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METALS MAGAZINE

INNOVATION AND TECHNOLOGY FOR THE METALS INDUSTRY



PIONEERS AT HEART: A PASSION FOR INNOVATION IN THE WORLD OF METALS

DISCOVER THE MUMBAI COMPANY LOCATION
OF PRIMETALS TECHNOLOGIES

HBIS TANGSTEEL RELIES ON DIGITAL SOLUTIONS
FOR ITS AUTOMOTIVE-STEELS PRODUCTION



“ The ambition to pioneer new solutions is at the core of what Primetals Technologies stands for.”



EDITOR'S COLUMN

DEAR READER,



DR. TOM WIDTER
EDITOR-IN-CHIEF, METALS MAGAZINE

What does it mean to be a pioneer? This is the question that this issue of Metals Magazine is designed to answer. Let me start off by telling you a personal story. A few years back, I made the decision to climb the Matterhorn, one of the most iconic mountains in the European Alps. I am a Swiss citizen, and you might therefore think that it was basically "in my genes" and that I needed no major preparation to tackle the ascent. But the opposite was true. Not only does the Matterhorn require you to endure a 9-hour climbing day, the route to the top is also complex enough to make you thoroughly dependent on a knowledgeable guide. You should be well-versed in walking through rock and snow, and you must be able to control any fear of heights you might have. Bringing along the right equipment is also crucial, so as to prepare you for any eventualities. When my guide and I finally reached the pointed peak, the feeling was overwhelming. But it was also a humbling experience. I thought of the climbers who had conquered the mountain before me—particularly those who had to find the first safe route; those who carved paths into rock formations; those who put in ropes and safety hooks to protect their followers. I was in awe of what those early pioneers on the Matterhorn had achieved.

The ambition to pioneer new solutions for the metals industry is at the core of what Primetals Technologies stands for. With this issue of Metals Magazine, we aim to convey our passion for innovation by illustrating some of our greatest technological accomplishments—and by introducing you to the people instrumental in creating them. To complement these portraits, the Metals Magazine team has developed several new story formats around the idea of pioneering. Bringing these new formats to life has been a challenge—a bit like climbing a mountain. Now that we've reached the top, all I can say is that I hope you will find this issue compelling.

Yours sincerely,

A handwritten signature in blue ink that reads "Tom Widter". The signature is written in a cursive, slightly stylized font.

Dr. Tom Widter
Editor-in-Chief of Metals Magazine
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At Primetals Technologies, we like to push the limits of how metals are produced. We are pioneers at heart, ready to team up with our customers and explore the frontiers of tomorrow.

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METALS MAGAZINE IS ALSO AVAILABLE FOR TABLET COMPUTERS

The "Primetals" app is available for iPads and Android tablets and can be downloaded for free in the respective App Store. The app features a collection of articles from the current and past issues of *Metals Magazine*, as well as interactive presentations of select technologies.

PRIMETALS TECHNOLOGIES APP

Search for "Primetals" in the App Store of your choice to download the app.



MESSAGE FROM THE CEO

DEAR CUSTOMERS,

This is the first time that I have the pleasure of introducing you to a new issue of Metals Magazine. My name is Satoru Iijima, and I was appointed Primetals Technologies' new CEO on April 1, 2018. Today, I would like to take the opportunity to talk to you about three things: about stories, change, and success.

My own story is deeply interwoven with the metals industry at large. I studied mechanical engineering at WASEDA University in Tokyo and started my career at Mitsubishi Corporation in 1986. My assignments brought me to Dusseldorf, Germany, where I worked as a manager for the Plant and Heavy Machinery department for five years, and, later on, to the United States. Before taking on the role of CEO of Primetals Technologies, I was in charge of our U.S. based company locations. As with my earlier responsibilities, this position allowed me to learn, to further refine my understanding of what metals producers care about in this day and age, and to grow as a person. I am sure that my current function will equally shape me on a personal level and mark one of the most relevant points in my biography.

But it's not only people who have a story to tell—the same is true for technological solutions. Primetals Technologies is well-known for its innovations, many of which originate from constant dialog with our customers. Our engineers are determined to solve problems on behalf of our customers and develop new solutions in close collaboration with their own experts. This issue of Metals Magazine presents a large number of new technologies and tells their stories—how they came to be, what challenges had to be met during their realization, and how they changed the way that steel and other metals are produced. I am proud of all the technological breakthroughs that we as a company have made, but especially of those that have served as a catalyst for the kind of change that still resonates within the industry today.

Change is also something I want to bring to Primetals Technologies in my role as CEO. We will clearly continue to provide our customers with all the things they have come to expect from us. We will continue to listen closely to their needs, and we will partner with them to find the ideal solution for their respective purposes. We will assist our customers in determining what business strategy and what product portfolio will enable them to succeed in the industry in the future. But we will also change the way we work and some of our focus areas: We will double down on our already significant efforts in the field of digitalization. We will put even more attention on environmental technologies. And we will never stop asking ourselves how we can best contribute to future-proofing the steel industry in an ever-evolving world.

Finally, I would like to talk about success. I firmly believe that ultimately our success—the success of Primetals Technologies—is closely linked to that of the metals producers we work with. I am committed to ensuring that the worries of our customers are also our own worries. I am dedicated to solving the problems our customers are facing, with smart, holistic, and highly innovative solutions. Our extensive R&D efforts are directed toward the development of new and improved technologies that will give metals producers a head start on their path to the world of tomorrow—a world where Industry 4.0 technologies are essential for sustained success. These technologies lead to better end products, highly efficient operations, and more environmentally friendly production.

I look forward to joining you, our valued customers, on this journey toward a bright and digital future, and I will always have an open ear for any questions or suggestions you might have. Together, we will be stronger, and together, we will be successful. ●



SATORU IIJIMA
CEO and Chairman of
Primetals Technologies

“ I firmly believe that ultimately our success—the success of Primetals Technologies—is closely linked to that of our customers.”

Satoru Iijima

PROJECT AND COMPANY NEWS HIGHLIGHTS

Primetals Technologies supports its customers throughout the world with advanced solutions, equipment, and services at every step of the iron- and steel-production process.



- | | |
|------------------------------------|---------------------------------|
| 1. Ciudad Lázaro Cárdenas, Mexico | 9. Kardemir, Turkey |
| 2. Russellville, Kentucky, U.S.A. | 10. Cherepovets, Russia |
| 3. Bethlehem, Pennsylvania, U.S.A. | 11. Manama, Bahrain |
| 4. Santa Cruz, Brazil | 12. Aktobe, Kazakhstan |
| 5. South Wales, United Kingdom | 13. Rizhao, China |
| 6. IJmuiden, Netherlands | 14. Fuding, China |
| 7. Freital, Germany | 15. Ningbo, China |
| 8. Dąbrowa Górnicza, Poland | 16. Fukuyama, Japan (see pg. 9) |

Geographic locations
of the project news topics
addressed in this section



MEROS lowers SOx emissions in sinter off-gas by more than 97 percent.

PRIMETALS TECHNOLOGIES TO INSTALL FIRST MEROS OFF-GAS CLEANING SYSTEM IN JAPAN

MEROS systems significantly reduce emissions produced during the sintering process.

JAPAN: Primetals Technologies has received an order from Japanese-based JFE Steel Corporation to supply a MEROS (Maximized Emission Reduction of Sintering) off-gas cleaning system. It will be installed at the steel producer's new sinter plant in Fukuyama, Japan, which will also be supplied by Primetals Technologies. The MEROS system will be designed to optimally clean the process gas that results from the operation of the sinter plant. It will be the first adsorbent injection-type dry gas-cleaning system to be implemented at a Japanese sinter plant, and will eliminate the use of water in the gas-cleaning process. JFE Steel Corporation's new sinter plant has a rated annual capacity of 4.8 million tons and will commence operation in the fourth quarter of 2019, along with the sinter plant. MEROS systems are capable of lowering SOx content in the off-gas by more than 97%, and PCDD/F (Dioxins) concentration to less than 0.1 ng-teq/Nm³. Also, they significantly reduce dust emissions. Further MEROS systems were recently ordered by steel producers in Turkey (see news item no. 9) and India.



Hot-strip mill from Primetals Technologies, as will be supplied to ArcelorMittal in Mexico

ARCELORMITTAL TO EXPAND ITS MEXICAN OPERATIONS WITH NEW HOT-STRIP AND SKIN-PASS MILLS

1. MEXICO: Mexican steel producer ArcelorMittal México S.A. de C.V. placed an order with Primetals Technologies for a hot-strip mill and a hot skin-pass mill for its production site in Ciudad Lázaro Cárdenas, Mexico, located at the Pacific coast. The company is already producing slabs on site, which it will be able to further process in its future mills. The hot-strip mill will be erected on a turn-key basis, including the power supply, mechanical equipment, drives, and automation. Primetals Technologies' unique Through-Process Optimization will improve efficiency, stability, and product quality across the full production route. The project will be executed by an open consortium that includes Primetals Technologies and the Mexican construction companies LOMCCI S.A. de C.V. and WP Constructora S.A. de C.V. The plant will be designed for a total annual capacity of 2.5 million tons of hot strip. The hot skin-pass mill will be capable of processing 650,000 tons per year. Both mills are scheduled for startup in 2020.

“ This partnership underlines our position as a technological pioneer in the areas of digitalization and Industry 4.0 for the metals business.”

EMERSON ELECTRIC CO. TO MEET SEASONAL DEMAND FULLY PREPARED

2. U.S.A.: To meet increased seasonal demand for air-conditioning units, Emerson Electric Co. (EEC) signed a contract with Primetals Technologies for the supply and installation of a roller hearth furnace and a lamination-annealing line at its plant in Russellville, Kentucky. Air-conditioning units that use small electric motors represent a significant portion of EEC's portfolio. The respective market starts to build up in late spring, as consumers buy air conditioners in anticipation of warm summer days. The new lamination-annealing line, based on Flinn & Drefflein technology, includes an atmosphere generator, and will heat-treat low carbon and ultra-low carbon steel to make it softer and impart specific magnetic properties. Primetals Technologies is responsible for the equipment installation and the startup and commissioning services. The new equipment is expected to be fully operational in spring 2019.



Lamination-annealing line and roller-hearth furnace from Primetals Technologies



Primetals Technologies and ITR join forces to provide even better predictive-maintenance solutions: Jonathan Davis, ITR's CEO (center left) and Karl Purkarthofer, Head of Metallurgical Services at Primetals Technologies (center right), shake hands on the occasion of the signing ceremony.

PRIMETALS TECHNOLOGIES AND ITR SIGN COOPERATION AGREEMENT ON PREDICTIVE-MAINTENANCE SOLUTIONS

3. U.S.A.: Industrial Technology Research (ITR), headquartered in Bethlehem, Pennsylvania, U.S.A., and Primetals Technologies have signed an exclusive cooperation agreement, effective from April 2018. The agreement covers the application of predictive-maintenance solutions in steel-related industries worldwide. The two companies have successfully been working together in the field of condition monitoring for over ten years and share a large customer base. "With ITR's technology, know-how, and capabilities, especially in the area of prediction, we'll be able to serve our customers even better and provide them with cutting-edge condition-monitoring and predictive-maintenance solutions," said Karl Purkarthofer, Senior Vice President and Global Head of Metallurgical Services. "This partnership also underlines our position as a technological pioneer in the areas of digitalization and Industry 4.0 for the metals business."



The first application of the SRD (Single-Roll DynaGap) segment in Ternium's integrated steel works in Santa Cruz, Brazil, improves internal quality of slabs.

NEW SINGLE-ROLL DYNAGAP SEGMENTS FOR SLAB CASTER AT TERNIUM, BRAZIL

4. BRAZIL: The SRD (Single-Roll DynaGap) segment is a new technology that further improves interior quality of slabs for steel grades that place high demands on the casting process. The segment has been specially developed for use in the area of final solidification, and it allows the upper rolls to be pressed down individually onto the solidifying strand—enabling the final solidification point to be followed precisely. The first installation of SRD segments was carried out at one strand of a slab caster in the Ternium integrated steel works in Santa Cruz, Brazil. Subsequent tests showed superior internal slab quality compared to slabs from the second strand, which uses conventional segments. As a consequence, Ternium decided to equip the second strand of the caster with SRD segments as well.

> Learn more about the SRD segment on page 65.

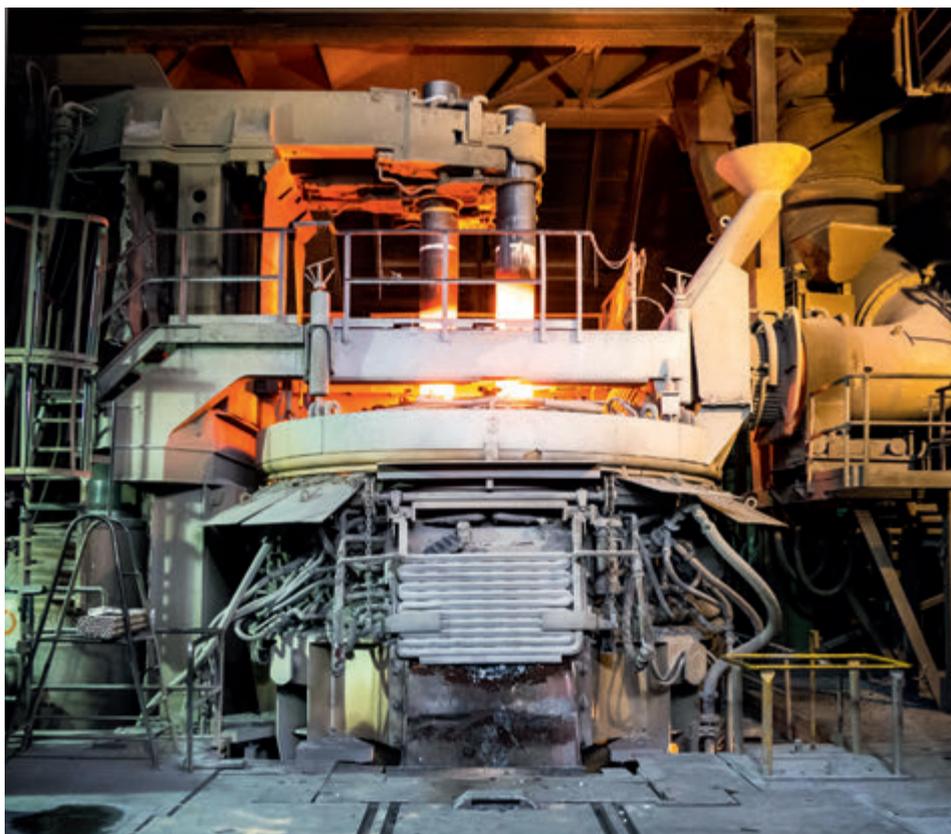
The Ternium integrated steel works in Santa Cruz, Brazil, is the first to use SRD Segments for superior interior quality in slab casting.

