Our precision strip is found throughout the vehicle – with the exception of the body.”

Between 25,000 and 30,000 metric tons of slabs can be stored on site in Hohenlimburg, despite the cramped conditions. Approximately the same amount of material is delivered to customers every week. They also have a say in the final characteristics of the materials. “Our customers can request us to roll out a specific slab at short notice,” says Dr. Anastasia Viviana Höhne, a product developer in Hohenlimburg who designs new steel grades. “Our rolling programs are much smaller and cover a wider grade portfolio than the steel mill in Duisburg. This allows us to be extremely flexible.”

What makes the production process in Hohenlimburg even more agile is the fact that it digitally integrates the customers. This allows them to view the progress of an order and stock levels, and influence the production of the starting material and scheduling. “We plan the casting programs based on customer orders and pass them on to HKM, Hüttenwerke Krupp Mannesmann, in Duisburg,” says Gruß. The company recently received an award from Focus Money magazine for this Industry 4.0 solution.

To complement its range of mild, unalloyed steels, microalloyed, low-pearlite fine grain steels, alloyed carbon steels, and numerous other grades, the Hohenlimburg-based company has recently added bainitic steels to its portfolio. This is a relatively young steel group whose first generally applicable standard was only published in 2015. Precision Steel’s HBS steel is available in mid- to high-level strengths: HBS 600, HBS 800, HBS 900, and HBS 1,000. These grades are ideally suited for the low-weight production of high-strength chassis and structural parts, which includes many crash-relevant safety components. The infographic illustrates how the Hohenlimburg company rolls its special precision strip. Take a peek over the shoulder of our steel experts…

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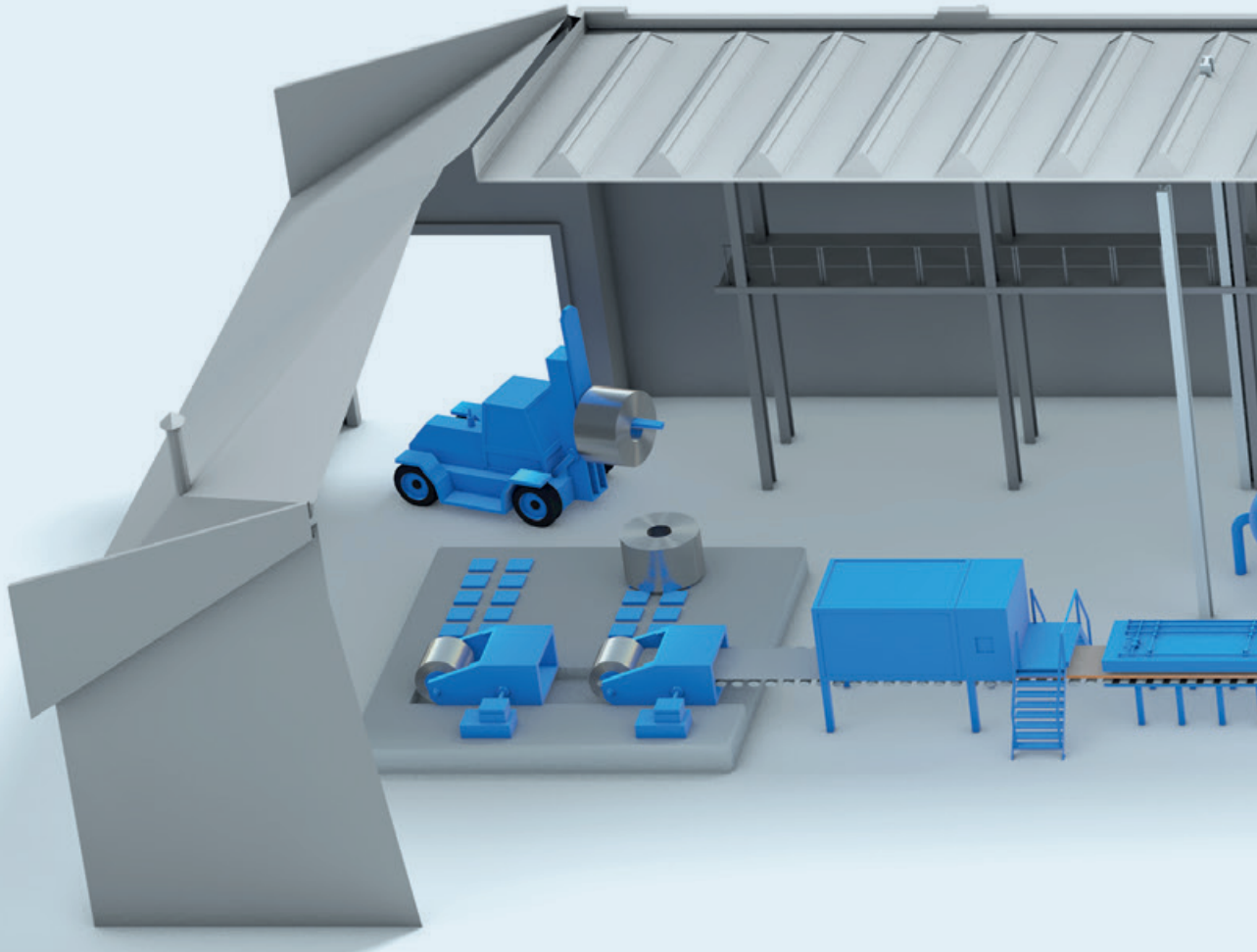
Hohenlimburg precision strip – pr