TRANSFER-BAR COOLING SYSTEM COMMISSIONED AT TATA STEEL

5. UNITED KINGDOM: A transfer-bar cooling system supplied by Primetals Technologies was recently commissioned for the hot-strip mill of Tata Steel's Port Talbot integrated steel plant located in South Wales, United Kingdom. The purpose of the cooling system, installed after the roughing mill, is the precise control of the strip's temperature before it enters the finishing mill, without having to slow down the roughing mill. This results in an increase in production capacity of approximately 150,000 tons of hot strip per year. The system is based on Primetals Technologies' Power Cooling technology.

ELECTRICS AND AUTOMATION FOR TATA STEEL PACKAGING IJMUIDEN

6. NETHERLANDS: The continuous-annealing line CA 12 at Tata Steel Packaging in IJmuiden, Netherlands, which was modernized by Primetals Technologies with new electrics and automation equipment, recently recommenced operations. The objectives of the modernization project were a one-to-one replacement of the existing control system, including Human-Machine-Interfaces (HMI) and motor drives, with the aim of ensuring proper operation for the next 20 years. The project was realized within 14 months from order to performance testing.



Electric arc furnace, modernized by Primetals Technologies at BGH Edelmetallwerke GmbH in Freital, Germany

Modernized roofing and tilting systems will enable the use of longer EAF electrode segments.

BGH EDELSTAHLWERKE ISSUE FAC FOR FURNACE- MODERNIZATION PROJECT

7. GERMANY: BGH Edelmetallwerke GmbH, a German steel producer, issued the Final Acceptance Certificate (FAC) for an electric arc furnace modernization project to Primetals Technologies in January 2018. The upgrade was implemented at BGH's minimill plant in Freital, where the company also runs downstream secondary metallurgy, an ingot-casting plant, and a horizontal continuous caster. Further processing is done in a rough-block mill and a wire-rod mill. The modernization project included the optimization of furnace movements and the conversion of the tapping system. A ladle car was installed as part of the upgrade, as well as a new ladle heating system and a new alloying facility. The project was executed in two stages and completed during the summer shutdown of 2017. Over the course of the upgrading works, Primetals Technologies modernized the furnace rocker, as well as the roof-raising and tilting systems of the electric arc furnace to speed up furnace movements and allow for the possibility of using longer electrode segments. The tapping system that empties the furnace was converted during the second project stage, which also saw the delivery of a new ladle car and the installation of a ladle heating system and an alloying facility for ladle treatment. Primetals Technologies was responsible for all engineering and equipment supply, and supervised the installation and commissioning of all new systems.

PROVISIONAL ACCEPTANCE OF SECOND LD CONVERTER AT ARCELORMITTAL POLAND

8. POLAND: Primetals Technologies has received the Provisional Acceptance Certificate from ArcelorMittal Poland S.A. for the replacement of the second LD (BOF) converter at its Dąbrowa Górnicza steel works. Like its counterpart, converter No. 1, which had already been replaced by Primetals Technologies and commissioned in late 2016, converter No. 3 was a turn-key construction. Its replacement had already been agreed as an option in the third quarter of 2015. The order included the supply of the vessel and trunnion ring, and a renewal of the converter bearings and the enclosure, as well as the removal of the existing vessel and assembly and installation of the new one. One of the highlights of the new converter is the maintenance-free Vaicon Link 2.0 suspension, which has a remarkably long service life and minimizes the stresses caused by thermal deformations.



Computer-animated image of the MEROS plants from Primetals Technologies that are to be installed at Karabük Demir Çelik Sanayi ve Ticaret A.S. in Kardemir, Turkey.

KARDEMİR TO RECEIVE TWO FURTHER MEROS GAS-CLEANING SYSTEMS

9. TURKEY: Turkish steel producer Karabük Demir Çelik Sanayi ve Ticaret A.S. (Kardemir) has placed an order with Primetals Technologies to supply two new MEROS off-gas cleaning plants for Kardemir's sinter plants No. 1 and No. 2, and to upgrade a previously ordered MEROS system at sinter plant No. 3. Each MEROS system can process 400,000 Nm³/h of sinter off-gas, reduce SO_x by more than 90%, and dramatically lower dust emissions. The two new MEROS plants for Kardemir are designed to use sodium bicarbonate as a desulfurization agent, while the existing system will be upgraded to employ sodium bicarbonate instead of lime. Start-up of the new MEROS plants is expected by the end of 2018. With this investment, air quality in the valley of Karabük will be vastly improved—thanks to the MEROS process, which uses several modules for the injection and distribution of adsorption and desulfurizing agents into the off-gas flow. This efficiently binds and removes heavy metals, harmful and hazardous organic components, as well as sulfur dioxide and other acidic gases. The dust particles are then collected in energy-efficient bag filters.

With this investment in MEROS off-gas cleaning systems, air quality in the valley of Karabük will be vastly improved.

PRIMETALS TECHNOLOGIES TO MODERNIZE HOT-STRIP MILL OF SEVERSTAL IN CHEREPOVETS

10. RUSSIA: Primetals Technologies has received an order from Russian steel producer PAO Severstal to modernize the company's hot-strip mill "HSM 2000" in its Cherepovets steel works. The main targets are to improve tolerances of product width and thickness control as well as to increase overall production quality for further processing and the efficient production of new products. Also, operational safety and working conditions will be improved. To these ends, an edger of the hot-strip mill will be upgraded, and short-stroke hydraulic gap-control cylinders (HAGC) will be installed at the finishing mill. In addition, a Primetals Technologies Level 2 control model, consisting of physical-process models with advanced optimization strategies and neural-network algorithms for adaptation, will be installed. The cooling line will be outfitted with a Power Cooling unit, allowing for an alloy-saving production of high-end steel grades. The cooling-section control, which will be renewed entirely, will ensure that the correct cooling strategy and cooling path is followed. The control also includes intelligent water management to cope with the highly dynamic requirements of large water-flow rates.

"BEST-EVER AUTOMATION UPGRADE" SUCCESSFULLY COMPLETED AT GARMCO, BAHRAIN

11. BAHRAIN: "It is our best-ever automation upgrade": this is how Gulf Aluminium Rolling Mill Co. (GARMCO), a leading producer of rolled aluminum products in the Gulf region, praised its collaboration with Primetals Technologies for the modernization of the automation technology in their cold-rolling mills 1 and 2 in Manama, Bahrain. In May 2017, only six weeks after rolling the first coil, Primetals Technologies had received the Final Acceptance Certification (FAC) for the undertaking. What made these outstanding results possible was exemplary project management during hot commissioning. The Primetals Technologies team also provided excellent support during the subsequent 12-month warranty period that followed final-acceptance certification. By modernizing cold-rolling mill 1, GARMCO achieved greater availability and higher productivity, along with improved thickness and flatness tolerance. The rapid resumption of regular production after a three-week downtime and the successful factory acceptance test during operation only six weeks later once again confirmed the benefits of standardized software combined with an experienced execution and commissioning team.



Commissioning team at GARMCO in Manama, Bahrain, with the first coil from the modernized cold-rolling mills.



The plant of Aktobe Rail and Section Works LLP in Kazakhstan

NEW MAINTENANCE SYSTEM TO BE IMPLEMENTED AT ARBZ IN KAZAKHSTAN

12. KAZAKHSTAN: Primetals Technologies will be implementing a new spare-parts management concept at Aktobe Rail and Section Works LLP (ARBZ). The system comprises a comprehensive selection of spare parts with fixed pricing as well as a two-year warehousing contract. Primetals Technologies will handle all supply-chain activities, including the management of subcontractors, and provide permanent on-site technical support for immediate response and continuous improvement of all operations. The rail and section mill was also supplied by Primetals Technologies, with final acceptance issued in August 2017.

Primetals Technologies will handle all supply-chain activities and provide permanent on-site tech support.

FOURTH ARVEDI ESP LINE STARTED UP AT RIZHAO STEEL IN CHINA

13. CHINA: At the Chinese steel producer Rizhao Steel Co. Ltd., the fourth Arvedi ESP (Endless Strip Production) plant supplied by Primetals Technologies was started up in April 2018. The casting and rolling plant will produce 1.7 million tons of high-quality ultra-thin hot strip with thicknesses of down to 0.8 millimeters. The plant features a Through-Process Optimization (TPO) implementation, making it ready for Industry 4.0.



Shaking hands in front of the first coil produced on the fourth Arvedi ESP line at Rizhao.



An Arvedi ESP plant in operation

PRIMETALS TECHNOLOGIES SUPPLIES NEW ARVEDI ESP LINE AND TWO QUANTUM ELECTRIC ARC FURNACES TO HENAN YAXIN

14. CHINA: Chinese steel producer Henan Yaxin Steel Group Co., Ltd. (Henan Yaxin) has placed an order for the supply of an Arvedi ESP (Endless Strip Production) line and two EAF Quantum furnaces at its company location in Fuding City. The casting-rolling facility will be part of a new steelmaking facility currently under construction. The liquid steel will be produced with two EAF Quantum electric arc furnaces, which will contribute to very high overall energy efficiency. The Arvedi ESP line has a design capacity of 1.6 million tons per year with the potential to expand to 2.5 million tons later on. It is capable of rolling strip to strip thicknesses of down to 0.8 mm. This will enable Henan Yaxin to produce high-quality ultra-thin strip to enter new market segments. Compared to conventional casting and rolling processes, energy consumption and the related costs are reduced by up to 45%. Another benefit is the vast reduction in CO₂ and NO_x emissions. The project is the first environmentally friendly minimill installation worldwide in which EAF Quantum and Arvedi ESP are combined. It will allow Henan Yaxin to better serve the highly attractive local and export markets for high-quality thin-gauge strip products. The 180-meter-long plant is far more compact than conventional casting and rolling mills. It will produce carbon steels, high-strength low-alloyed, and dual-phase grades.

> Learn more about Arvedi ESP on pages 66-73

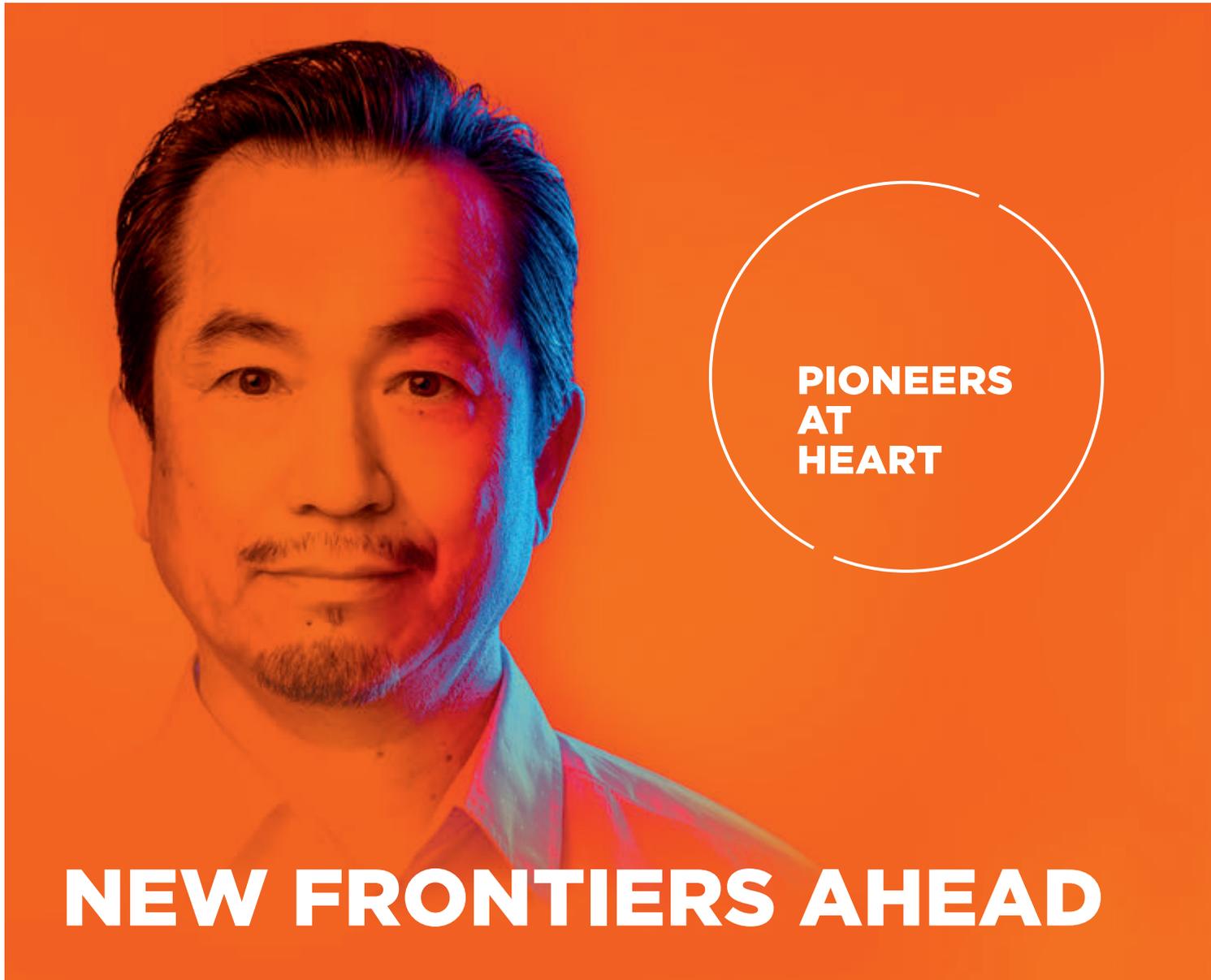
Arvedi ESP (Endless Strip Production) reduces energy consumption by up to 45% and enables major reductions in CO₂ and NO_x emissions.

TWO COPPER-ROD MILLS ORDERED BY SOUTHWIRE FOR NINGBO IN CHINA

15. CHINA: Ningbo Jintian Copper Group Co. Ltd.—one of the largest copper-processing manufacturers and a company ranking among the top 500 in China—has signed contracts with Southwire Company, LLC of Carrollton, Georgia, U.S.A., for two identical SCR 7000 copper-rod mills to be supplied by Primetals Technologies in 2019. The equipment is intended to enable expansion into new geographic markets. The first new mill will operate in Hangzhou, Zhejiang Province, China, and the second mill will be installed in Guangzhou, Guangdong Province. Startup is expected in the summer of 2019 for the first mill and in early 2020 for the second. Each will have an annual capacity of approximately 315,000 tons. These new orders bring the total number of copper-rod mills supplied by Primetals Technologies to Southwire for Ningbo to four, increasing their total installed capacity to nearly one million tons per year. The mills will produce electrolytic tough pitch copper for the building construction wire and cable markets.



An SCR-7000 copper-rod mill processing line supplied by Primetals Technologies to Southwire Company, LLC.



**PIONEERS
AT
HEART**

NEW FRONTIERS AHEAD

Have you ever reached the top of a mountain and wondered who conquered it first? Or set out to sea and pondered the first adventurers who crossed the oceans not knowing what may lie ahead? Are you fascinated by Robert Peary and his expedition to the North Pole, with all the painstaking preparation and endurance the expedition must have required?

At Primetals Technologies, we are determined to explore new frontiers. We are driven to pioneer new solutions in metals production. We aim high, we try hard, and we persevere. Sometimes, we succeed. Sometimes, we fail and we learn from our attempts. And sometimes, we make a breakthrough.

Innovation is part of our DNA. Our curiosity fuels our passion to find new solutions. It is what gets us up in

the morning. But there is something else we care about, and that is our customers in the steel industry. It is our mission to provide the best possible support to metals producers around the world in all kinds of scenarios: from turn-key projects and the installation of new production lines to upgrades and maintenance services, we build close partnerships with our customers to ensure that their operations remain profitable for years to come.

PASSION FOR INNOVATION

“My interest is in the future because I am going to spend the rest of my life there,” said Charles Kettering, the famous American inventor and engineer. The same is true for the men and women at Primetals Technologies. Our extensive R&D efforts are directed toward advanced and future-oriented solutions—solutions that



will maximize the efficiency, reliability, and environmental compatibility of tomorrow's metals-production facilities. And because we are all on the road that leads to Industry 4.0, we are continually refining and extending a portfolio of technologies that will give steel producers a head start on their journey toward the smart plant of the future.

SHAPING THE DIGITAL FUTURE

Digitalization is changing metals production, and we are changing with it. The frontiers of today are vastly different from those of yesteryear, and our dedication is to the future. Still, it makes sense to showcase what we stand for by presenting some of our engineers' and technology specialists' finest achievements. These successes are meant to serve as references for the many more projects that we have accomplished over time—

for and together with our customers and partners. They are indicators of the kinds of goals we set ourselves. And they point to what it is you can expect from us—today, tomorrow, and beyond.

In an ever-changing environment, delivering solutions, continuous innovation, and an unwavering commitment to our customers are the cornerstones of our philosophy.

Over the course of the next eight pages, we examine some of the most impressive technologies we have created over time, many of which are the results of long-term customer partnerships. And we invite you to discover some of our finest engineers, all pioneers at heart, who have made it their challenge to explore new frontiers for those who've placed their trust in them.

GREEN TECHNOLOGY FOR SINTERING

When the first MEROS plant began operating in August of 2007, everyone who visited the site of Austrian-based plant owner voestalpine thought that the sinter plant had been switched off. The air was just so clean. "It was a great moment," says Dr. Alexander Fleischanderl, who was one of the pioneers behind the new sinter off-gas cleaning solution. "From one day to the next, sintering turned from a 'dirty' process into an environmentally friendly one. MEROS was immediately so effective that we overachieved on all the targets we had set for ourselves."

There are several factors that contribute to the success of MEROS: It relies on a series of treatment steps, in which dust and other harmful components are removed from the off-gas, all the while realizing a working principle that is completely water-free. "We get several direct and indirect benefits from MEROS being a dry technology," says Dr. Fleischanderl. "We overcome many of the limitations associated with wet gas cleaning, such as a lack of effectiveness in filtering volatile organic compounds and dioxins. Also, MEROS doesn't pollute any water, which would then have to be treated." By today, MEROS has gained enormous respect within the steel industry—so much so that the core technology has led to additional dedicated dry gas-cleaning solutions for the blast furnace (MERIM) and the LD (BOF) converter (MERCON). "MEROS was pioneered from the heart," says Fleischanderl, "and we will continue to innovate with passion for the environment."

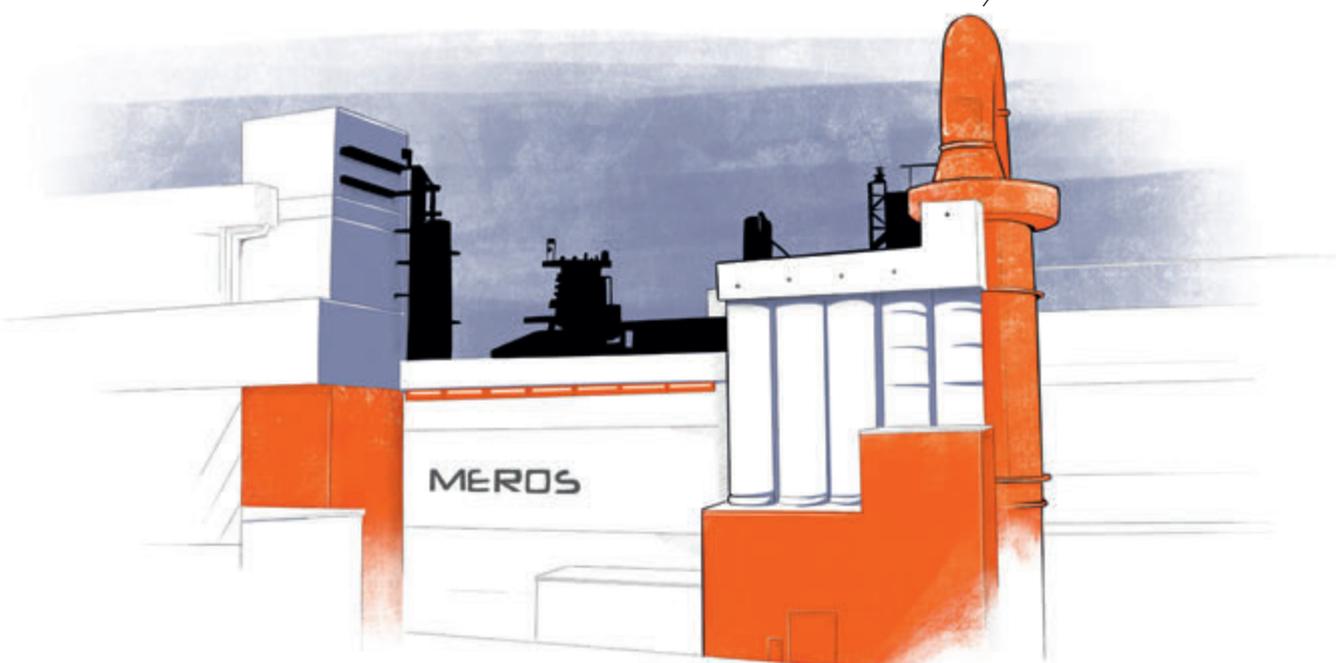


DR. ALEXANDER FLEISCHANDERL ...

... joined Primetals Technologies' predecessor company VAI in 1997 and is now Technology Officer Upstream and VP of Iron- and Steelmaking.

MEROS ...

... originated in 2004 and was given its current name, which stands for "Maximized Emission Reduction of Sintering," in 2007.



REVOLUTIONIZING STEELMAKING

LD steelmaking forever changed the way in which steel is produced: the majority of the output of today's steel plants is based on the process also known as the "basic oxygen furnace" (BOF) production process. "LD" stands for "Linz-Donawitz," and it is the two cities that make up this name where the groundbreaking innovation was developed. While several people were instrumental in bringing LD steelmaking to life, Dr. Herbert Trenkler was clearly one of the most relevant.

Dr. Trenkler first got involved with "oxygen metallurgy," as it was then called, in the late 1930s. At the time, he was working as a steel mill manager's first assistant at Gutenhoffnungshütte AG in Neuoberhausen, Germany. As Trenkler progressed within the steel industry, he continued his research into oxygen blow-in based steelmaking. In March 1948, he became manager of VÖEST's steel plant in Linz, Austria. In this role, he encouraged his team to invest significant resources into the research of oxygen-converter technology. Trenkler was determined to bring the new process to fruition and to implement it in his steel mill at full production scale. His efforts finally paid off when in November 1952 the first-ever LD steelworks went into operation. The second one was started up only a few months later in Donawitz, Austria. From there, LD steelmaking went on to become the world-renowned production method that it is today—and many more innovations from the same location in Linz were to follow.

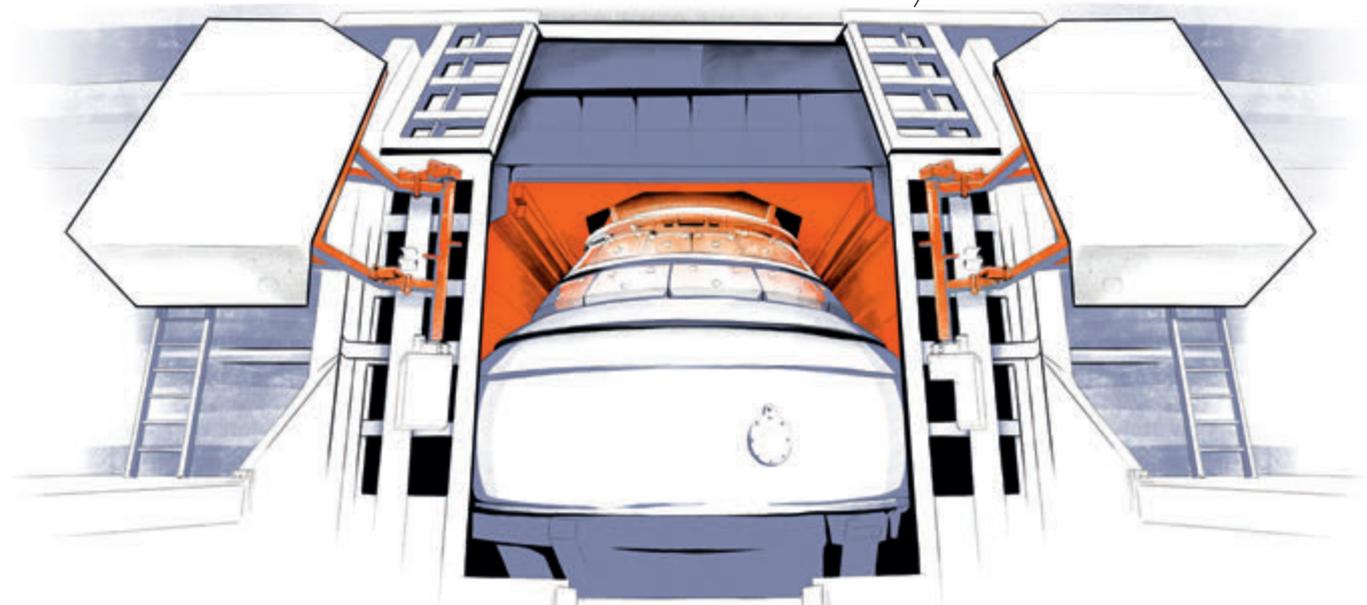


DR. HERBERT TRENKLER ...

... became manager of VÖEST's steelworks in Linz, Austria, in 1948 and facilitated the inception of the LD converter. Primetals Technologies Austria originated from Voest-Alpine Stahl AG as VAI in 1988.

LD (BOF) STEELMAKING ...

... was pioneered in 1952 with the startup of the first-ever LD steel-making facility in Linz, Austria.