The Precision Steel business unit employs a state-of-the-art rolling mill to produce hot-rolled strip with special material properties and extremely close manufacturing tolerances. All processes are fully automated and are controlled and monitored by digital systems.

Coiler

Measuring station

Coiling and dispatch

At the end of the production process the strip is wound into coils on our state-of-the-art coiler. After an intensive quality inspection the coils are dispatched tocustomers for processing.

Cooling an

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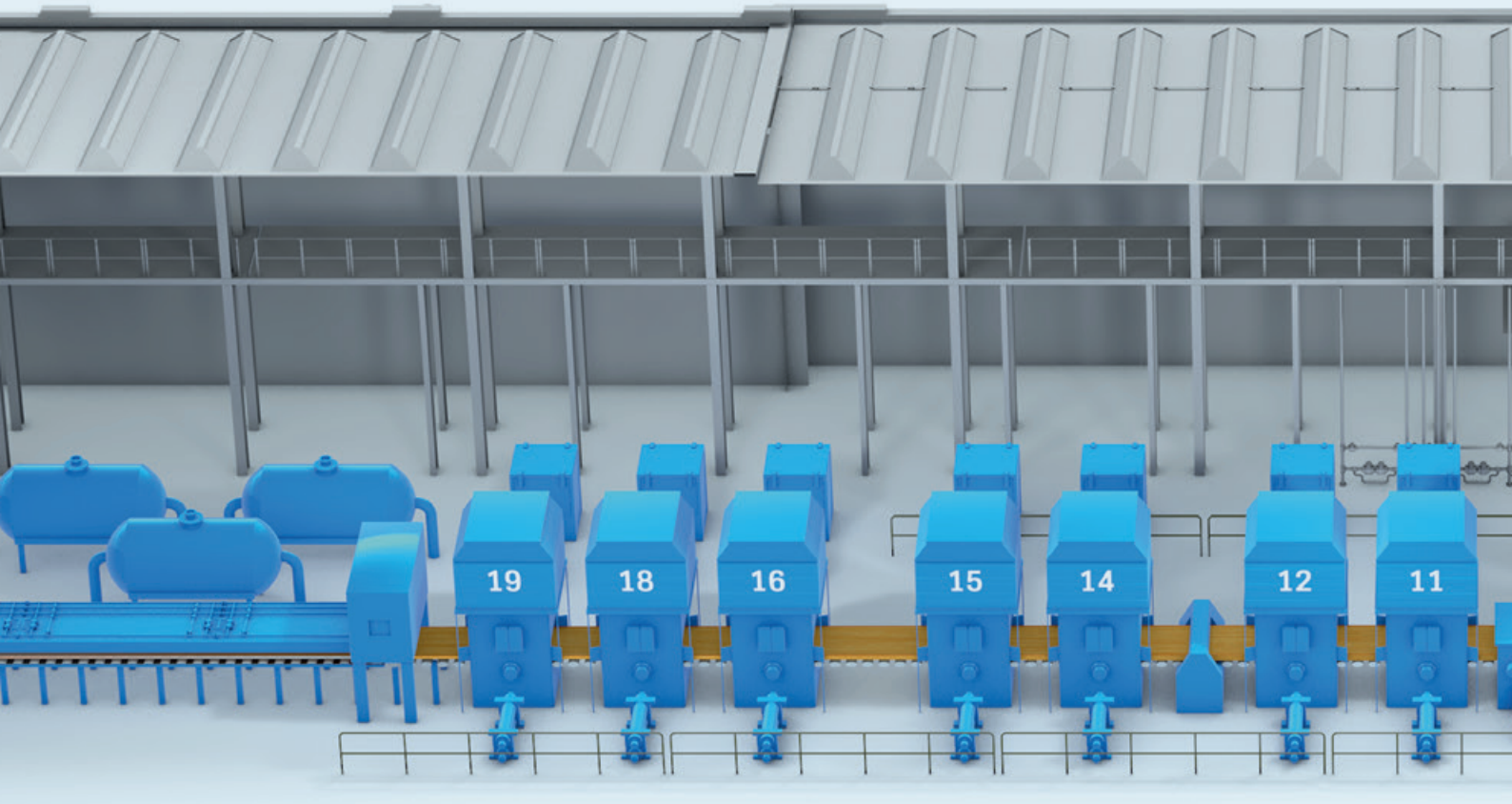