RECOVERING ENERGY WITH BRAINPOWER

The EAF Quantum is a highly advanced electric arc furnace that can bring significant energy savings compared to conventional EAFs. It is environmentally compatible, highly available with tap-to-tap times of only 33 minutes, and can reduce the need for manual control with its smart automatic functions. The most impressive aspect to EAF Quantum is the furnace's ability to pre-heat scrap using the off-gas that results from its own melting process. The off-gas is intelligently routed into a specially designed shaft that is part of the furnace's scrap-charging system. The charging works by transferring scrap from a subsurface dumping station directly into the furnace with an elevator system. Before it is loaded, 100% of the scrap travels through a trapezoidal preheating shaft, where it is retained for just the amount of time needed for optimal energy recovery.

Hansjörg Huber is the engineer who crafted the core design of the EAF Quantum. "The most difficult aspect was to get the charging system exactly right," he says. "This required a lot of brainpower, and a lot of persistence—not only on my part but from the entire team that eventually contributed to the solution." Another challenge was perfecting the kinematics of the furnace shell. "We wanted it all: more precise tapping, higher availability, minimal downtimes, and furnace automation." To achieve his goals, Huber kept to his motto, "crazy but basic"—driven to innovative but also down-to-earth. An excellent formula for pioneering the future.

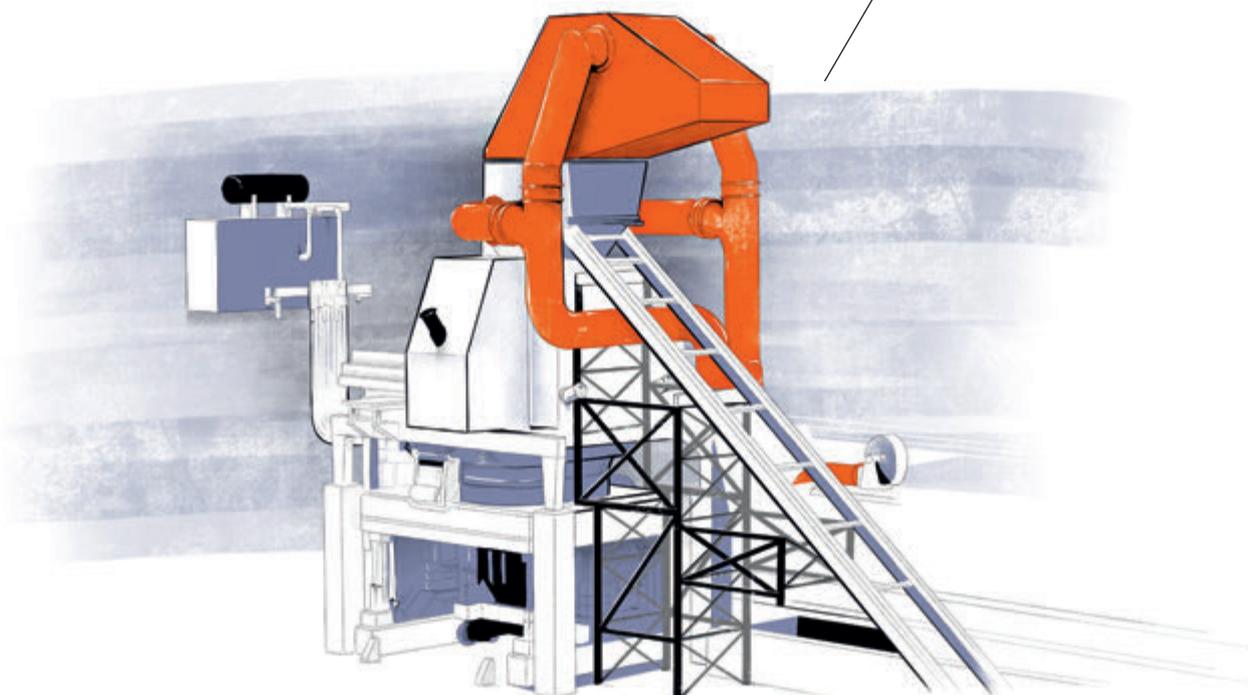


HANSJÖRG HUBER ...

... has 38 years of experience in electric steelmaking and is now Senior Expert of Technical Proposal Management at Primetals Technologies.

EAF QUANTUM ...

... is a huge step forward in terms of energy efficiency and environmental compatibility, thanks to the EAF's built-in energy-recovery system.



CASTING SOLUTIONS IN THE DIGITAL DOMAIN

Many of the digital casting technologies Primetals Technologies is known for would not have come to fruition the way they did, had it not been for the ingenuity, persistence, and commitment to excellence of Dr. Karl Mörwald—among them Dynacs and DynaGap*, which later led to innovations such as DynaPhase and the DynaJet Flex Nozzle. Mörwald sadly passed away in 2011 but left a technological legacy that is second to none. His passion for creating new, smarter solutions inspired those who worked with him, and his spirit can still be felt in the hearts and minds of Primetals Technologies' casting experts of today.

Mörwald was a pioneer in the truest sense, always on the lookout for new opportunities. "He had a strong desire to take things further, and he instinctively knew what aspects of a technology to optimize in order to make the greatest-possible leap forward," say those who knew him well. Not only did he strive to improve existing processes but he also wanted to craft solutions that had never been attempted before. He used his expertise in mechanics to build new, interdisciplinary teams within Primetals Technologies, which he led to unparalleled results. "Good enough was never an option to him," is the consensus. Mörwald cared strongly about the standardization of new casting technologies to ensure that they could be implemented in a maximum number of plants with minimal adaptation—much to the benefit of many a steel producer and to the immortality of Mörwald's ideas.

* Read more about DynaGap on pgs. 60–65.

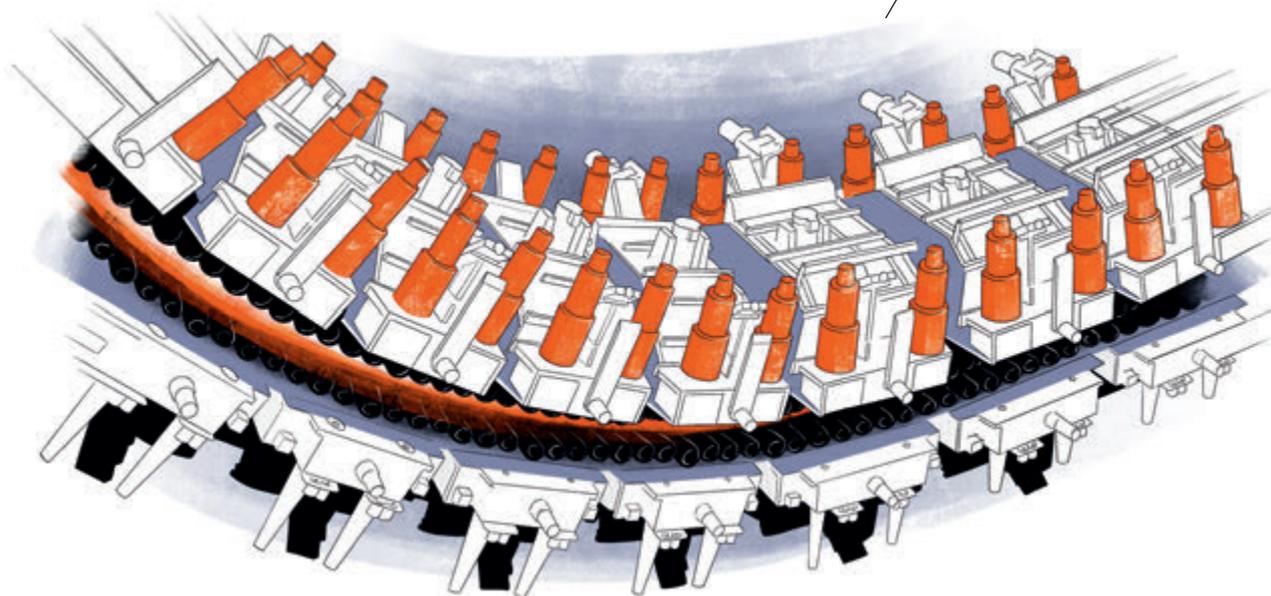


DR. KARL MÖRWALD ...

... became Head of Technology, Continuous Casting, at Primetals Technologies (at the time VAI) in 1997 and led company-wide R&D efforts from 2008 to 2011.

DIGITAL CASTING SOLUTIONS ...

... such as Dynacs and DynaGap came to life because of Dr. Mörwald's leadership, ingenuity, and passion for innovation.



PERFECT SHAPE FOR HOT-ROLLED STRIP

Controlling the crown shape and flatness of hot-rolled strip used to be a notoriously difficult. The 1980s witnessed a great leap forward in this context: the introduction of first pair-cross mill at the Hirohata works of Nippon Steel in Japan. The idea was simple, though hard to pull off: The upper and lower roll pairs are put in a slightly crossed position in order to counter the effect of roll bending on strip geometry.

As rolling speeds were gradually stepped up for higher productivity, and mills were increasingly required to be able to produce high-strength steels that demand high reduction, the central challenge in pair-cross mills shifted to preventing mill vibration. This is where Akira Sako of Primetals Technologies left a permanent mark. A native of Hiroshima prefecture in Japan, he joined Mitsubishi Heavy Industries in 1987 and later moved on to work at Mitsubishi-Hitachi Metals Machinery, advancing to leader of the 3D CAD Group in 2003, and to general manager of the Rolling Mill Design Department in 2010. The mill stabilizing device that was developed under Sako's leadership made it possible to run 3rd generation pair-cross mills with high reduction, avoiding harmful vibration and retaining excellent crown-control accuracy. At the same, the elegant simplicity of Sako's design required fewer mechanical components and thus saved costs. Today, Akira Sako continues to improve hot-rolling mill technology as a Senior Key Expert at Primetals Technologies Japan.

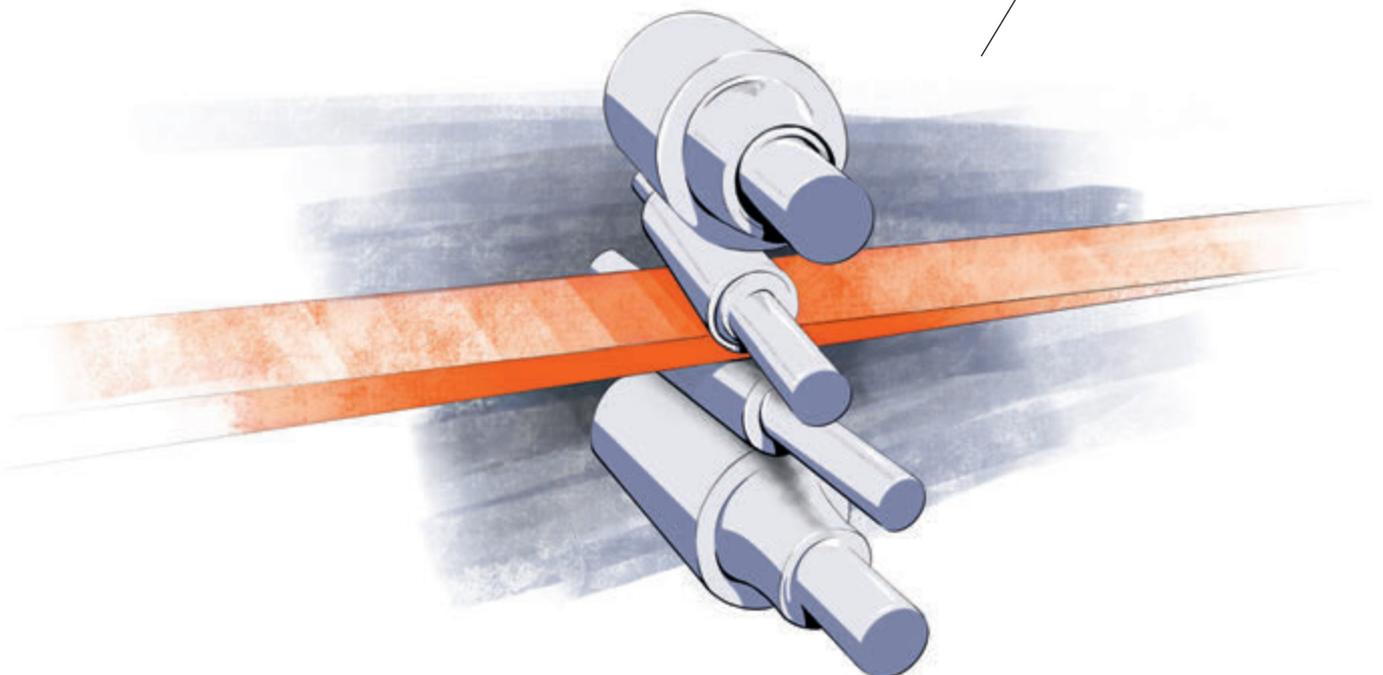


AKIRA SAKO ...

... is a Senior Key Expert at Primetals Technologies, where he did pioneering work on the 3rd-generation pair-cross mill.

THE PAIR-CROSS MILL ...

... achieves excellent crown control by "crossing" the axes of the upper and lower rolls.



BOOSTING SPEED IN PICKLING LINES

Demand for ultra-low carbon and high-tensile steels has been steadily growing in the household-appliance and automobile industries. But many producers face a challenge, as these types of steels take two or three times as long to descale in conventional pickling lines. The iBox (immersion box) from Primetals Technologies was created to solve this problem—without the need for a circulation heating or jet pickling system.

Kosei Tsuji from the Hiroshima location of Primetals Technologies was central to this development effort. From his frequent interactions with customers, he knew that many of them had problems with jet pickling or circulation-heating type pickling methods. But box pickling was at that point only available as a retrofitting option for deep-bath tanks. That's how Tsuji came up with the idea of adapting iBox for newly installed tanks—delivering top performance without a circulation-heating system. The benefits promised to be substantial: iBox would reduce energy and maintenance expenditures and push down the cost of manufacturing and installation at the same time—since, for example, the pickling tanks would require less piping for the acid. A major challenge were the complicated fluid dynamics in the pickling tanks. With repeated tests and analysis in chemical engineering, Tsuji and his team developed a solution that elegantly avoids mixing different acid concentrations and delivers the performance their customers were looking for.

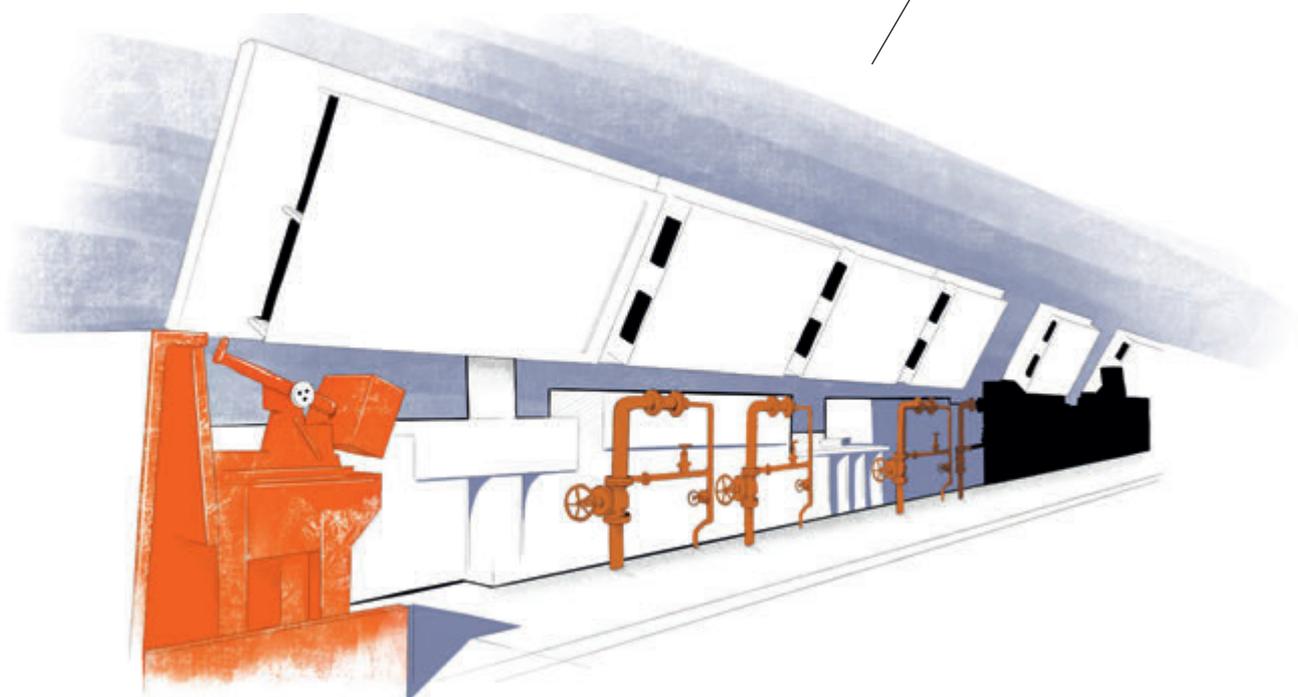


KOSEI TSUJI ...

... is a Senior Key Expert for processing lines at the Primetals Technologies Hiroshima location.

THE IBOX PICKLING TANK ...

... achieves high descaling performance without the need for circulation heating or jet nozzles.



HIGHER REDUCTION WITH SMALLER ROLLS

Demand for advanced high-strength steel grades in the automotive industry has seen remarkable growth over the past few years. In automobiles, thinner-gauge high-strength material reduces fuel economy and increases safety at the same time, and thinner, harder electrical steel sheet increases efficiency in motors for electric vehicles. The Hyper UCM (Universal Crown Control Mill) from Primetals Technologies is tailored to satisfy exactly these demands: with work rolls 20–30% smaller than the predecessor model, it can roll thinner gauges of higher-strength material with fewer rolling stands.

Shinichi Yasunari was key in developing this pathbreaking new generation of UCM. He started his career at Hitachi in 1986 and had worked his way up to head of the Cold Rolling Project Division at Mitsubishi-Hitachi Metals Machinery when the company became a part of Primetals Technologies. Embarking on an ambitious project to improve the UCM, he and his team of engineers carried out a comprehensive study to find the ideal combination of roll diameters for backup, intermediate, and work rolls so as to achieve optimum strip shape and keep contact pressure between rolls in the defined range. The result—what we now call the Hyper UCM—has higher reduction ability, delivers outstanding product quality at higher productivity, and lowers investment and maintenance costs at the same time. Shinichi Yasunari continues his pioneering work at the Hiroshima location of Primetals Technologies.

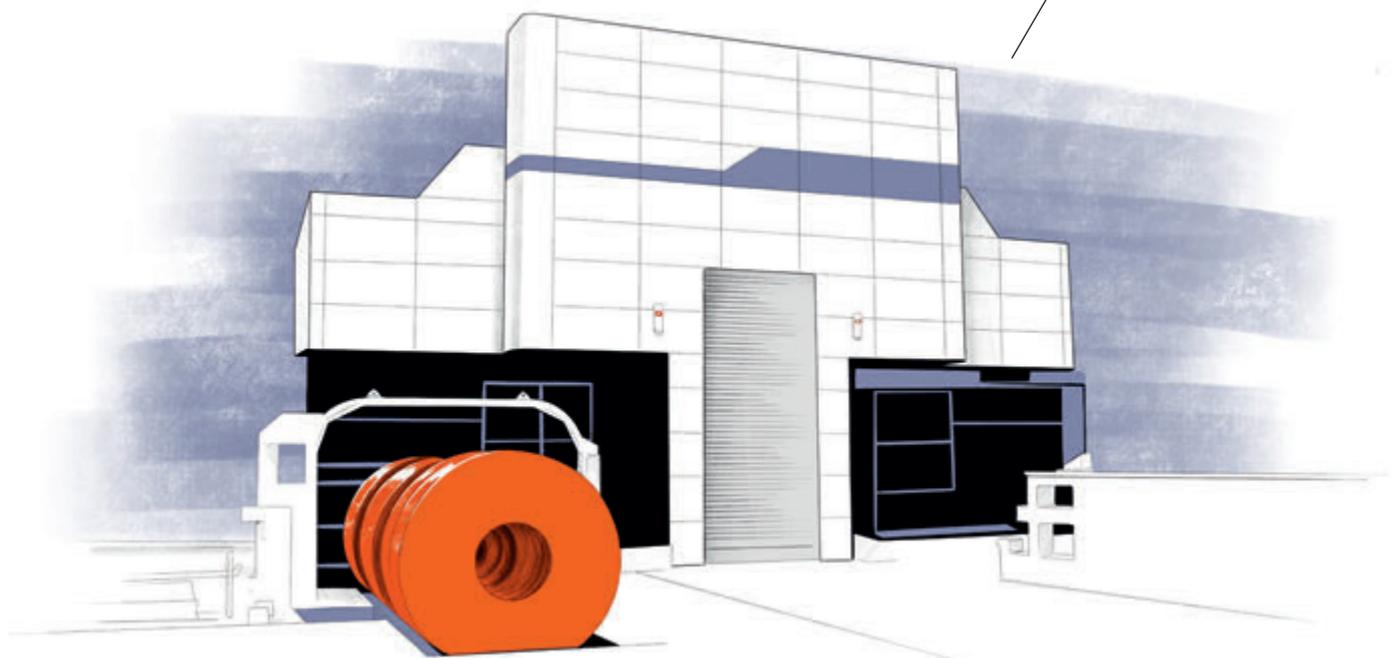


SHINICHI YASUNARI ...

... did groundbreaking work on the Hyper UCM and is now a Deputy Head of Project Management at Primetals Technologies.

THE HYPER UCM ...

... rolls thinner-gauge strip of higher-strength material by using optimal-diameter work, intermediate, and backup rolls.



TRACKING QUALITY

ALL THE WAY THROUGH

While quality tracking and quality assurance on single aggregates is quite common, there hasn't been an overarching system that connects all the dots. Until recently, that is. "Through-Process Quality Control," TPQC for short, is a software tracking system that taps into a wide array of data sources in an integrated plant and covers all parts of the metals-production chain—from hot metal all the way to the packaged coil. It is part of Primetals Technologies' Through-Process Optimization (TPO) and a major milestone for Industry 4.0 in metals production.

Dr. Klaus Seyerlehner of Primetals Technologies Austria has been instrumental in the development of TPQC from the get-go. He had been working on process optimization in continuous casting and considered it straightforward to expand the scope of his efforts to optimizing the entire production chain. "One of the biggest challenges was to store the massive amounts of data in a way that maximizes retrieval performance when accessing it," Seyerlehner says. He's particularly proud of the fact that TPQC breaks down traditional barriers between people and departments working on different parts of the production chain, allowing them to share data for mutual benefit. "To be able to project data in any direction, for example, from a slab to the finished coil, but also in the other direction—from the coil to the slab—makes TPQC absolutely unique, and a truly exciting tool to use."

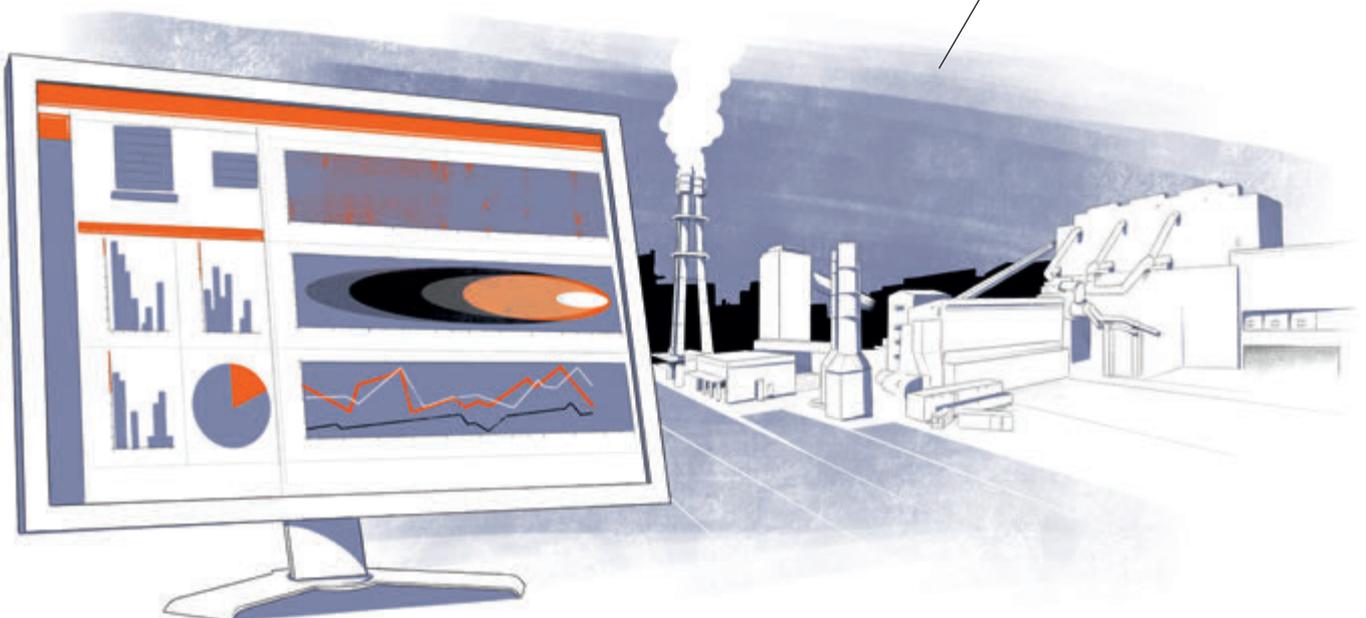


DR. KLAUS SEYERLEHNER ...

... is a software architect at Primetals Technologies, focused on innovation in the field of Through-Process Quality Control.

THROUGH-PROCESS QUALITY CONTROL (TPQC) ...

... is a software solution that collects and analyzes data from the entire production chain to optimize final-product quality.

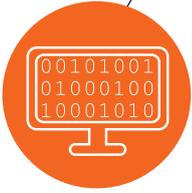




PIONEERING THE FUTURE OF METALS PRODUCTION

While we are proud of the innovative solutions we have created to date, our focus is not on the past but on the future of metals production. Our R&D specialists are working tirelessly on new technologies that will be instrumental in moving the metals industry forward. At our numerous company locations around the world, new innovations are currently being crafted, all of which share one common goal: they are designed to ensure the long-term success of our customers in the metals business. It is our customers and partners in the industry who inspire us to find new frontiers, take up new challenges, and strive to push the boundaries.

Some of these new technologies are showcased both directly and indirectly in the following articles of this issue of Metals Magazine. However, before we leave you to discover these—often intensely customer-oriented—solutions, we would like to outline our most strategically relevant focus areas in the years to come. It is these areas that we feel will matter the most, to us and to the metals industry at large. It is these areas that we will prioritize in our thinking and in setting our daily targets. And it is these areas that we will be working on with great dedication and commitment on behalf of our customers in the global metals business.