Laminar cooling section

Finishing mill/four-high stands

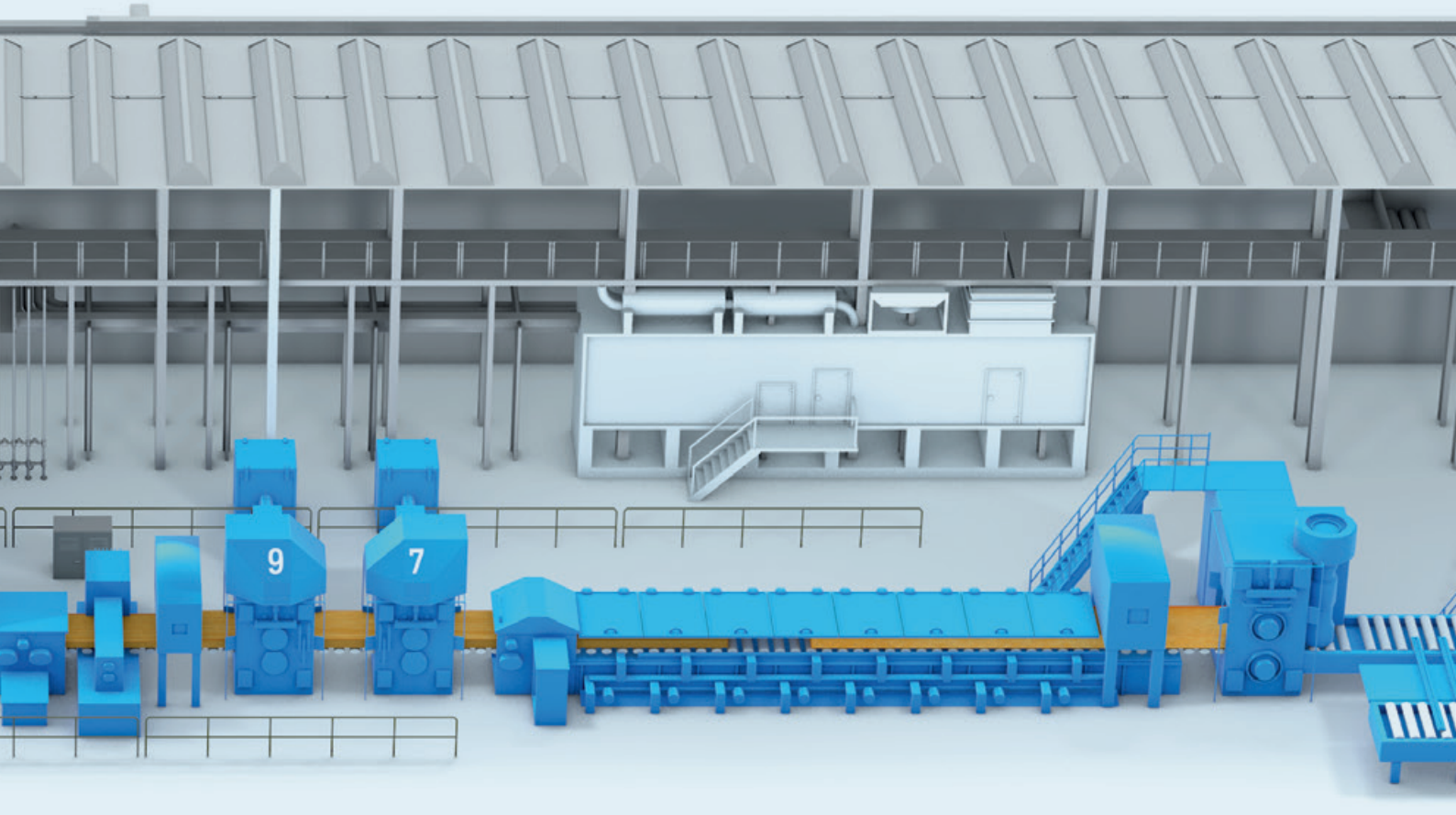
d checking

rip passes through the **laminar cooling** cision measuring devices record the strip r quality inspection purposes. A further tation checks the further strip process lownstream from the process-controlled section. This ensures that quality deviations fied and eliminated directly.

Rolling into shape

In the **finishing mill** seven fully automated rolling stands reduce the roughed strip as required. The premium precision strip now meets the specifications requested by the customer. The result is hot strip with close tolerances and special material properties – our precision strip.

eets the most demanding requirem



Edger 10/ cropping shear | Intermediate mill/ two-high stands | Edger | Ecopanel | Measuring station | Roughing mill