DIGITALIZATION & INDUSTRY 4.0

At Primetals Technologies, we believe that digitalization will ultimately lead to a fully automated plant. All of the processes that occur in steel-production facilities will be optimized by advanced artificial-intelligence algorithms, which will be based on both Big Data and our sophisticated Through-Process Optimization technology. The progress we are currently making in the field of digitalization will mean that end-product defects will progressively become a rarity. Workplace safety will improve dramatically with the use of robots in the more dangerous working areas of a steel plant. Refined condition-monitoring systems and augmented-reality solutions will help to anticipate, streamline, and schedule any necessary maintenance activities. Web-based services, provided by our powerful m.space platform, will make many things easier; for instance, ordering spare parts, organizing production-specific training, or storing sensitive documents. The path to Industry 4.0 will be neither straightforward nor short, but we are convinced it will be a fascinating journey for all involved.



GREEN PRODUCTION TECHNOLOGIES

There are many facets to green production, and they all contribute to environmentally responsible operations and long-term sustainability. One of the solutions already available from Primetals Technologies is the MEROS system, which removes dust and harmful metallic and organic components from sinter off-gas and achieves gas-cleaning levels that would be unattainable with conventional methods. Selective Waste-Gas Recirculation is another sintering-related solution that helps to protect the environment and save energy at the same time. Arvedi Endless Strip Production has gone from strength to strength in recent years; not only does it make true endless casting and rolling a reality, it also reduces energy consumption and slashes associated costs, with savings of up to 45%. The EAF Quantum is an electric arc furnace that pre-heats scrap in a specially designed shaft using furnace off-gas, increasing efficiency by 20% compared to conventional furnaces. Aside from these tried-and-tested eco-friendly solutions, Primetals Technologies is continually developing new approaches for even greener metals production.



ASSET-PRODUCTIVITY MAXIMIZATION

A thorough knowledge of what goes on in a plant is crucial for any steel producer; as is making this information available to those who need it, when they need it. The Maintenance and Asset Technology (MAT) from Primetals Technologies is designed to guide all maintenance-related activities by providing maintenance staff with customized, knowledge-based support. All instructions given by MAT are aligned with the core maintenance strategy of the respective steel producer. Other important aspects of asset productivity are plant upgrades and modernization projects. In many cases, they can provide more economic alternatives to building a new facility from scratch. Plant modernization, which can often be executed during scheduled plant downtimes, preserves existing value from previous investments and extends plant lifetime. Primetals Technologies offers many more solutions that promote asset productivity and continues to extend its portfolio in this area.



PLANT AND BUSINESS DEVELOPMENT

How can an entrepreneur best break into the metals business? What steps should a veteran steel producer take to improve operations, make portfolio adjustments, and find the right market segments to maximize profitability? The specialists at Primetals Technologies have decades of experience, both in building greenfield metals-production plants and in providing the proper guidance when new opportunities for established producers arise—for instance the manufacture of advanced high-strength steels. In all of these scenarios, detailed market analysis and technology-oriented consultation are required. Primetals Technologies offers support in project development at the earliest stages, opportunity and feasibility studies, environmental concepts and solutions, process- and technology-related know-how, and logistics optimization. These services are all possible thanks to Primetals Technologies' vast application knowledge and its uniquely innovative solutions. ●

RISING TO THE TOP **THROUGH INNOVATION**



HBIS TANGSTEEL'S DECISION TO BUILD A HIGH-QUALITY, DIGITALIZED COLD-ROLLING COMPLEX IS OPENING DOORS TO INTERNATIONAL MARKETS. WHAT GOT THEM THERE? A CLOSE PARTNERSHIP WITH PRIMETALS TECHNOLOGIES.



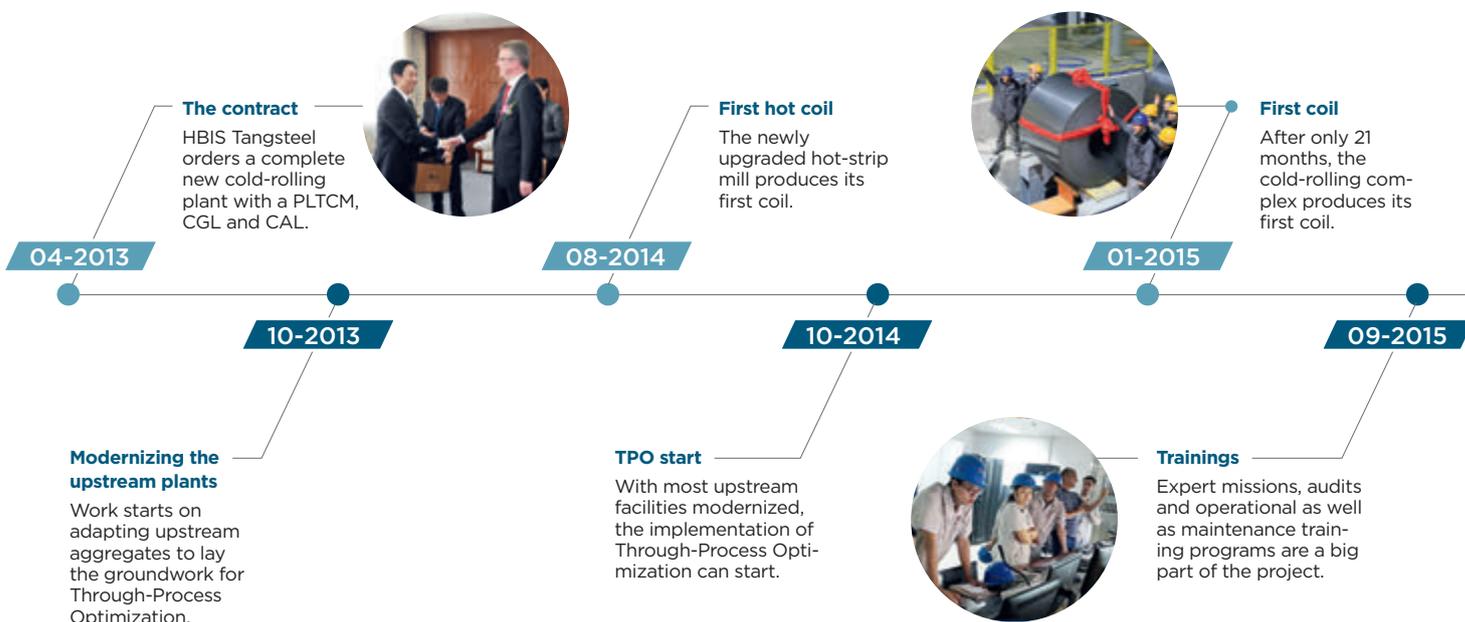
HBIS Tangsteel's production facilities are among the most powerful in the world and in China in particular—in terms of overall production capacity, end-product quality, and technical standards. Cutting-edge know-how based quality control facilitates short product-development times and reinforces the recently established ability to manufacture advanced high-strength steels. Primetals Technologies has accompanied and supported HBIS Tangsteel on their path to technical superiority in a partnership that has lasted six years and counting.

The project that HBIS Tangsteel and Primetals Technologies embarked on in the spring of 2013 was a particularly ambitious one. A contract had been signed to supply a linked pickling line and tandem cold mill, a continuous galvanizing line, and a continuous annealing line—all within a time-frame of just 21 months to the first coil. What followed were tremendous efforts from HBIS Tangsteel and Primetals Technologies to rise to the challenge. The two companies formed a strong partnership based on great commitment and a mutual goal: to have all of the new lines ready on the very same day. "Some of those involved doubted that it would be possible to get everything done in time," says Johann Siegl, Project Director at Primetals Technologies. "It was my job to prove them wrong." And with everyone's undivided support and a great team, he did.

A BIG DAY FOR EVERYONE

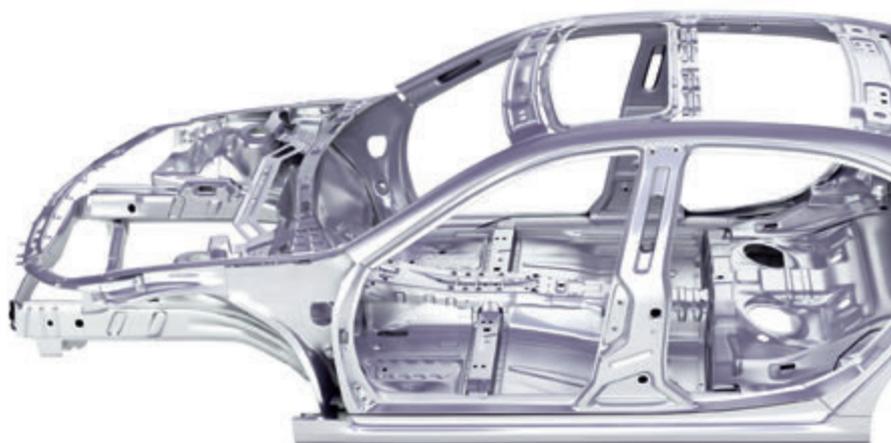
January 15, 2015, turned out to be the day when the entire undertaking was put to the test, because the first coil was to be rolled. "The whole project was very special to me," says Johann Siegl, "but that day will remain in my memory as one of the most challenging and gratifying of my professional career." It was a test of not just the technological equipment that had been installed, but also of the collective team that the two partners had formed: "Everybody gave 120 percent to accomplish what we set out to do."

Together, they first put the linked pickling line and tandem cold mill into operation. Then they started up the continuous annealing line, which would soon contribute to vastly improved strip quality, eventually allowing



**HIGH-STRENGTH
AUTOMOTIVE STEEL**

Getting into the international automotive steel market was a driving force for HBIS Tangsteel.



HBIS Tangsteel to target the automotive industry with their products. Finally, the continuous galvanizing line was initiated, and with equal success. The collective team was unashamedly proud of the achievement. A project of great complexity had been brought to fruition within the shortest possible time, and the thorough orchestration of all suppliers had worked out to everyone's satisfaction.

UPSTREAM MODERNIZATION

However, the new cold-mill complex was only the beginning of a larger plan to advance HBIS Tangsteel's capabilities. As early as the construction phase of the processing lines, the steel producer consulted with Primetals Technologies about additional upgrading measures for their upstream facilities. "The staff of

HBIS Tangsteel found that they could trust the still nascent partnership, which of course was a great honor to us," says Siegl. "We trusted each other, and were therefore able to go into deep discussions on how upstream operations could be enhanced to be the perfect counterpart to their new downstream competences."

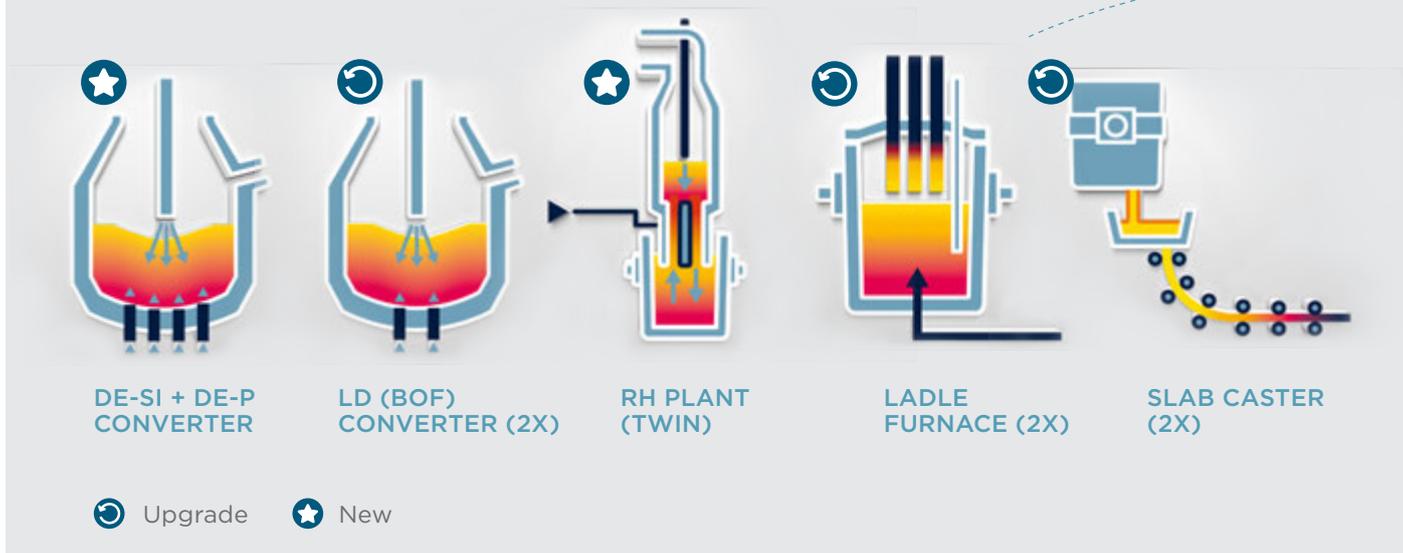
Together with HBIS Tangsteel's engineers, specialists from Primetals Technologies devised detailed plans to modernize the converters as well as the RH plant, ladle furnaces, slab casters, and the hot-strip mill, so that the complete steel-manufacturing process would be in alignment with state-of-the-art production methods. These plans were given the go-ahead in early 2014. Included with the upgrades to the pre-existing »



DIGITALIZING THE ENTIRE PRODUCTION CHAIN

To get HBIS Tangsteel ready for successful competition in the international automotive-steel market, Primetals Technologies embarked on a massive project with the company to upgrade existing upstream facilities and build a new cold-rolling complex. The undertaking was combined with extensive training, consulting, and culture-shaping measures. But the most vital part of the project was the implementation of Through-Process Optimization (TPO) along the entire chain of production—in order to fine-tune the aggregates for speedy product devel-

opment and maximum quality. The software works with roughly 8000 signals from 20 plants and systems. Almost 400 automation rules have been developed and 132 KPIs are continuously being monitored, with Big Data analytics tools working in the background. And things don't stop there. In the medium term, Tangsteel's parent company HBIS may choose to roll out Through-Process Optimization more broadly across its operations—integrating and analyzing data from several HBIS plant locations across China, with potential benefits on a large scale.