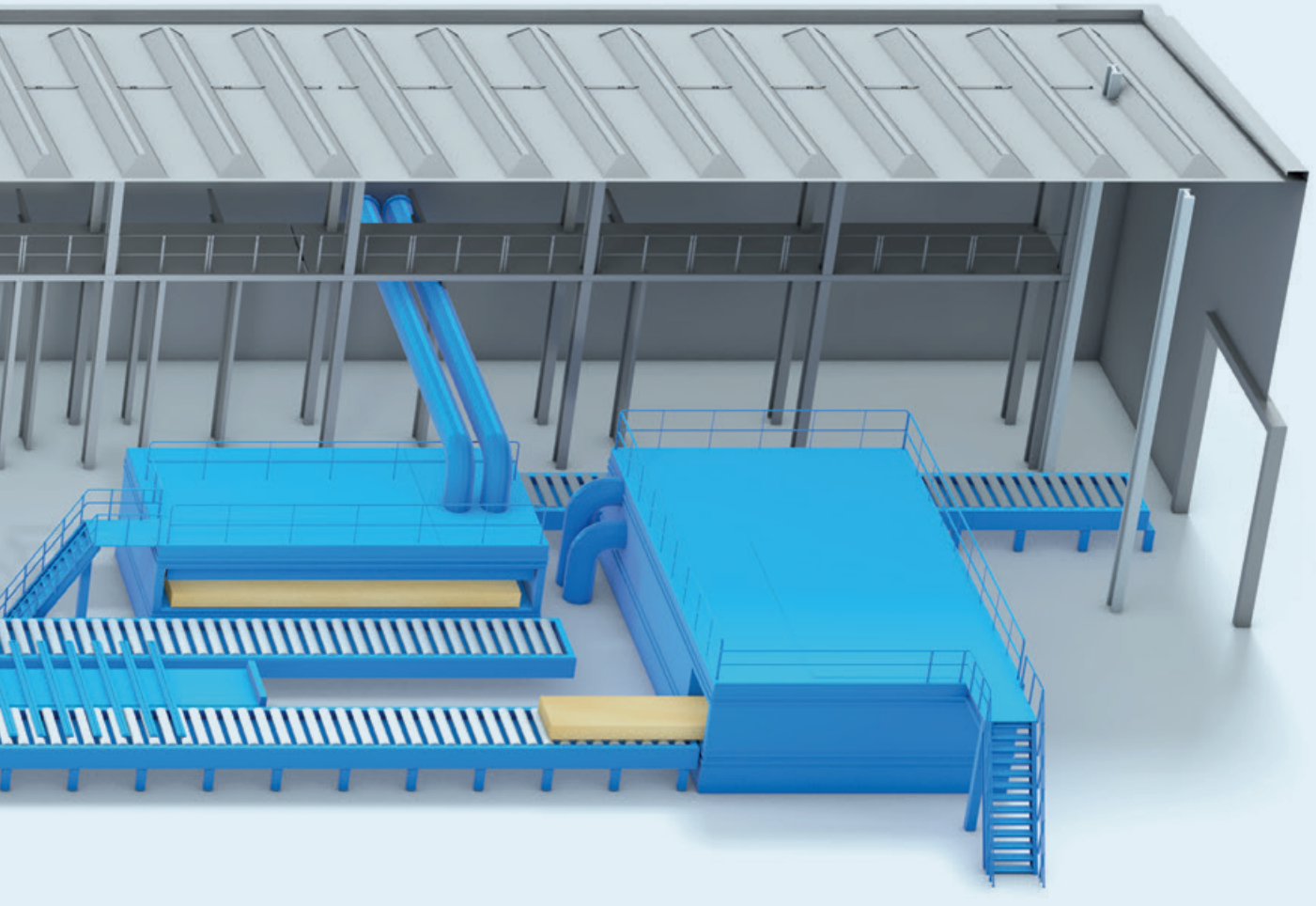
Preparation for the finishing mill

To enable precision processing of the strip in the subsequent rolling process the temperature must remain stable from beginning to end. This is ensured by a **thermotunnel (Ecopanel)** upstream from the finishing mill. The **intermediate mill** and **edgers** prepare the roughed strip for the final rolling process, matching the strip closer to the final thickness and width. Before the strip passes through edger 10 into the finishing mill the **cropping shear** cuts the start and end of the roughed strip to ensure it is straight.