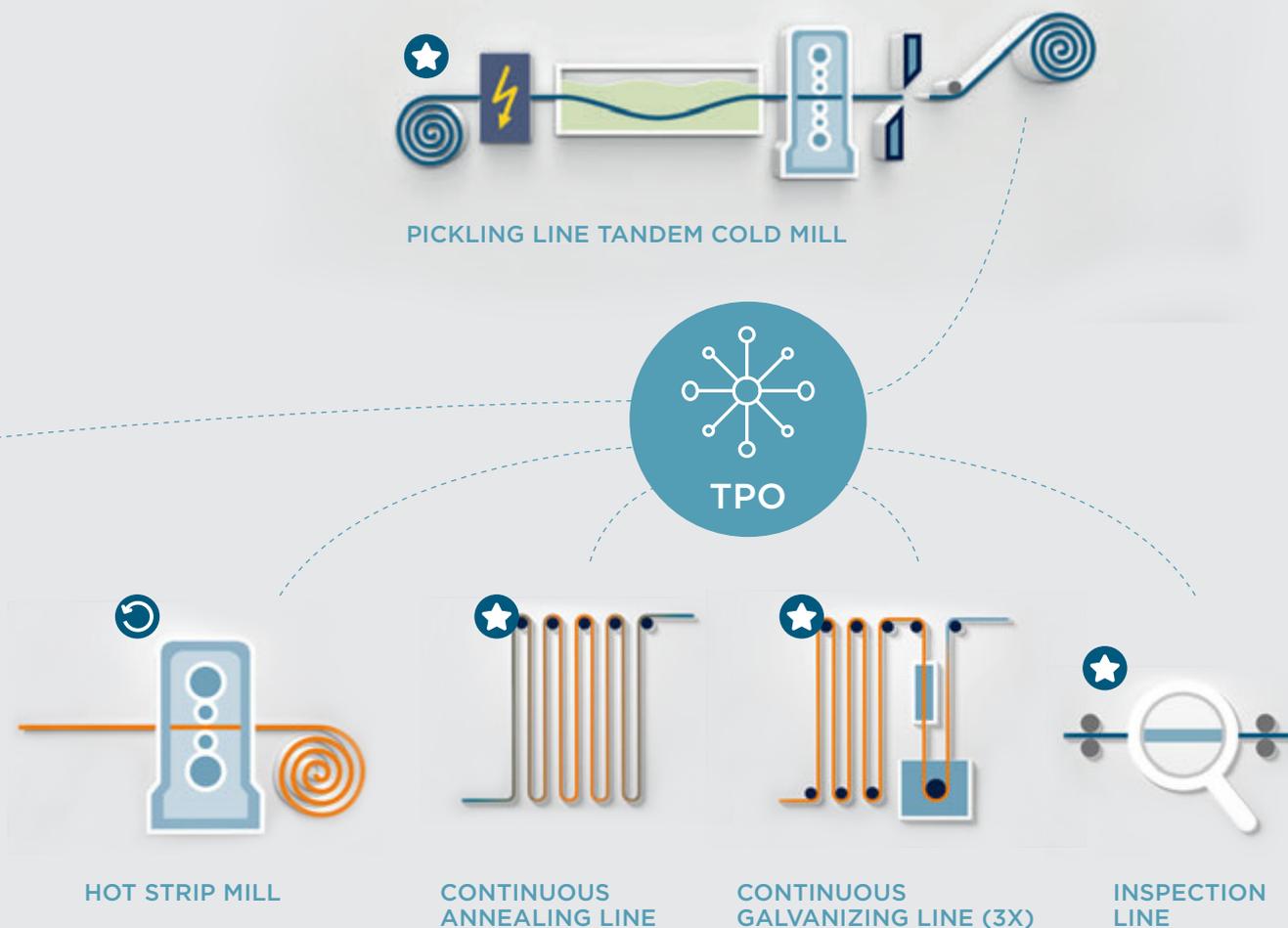
equipment were comprehensive Level 2 automation systems.

THROUGH-PROCESS OPTIMIZATION

The upgrades to the upstream area paved the way for the integration of Primetals Technologies' unique Through-Process Optimization (TPO). TPO consists of Through-Process Quality-Control (TPQC), a powerful and highly customizable rule-based IT system, and Through-Process Know-How (TPKH), the rich and wide-ranging process know-how and metallurgical expertise that Primetals Technologies has acquired over the decades. TPO provides steel producers with deep insights and positively impacts a plant's overall production output, product quality, the speed with which new products can be developed, the ramp-up time after upgrades or modifications to the production lines, and the ease and efficiency of troubleshooting and process optimization.

“TPO increases overall output, speeds up product development, and makes troubleshooting and process optimization easier.”

Dr. Jan Friedemann Plaul



For TPO to fully realize its potential, it has to be implemented across the full production chain of the plant. In the case of HBIS Tangsteel's facilities, this meant that many aggregates had to be upgraded and Level 2 automation had to be installed, which then allowed for the introduction of Primetals Technologies' exceptional TPQC software. The teams from both sides partnered up to ensure that all production-related equipment would be capable of generating the data required for TPQC to comprehensively cover the full production setup.

EXPERT CONSULTATION

To optimally support local management and crew in starting to use their new equipment, Primetals Technologies arranged several rounds of training sessions—with over one hundred experts from both Primetals Technologies and other specialized companies. HBIS Tangsteel's leadership team and production staff were

impressively open to analyzing and improving some of their established internal processes. Their aim was to optimize operations to make best-possible use of all newly installed solutions. Numerous experts from Primetals Technologies made it their priority to foster HBIS Tangsteel's internal development, not just with detailed training sessions but also with impulses for how certain shifts in corporate culture might further improve overall performance. It was a remarkable learning experience for all involved.

SUCCESSES WITH TPO

"Primetals Technologies' TPO solution impressed us more and more the longer we worked with it," says Pei Hongjiang, the Deputy General Manager of the Production and Quality Department at HBIS Tangsteel. "We can now make faster and more informed decisions when something unexpected happens." Pei is particularly pleased that his company acquired additional »



GETTING PRODUCERS READY FOR THE AUTOMOTIVE MARKET

Dr. Jan Friedemann Plaul is Vice President of Through-Process Know-How at Primetals Technologies.

What does it take for a steelmaker to compete in today's market for automotive steel?

Plaul: In addition to the technical ability to produce high-quality automotive steels, producers need to build and maintain a close relationship with their customers. They need a capability to understand their partners' needs and act on new technical requirements very quickly. What's crucial for this is a deep understanding of processes and products—in order to fine-tune and streamline them for the best results.

How was Primetals Technologies able to help HBIS Tangsteel on its path to becoming a supplier for international customers?

Plaul: The basis, of course, was the future-oriented plant technology that we implemented. But another important part was our continued support with expert know-how for developing new products and bringing them to market, as well as in-depth analysis with regard to optimizing overall plant efficiency.

What did you find most rewarding when working on the project?

Plaul: I was very impressed with the way the project was executed within such a short time-frame, and how quickly the plant started operating successfully. During all phases, HBIS Tangsteel treated us as a partner, and not just as a supplier. The result was a very strong relationship.

certificates such as one from Italian FIAT Automobiles: "Our new certificates validated for us that we were on the right track. But our success in upgrading and extending our product portfolio was even more important. We can now manufacture a variety of advanced high-strength steels, which is something we are very proud of." HBIS Tangsteel's products are in high demand especially on the Chinese market but also worldwide, and the successful implementation of TPO is seen as one of the most important contributing factors to putting the company in this position.

"The major benefit of the TPQC system—aside from the intelligent Quality Control functionality—is the quick and direct access to high-resolution process data along the entire steel-production route," says Dr. Jan Friedemann Plaul, Vice President of TPKH at Primetals Technologies. "This data can be processed by modern data-analytics tools to support the development of new steel grades. With this technology, development time for new products can be shortened dramatically."

"Another important benefit of TPO is that it enables Key Performance Indicator (KPI) tracking, which HBIS Tangsteel makes extensive use of," Dr. Plaul continues. "We spent significant time setting up and fine-tuning all process-related and quality-relevant indicators to monitor all relevant parts of the company's operations. This required close alignment with their long-term goals. We partnered on a very deep level to make sure the full production chain was optimally covered."

Like any globally active steel producer, HBIS Tangsteel is strongly results-oriented, adds Plaul: "TPO not only helps to verify that targets are met, but also offers swift, easy, and comprehensive troubleshooting in case something does not go exactly according to plan."

When asked about what he considers the most fascinating aspect of the TPO project at the Tangshan works, Plaul points to its sheer complexity. "Together with HBIS Tangsteel, we succeeded in setting up »

“ The TPO solution impressed us more and more the longer we worked with it.”

Pei Hongjiang

The "PropertyMon" monitors quality with electromagnetic measurements along the entire length of the strip.



TPQC so that it could deal with the process units of their entire steel-production route, which clearly was no small feat. A great number of people, with different cultural and technological backgrounds, worked in unison to ensure the most efficient production of modern steel grades at best quality.”

A BRIGHT OUTLOOK FOR HBIS TANGSTEEL

Among the steel grades HBIS Tangsteel is able to produce today are several types of advanced high-strength steels, which the company supplies to the automotive industry and other sectors. HBIS Tangsteel today is a global player with customers in 150 countries and belongs to the major league of the steel industry—a result not only of the company’s own

determination and dedication to excellence, but also of the solutions supplied by Primetals Technologies.

The partnership is set to continue: In a move that will further strengthen their ties, the two companies formed a joint venture for services that started operations in September 2017 with a 400-strong crew. In several locations within Hebei province, Primetals Tangshan Technology Services (PTTS) will offer comprehensive technology-based services in offline maintenance, equipment refurbishment, condition monitoring, as well as operational support.

Another aim for future collaboration is to intelligently link the various operations of HBIS Group across the



1. Two continuous galvanizing lines and their surface-inspection systems are part of the plant’s Through-Process Optimization.

2. HBIS Tangsteel is now targeting international automotive-steel markets with its high-quality products.



“**The TPQC system plays an important role in process control and quality supervision at Tangsteel.**”

Pei Hongjiang

region, gradually integrating them all into an overarching Through-Process Optimization system. This move will facilitate inter-company benchmarking and the transfer of product-development know-how. And it will even make it possible to assign orders based on cost and quality criteria derived from the exchange of data.

More is currently being planned in what has turned out to be an exceptional success story for all involved. With HBIS Tangsteel's refined portfolio, the steel producer is on track for a bright future, and the company will undoubtedly go on to become one of China's most relevant market leaders in the world of metals production. ●



REAPING THE BENEFITS OF A LASTING PARTNERSHIP

Pei Hongjiang is the Deputy General Manager of the Production and Quality Department at HBIS Tangsteel.

How does HBIS Tangsteel benefit from the upgrades and new plants that Primetals Technologies supplied?

Pei: This project enabled Tangsteel to start the production of high-strength automotive sheet. Soon after its startup at the end of 2015, Tangsteel started mass supply to major local household-appliance manufacturers. Since 2016 the production of automotive sheet has increased steadily and the product has been supplied not only to local producers but also well-known international car makers.

What are the specific advantages of digitalizing your operations?

Pei: By using automation-control systems from Primetals Technologies, our production lines have reached the top level of automation as compared to local companies. Also the TPQC system plays an important role in process control and quality supervision. Especially in the event of product quality deviations it can trace the root causes and help with further rectification and quality improvement.

The crew at HBIS Tangsteel received extensive training, both in China and in Europe. How did this help you achieve your goals?

Pei: Using its resources, Primetals Technologies arranged for local and foreign metallurgical and automation experts to provide process, know-how and operation training to Tangsteel personnel. This training has, among other things, played a critical role in the optimization of deep-drawing steel properties and the development of grades with special coating.

THE POTENTIAL OF DISRUPTION

**INTERVIEW WITH PROF. MICHAEL SHAMIYEH ABOUT
WHAT LARGER COMPANIES CAN DO TO PIONEER
NEW INNOVATIONS IN THE AGE OF DISRUPTION.**

Professor Michael Shamiyeh is a trained architect, a versatile scholar with a PhD in strategic management, and an expert in the field of “future-oriented thinking.” He teaches at Stanford University, U.S.A., the University of St. Gallen, Switzerland, and the University of Art and Design in Linz, Austria. Together with his academic partners, he has founded the Linz-based “Center for Future Design,” which aims to provide larger corporations with a new approach and the necessary tools to start thinking out of the box. We asked Shamiyeh about the challenges of pioneering disruptive ideas in established contexts.

What is your approach at the Center for Future Design?

Professor Michael Shamiyeh: We have a different take on how to introduce new ideas into traditional business practices. Rather than trying to adapt and get into “problem-solving mode,” we teach leaders to tackle challenges based on “future thinking.” This is a much-used approach in architecture, where you have to leave any pre-existing frames of reference behind to find a new modus operandi that reflects the times and the challenges at hand. The result is often disruptive but carries more potential than simply altering what existed previously, so it’s dramatically more powerful. At our Center for Future Design, we help companies discover how they can tap into this often unused potential.

Are disruptions more prevalent in information technology companies than in enterprises in the steel industry?

Shamiyeh: I think disruptions are becoming more prevalent in all areas of life, which extends to business administration. Professor Clayton Christensen from Harvard Business School coined the term “disruptive innovation” in the 90s, and we have clearly seen an increase in profound disruptions since then. According to Christensen, disruptions tend to originate in areas unrelated to where their ramifications are ultimately felt most strongly. It is not surprising to see, for instance, artificial intelligence technologies enter unexpected fields to play a major role and introduce extensive change.



“Pioneers should not just be brave but also excel at managing risk.”