Preformed

In the roughing mill reversing rolls forn slab into roughed strip in the first stag forming process. The roughly 10 m lo 250 mm thick slabs are rolled into app 60 m long and 50 mm thick roughed s In the **measuring station** the data fro forming steps are recorded and sent t process computer for evaluation.

ents



Skid transfer

Two walking beam furnaces

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Highly efficient

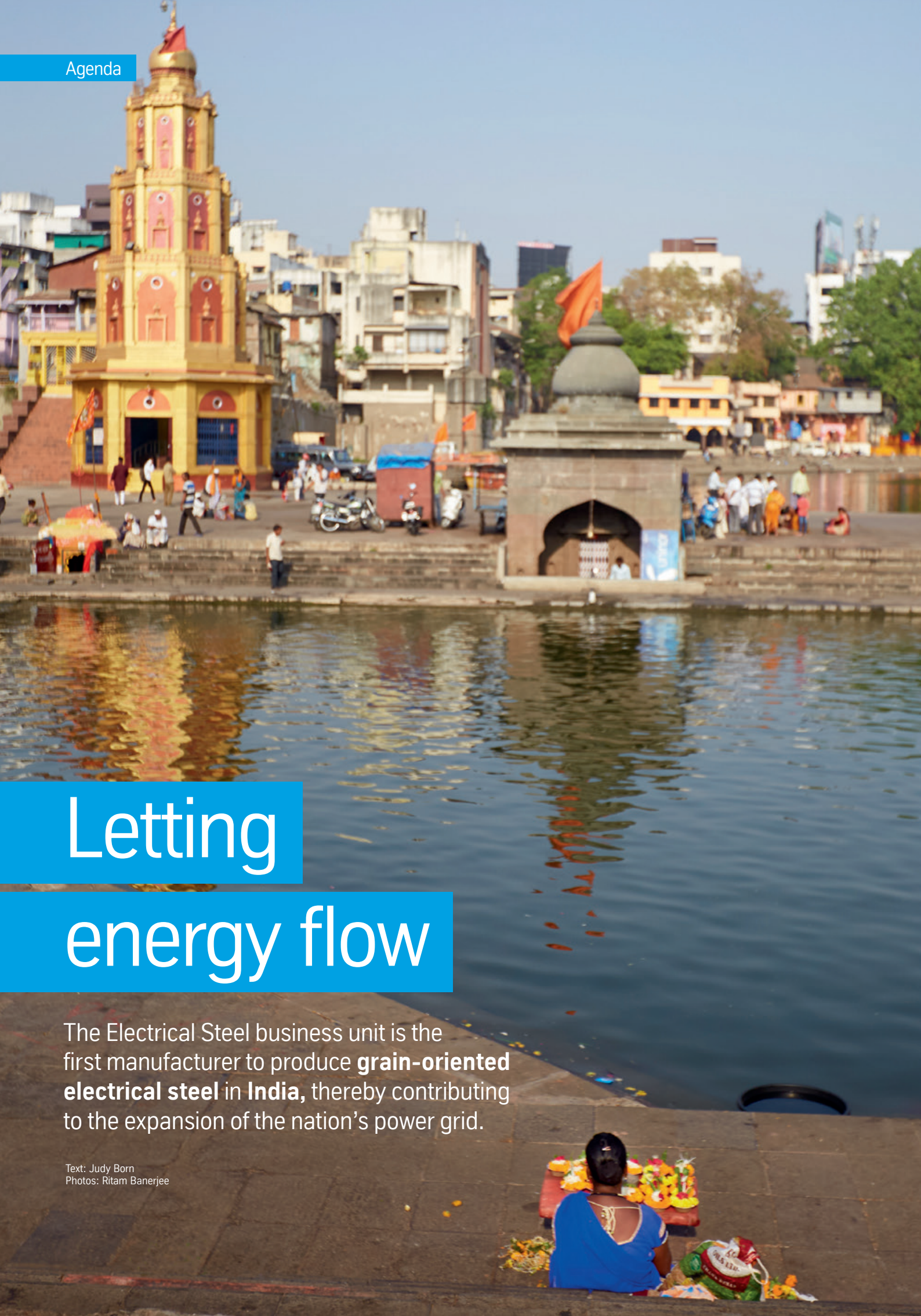
The two **walking beam furnaces** heat up the slabs in an energy-efficient process designed to protect the surfaces.

Getting the material on track

The roller tables and the **skid transfer** transport the slabs heated to approximately 1260 °C to the roughing mill.

Length: 300 m

Graphics: C3 Visual Lab



Letting energy flow

The Electrical Steel business unit is the first manufacturer to produce **grain-oriented electrical steel** in **India,** thereby contributing to the expansion of the nation's power grid.

Text: Judy Born
Photos: Ritam Banerjee

Spiritual energy: All kinds of offerings (upper left) are made at the many temples of Nashik (bottom left).

A cause to celebrate: Kesava Venkatesan (pictured below to the left) and Dr. Jens Overrath successfully realigned the Indian location.

It's early morning, but it's as hot and sunny out as it would be in Germany at noon in high summer. Along the fortified banks of India's Godavari River, in the ancient city of Nashik, a spectacle uncustomary to Western eyes is playing out: People are silently sitting alone and in groups, deep in meditation. Women in long garments are doing their laundry in the cloudy water, then laying it out to dry on the steps behind them. Children are laughing and jumping through the river as adults wash their dishes in it.

Nashik is located around 160 kilometers northwest of Mumbai, and it is one of the most important Hindu sites. Like several other Indian rivers, the Godavari is considered holy; its waters are believed to free people from all evils. For this reason, the Kumbh Mela festival, which takes place at one of four varying locations every three years, is a local highlight. Moreover, every 12 years, Nashik hosts festivities that attract millions of Hindu worshippers. They travel here to commemorate the god Shiva; according to legend, he once washed away his sins in Ramkund, the city's central bathing ghat.

Modern India seems worlds away on this morning, yet it's only a few kilometers off: Nashik is not only an important historic and religious site, but also an industrial hub that's continuously expanding in all directions. Moreover, it is home to one of the subcontinent's largest wine-growing regions. Thousands of national and international companies of various sizes and belonging to various industries are based in Nashik.

One of them is thyssenkrupp's Electrical Steel business unit. For 18 years, it has been manufacturing highly efficient electrical steel just outside the city, in Igatpuri. The location recently underwent a fundamental realignment, switching from non-grain-oriented electrical steel (NGO) production to a new product: "We've become the first producer of grain-oriented electrical steel in India," said Dr. Jens Overrath, CEO of Electrical Steel, shortly before the festive inauguration of the site's new production line. This shift represents a smart move: Sales of NGO have declined in the past few years, while the number of competitors has increased. "We already had a few varieties of grain-oriented electrical steel in our portfolio," says Kesava Venkatesan, Managing Director of Electrical Steel India, "so it made sense for us to expand our range."

Electrical Steel business unit

— Three countries, one product

powercore® brand grain-oriented electrical steel is produced in three locations: in Germany (Gelsenkirchen), France (Isbergues), and India (Nashik).

1,670

employees

optimize the properties of the low-loss material through a continuous process and exchange across the three plants.

Low-loss energy transfer

Grain-oriented electrical steel (GO) is present everywhere where electrical energy is converted, transported, and used, such as in distribution and power transformers. If power needs to cover great distances, the voltage needs to be increased over the voltage level present following generation. During transportation, the voltage level is approximately 1,000 times higher than that of a household power socket.

To make the power usable, the voltage needs to be reduced again. Grain-oriented electrical steel from thyssenkrupp is also used in current transformers, inductors, toroidal cores, and generators. The material used for energy-efficient transformers and high-power transformers is called powercore®.
The comprehensive expertise that the Electrical Steel business unit has gained over the decades is continuously improved and used to optimize

The plant in Nashik has been fitted with a laser system as well as a facility to apply magnesium oxide coating.

the product in the plant R&D departments in Gelsenkirchen, Germany, and Isbergues, France. “Naturally, this is a great boon to us,” says Venkatesen. “If it weren’t for the pooled specialist expertise of our colleagues from Germany and France, we never would have succeeded with our realignment.” Especially not in such a short period of time and at such a high level of quality. “We managed to complete this transformation in just a year,” says Overrath, not without a hint of pride. “The team in Nashik pulled off something tremendous – not just in terms of personnel and timing, but also in terms of engineering, where they accomplished an extraordinary feat.”

Power supply for India

The production line can currently manufacture 35,000 metric tons of grain-oriented electric steel per year. “There’s room to improve, though,” says Venkatesan. The core elements of the line are the facility for applying magnesium oxide coating as well as a laser system for treating the complex steel surfaces. “The demand for high-tech grades is increasing worldwide. Many of our international customers with plants in Asia expect the same high level of material quality that they can procure in Europe and the U.S.” It’s logical to follow these customer trends in the relevant markets.

There are a few more good reasons to produce powercore® in India. Firstly, the proximity to customers stabilizes the supply chain and enables comprehensive technical support. “Building a transformer is an extremely challenging undertaking, during which the customer continually turns to the supplier for assistance,” says Overrath. “If the supplier is ten thousand kilometers away, that’s not exactly helpful.” Secondly, the volume of materials ordered is advantageous. “Customers often only require five or ten metric tons,” says Venkatesan. “It usually isn’t worthwhile to import such small volumes, which means customers are typically forced to plan far in advance and contend with large warehouse inventories.”

Last but not least, the Indian government is heavily promoting the expansion of the country’s infrastructure. This particularly applies to the quick electrification of the country, through to its most remote regions. Fittingly, the opening ceremony for the new production line was attended by Dr. Aruna Sharma, Secretary of India’s Ministry of Steel. The significance of this event for German-Indian trade relations was further reinforced by the presence of representatives of the German Embassy in Delhi as well as the German Consulate General in Mumbai.
In the ancient city of Nashik, there are rows

Grain-oriented electrical steel

— Power made usable

The high-tech powercore® material ensures conversion in transformers and generators wherever electrical energy is efficiently converted, transported, and used.

1,000 times greater

than in a socket – that’s how high the electrical voltage is during transport. Grain-oriented electrical steel is required for the transformation process.

Spreading light: Dr. Aruna Sharma, Ruchika Govil (both of the Ministry of Steel), Peter Kern (German Consulate General in Mumbai), Dr. Jens Overrath, and Kesava Venkatesan (both of Electrical Steel) during the traditional oil lamp lighting ceremony.

New product, new systems: The most important part of the production line for manufacturing grain-oriented electrical steel (above); preparing the material for magnesium oxide treatment (below).

of densely packed mobile stalls peddling wares. Most of these sell jewelry, flowers, and other devotional objects to present as offerings in the city's many temples, of which there are roughly 200. Spirituality is a strong element of Indian culture; it's not only exercised in private, but also in the nation's spheres of business.

To wit: Jointly lighting an oil lamp is an established ritual at an inauguration ceremony such as the one for the new production line. This light represents knowledge driving away ignorance, as well as the inner riches that allow all external goals to be achieved. A single lamp can be used to light many others – analogously, the transfer of (specialist) expertise benefits the one who shares it as well as the one who receives it. This is a highly spiritual metaphor for the relationship between supplier and client – and to get a true sense of what that means, you'll need to come to India.

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