Can you name a few examples of such disruptive technologies?

Shamiyeh: Uber certainly comes to mind. The company revolutionized the way taxi companies work. Uber doesn't own and operate cars—it just connects drivers with passengers. The company is successful thanks to the network infrastructure provided by the Internet and the saturation of today's smartphones. Airbnb is a similar story: instead of building hotels, renting out rooms, and providing all the related services, Airbnb simply allows private parties to list spare rooms in their houses and apartments for guests to book. It's an entirely different model than that of the hotel industry.

In one of your essays, you state that today the most disruptive innovations are created not by incumbents but by new market entrants. Do you see this trend continuing?

Shamiyeh: Disruptions tend to happen on the margins of today's established industries rather than at their center. One important reason why this is the case is that larger corporations are often overly focused on their existing customers, and they base their product development strategy mainly on customer feedback. This can lead to a vicious circle in terms of self-referential innovation and a lack of out-of-the-box thinking. It is then up to new market entrants to challenge this approach and introduce disruptive innovations. »



What can market leaders do to compensate for their shortcomings and stay on the technological edge—or even to pioneer new innovations in their fields?

Shamiyeh: First and foremost, they have to be open to new sources of input. Likewise, they have to spot changes in the industry long before markets and competitors recognize that change is afoot. In essence, larger companies have to open themselves up to new ways of thinking. They can invite people with different backgrounds to give presentations, or they can make the conscious effort to hire new employees with contrasting skill sets. I use three terms to characterize this strategy: building awareness of other approaches and new ways of thinking, allowing the involvement of people with different backgrounds, and embedding new ideas and methods into existing operations.

Are there any important qualities in people who strive to actively shape the future?

Shamiyeh: Certainly. Pioneers such as Ferdinand Porsche [the automotive engineer and founder of the Porsche car company] usually have one common strength: they are capable of “re-framing” prevailing ideas and concepts. They can place models that stem from one distinct field into other contexts and produce

unexpected results. They are able to question common presuppositions and introduce new perspectives.

What is it that enables these pioneers to “re-frame” ideas?

Shamiyeh: It is their ability to switch from one frame of reference to another. Let’s again use Porsche as an example. Porsche was a trained plumber and electrician, who first brought his knowledge into the electrification of factories and later revolutionized the automotive world with the electrically powered wheel-hub motor. He could not have built car engines without his training, even though his training was intended to qualify him for something much less revolutionary. It was all about what he could do with his knowledge rather than what he was supposed to do with it. He reinvented himself—and his craft—and used what he had learned in a different way.

If the ability to “re-frame” is so important, why are universities not encouraging this practice more?

Shamiyeh: Well, in fact, some universities are actively doing this. Stanford University, for instance, actively encourages its students to get their master’s degrees in fields unrelated to their bachelor’s degrees. Students

“Disruptions tend to originate in areas unrelated to where their ramifications are ultimately felt most strongly.”



are almost expected to switch fields once or twice. In Europe, to this day, many students stay within the same field over the entirety of their education. In that way, I think they really miss out on the chance to thoroughly explore possibilities and re-frame their ideas.

Is bravery another essential characteristic for a pioneer?

Shamiyeh: Sure, you have to be brave to attempt doing something in a new and different way, because your ambitions will probably be misunderstood; but I would like to emphasize that in my opinion it is not necessary to take great risks to be a successful pioneer. A person can be brave and be a prudent risk manager at the same time—I am convinced that these two qualities are not mutually exclusive.

What's more important: bravery or excellent risk management?

Shamiyeh: There is no general answer to that question. What I would like to point out is that it's really not good advice when people tell you to “be brave and take risks.” Often, it's much better to be brave and conscious of the risks you are facing. Bravery is best achieved when it comes with a sufficient amount of reason and thought. There are many examples of well-

known pioneers who I believe would immediately subscribe to this notion, from Bill Gates to the founders of Google. If you read their biographies carefully, you will notice that they shied away from taking unnecessary risks, and yet they were incredibly brave and pioneered the innovations that would shape the future of their generation. ●

THE FORESIGHT JOURNEY

Professor Michael Shamiyeh and his partners from Stanford University, the University of St. Gallen, and the University of Art and Design in Linz offer a new and exclusive program called “The Foresight Journey.” The program is designed to provide managers with the knowledge needed to incorporate disruptive ideas into existing company structures. More information on this six-month course can be found at the website www.c-fd.eu.

THE KIND SPIRIT OF **WESTERN INDIA**



MUMBAI IS THE FEATURED COMPANY LOCATION IN THIS ISSUE OF METALS MAGAZINE



The Turbhe workshop of Primetals Technologies, situated ten miles east of the city of Mumbai, is home to 175 employees, making it the second-largest company location in India. The staff not only has comprehensive manufacturing expertise but also specializes in engineering work in the areas of electrics & automation and long rolling. A unique family atmosphere contributes to the location's high productivity, feeling of camaraderie, and mutual support—support that Dr. Tom Widter greatly appreciated when he visited the location at the peak of the monsoon season ...

An hour before my plane descends to Mumbai airport, the sky suddenly goes dark. Pitch black. Only minutes later, turbulence sets in, and the aircraft is shaken like a fish in a waterfall. Intense rain lashes against the windows, effectively reducing outside visibility to zero. The monsoon is in full force, with everything it is known and respected for. Just how the pilots manage to bring down the aircraft I don't know, but when they do, everyone applauds.

As I exit the plane, I am greeted by humidity levels unknown to Europe. The moisture seems to have crept into everything, from the nice carpet floor at Mumbai airport and the papers at immigration to the sheets of the hotel bed that I fall into after a long day of travel. I go to sleep knowing that, the next morning, I will be taking a two-hour taxi ride to Primetals Technologies' Turbhe location, 10 miles east of Mumbai, and that I'll be encountering some of India's most extreme sides—including the slums, people washing their clothes in the river, barely drivable roads, and more of the relentless rain.

But from the moment I set foot in India, I also encounter incredible beauty, great kindness, and the country's very own tastes and smells. Never before have I seen women wear dresses as colorful and elegantly simple, strangers helping each other in the street, and youngsters celebrating the moment rather than focusing on their future and its uncertainties. It seems to me that Indians live for these wonderful mutual experiences.

A PLACE OF GREAT SOLIDARITY

Soon after my arrival at the company location, I talk to Sharad Budhia, who is Head of Metallurgical Services at Primetals Technologies India. He confirms my first impression of the Indian people: "The willingness to support one another is deeply ingrained in the Indian spirit," he says. "It is amazing to watch the people of Mumbai during the monsoon season. Sometimes, it will rain so hard that traffic comes to a standstill. You can get stuck for hours and hours. And when that happens, the locals start to offer tea to complete strangers. They even serve them food, all out of compassion and solidarity. You will encounter this kind of hospitality in all of India, but particularly so in Mumbai. It is a very special place." Budhia is noticeably happy to live in Mumbai, and he is pleased with the Turbhe company location, its capabilities, and especially its workforce.

His feelings are shared by Shyam Mishra, Head of Manufacturing in Turbhe. Mishra ensures that the site's engineering and manufacturing capabilities are well aligned with the needs of the metallurgical services business, not just within India but worldwide. "I am particularly proud of our bending blocks, balancing blocks, Hydraulic Automated Gauge Control (HAGC) cylinders, shears, Morgoil bushings, and our various kinds of guides," he says as he ushers me through the workshop. "Making these products requires great skill and accuracy, as well as dedication to quality. These items nicely showcase the competences of our workshop." »

MUMBAI

The company location in Mumbai, India, unites an on-site workshop and engineering competence with a focus on components for metallurgical services.



PRODUCTS FOR A WORLDWIDE MARKET

Walking through the workshop, Mishra and I stop at a large pile of what he tells me are water-box nozzles. “We make around 5,000 to 6,000 of those per year,” he says. “A large quantity is exported to the U.S.A. and other countries.” No wonder the nozzles are in high demand: as I inspect them more closely, the sheer quality of manufacturing is strikingly evident. They have been made with great precision, and they are so consistent that I could not tell one from another.

As we continue to explore the site, Mishra turns to workman Mahendra Jambhle, who has just finalized several insert cooling nozzles, which will be used in water-box assembly by a Polish customer. Satisfied with his work, he shows us the manufacturing steps he has followed to ensure high product quality and reliability. Watching him, I can tell that he is passionate about what he does, and also highly skilled and experienced. He knows exactly what his machine is doing at any point in time.

I soon realize just how many different kinds of products the Turbhe workshop is capable of making. We pass by a worker manufacturing insert RE-150 elements, which are rugged and weighty and look utterly indestructible. The workshop offers much to the eye, and it is hard to choose what to focus on next. We

“A large percentage of our products is exported to the U.S.A. and other countries.”

arrive at our last stop in the small-machining section of the workshop, where Sanket Kolaskar is manufacturing nozzle components using a piece of equipment that was installed only recently. “This machine was actually inaugurated by our CEO Satoru Iijima a few weeks ago,” Kolaskar informs me. As he says it, I notice a specially designed plaque attached to the machine with Iijima’s name and photo. “We are all one company,” workshop head Mishra points out. “It was great to show our CEO what we can do here, and I think that he was very pleased.”

THE LARGE-MACHINING SECTION

The workshop is split into two main segments, the small-machining section, where we started our walk,



Workshop head Shyam Mishra and Assistant General Manager Pramod Sathe in front of their workshop capacity planner.



The Turbhe workshop makes 5,000 to 6,000 of these water-box nozzles per year and ships most of them overseas.



In the beginning, this bending block was just one large piece of metal. The workshop team then “sculpted” the final product.

and the large-machining section, which we are now entering. We turn our attention to a product significantly larger than any of the previous ones, a bending block. “It takes about 150 man-hours to make one of these,” Mishra explains. “We start with just a large square piece of metal and then ‘sculpt’ it until the final bending block has emerged.” I remember the famous quote by Michelangelo, who was asked how he went about creating his marvelous sculptures. “When I make a lion, I simply chip away everything that does not look like a lion,” he is believed to have said. The workshop staff at Turbhe might follow a similar approach, if arguably with a somewhat more practical goal in mind.

Surprised by the size and high utilization of the workshop area, I ask Mishra how many employees he currently manages. “In the workshop area alone, we are now employing 66 people, if I count both the workshop staff and those of our office workers who directly support the workshop,” he says. “Additionally, we have up to 22 contractor-sourced workers on site, and a staff of 7 who are assigned to supply-chain related tasks.” Most workers are on rotation, learning to master the relevant work processes on several machines. This measure both strengthens the team spirit and ensures that overall operations can be easily maintained in case someone is involuntarily absent.

The large-machining section features some pretty impressive equipment. HAGC cylinders can be tested on site with a high-pressure HAGC testing stand. Shyam Mishra guides me to a yellow-colored HAGC cylinder that his team has just finished reconditioning. They are very happy with the end result—and they are confident that their customer will feel the same way. Mishra then takes me to a room in which he keeps the babbitt-welding equipment. With the monsoon season in full swing, babbitt welding is currently on hold. Some of the workshop’s gear is even covered in plastic to make sure that the moisture doesn’t affect its operability. Since the workshop’s overall portfolio is large and the production pipeline is well-scheduled, this is not a problem.

Owing to this quite extensive portfolio, not all of the products made at the workshop are being manufactured at the time of my visit. An especially impressive product, the Heavy Duty 1080 Shear, was recently exported to Brazil but is not “on display” at the moment for me to photograph. The same is true for some of the larger chocks made in Turbhe. Those were recently shipped to Canada, the U.S.A., Mexico, Indonesia, and other countries. I luckily do encounter a newly made Morgoil bushing, a remarkable and highly sought-after product, huge in size and extremely evenly manufactured. »



Factory worker Mahendra Jambhle proudly presents the insert cooling nozzles that he made. These are for water-box assembly.



These are some of the ERG guides the workshop manufactures. The ones shown in the picture are made for the U.S. market.



The workshop team is especially proud of the recent reconditioning of this HAGC cylinder. They have a testing stand on site.

EXPERTISE IN GUIDE MANUFACTURING

Guides for handling stock in rolling lines are another one of the workshop's specialties. Many customers require custom guide designs, which the workshop staff and the on-site engineers tackle in close collaboration. In many cases, some ingenuity will be required, and the staff will go to great lengths to ensure customer satisfaction. "A while ago, a steel producer desperately required new guides but was a bit doubtful that our solution would work for them," I am told. "To convince them, we gave them the opportunity to examine the new guide concept directly in their facility. We implemented a quite elaborate test setup, which worked extremely well and gave the customer the assurance they needed to go ahead and purchase it." I ask Mishra how much customization work the factory usually handles. "Depending on the situation, about 10 to 15 percent of our total work volume at a given time will be customization work," he replies. "That figure will likely increase in the future."

On our way back to the small-machinery area, we walk by a large stack of Entry and Receiving (ERG) guides. The workshop manufactures these guides in large quantities, and much of the production is exported to countries such as the U.S.A., Argentina, Mexico, Taiwan, and the Czech Republic. Speaking to Mishra, it turns out that this type of guide is actually one of the simpler ones, and that the workshop makes a variety of much more complex guides for the local and overseas markets.

WHY SAFETY COMES IN CANS

As we conclude our workshop tour, Mishra and I stop at a large wall covered with posters drawn by the staff. We look at several dozen of the sketches, which the workers came up with to remind themselves to focus on their own safety and that of their colleagues. Some of the drawings strike a more serious note, some are more lighthearted, and some are openly amusing. I particularly like one that reads, "Safety comes in cans:



WHAT MAKES ME PROUD TO BE INDIAN ...

Employees of Primetals Technologies share many passions, such as pioneering new solutions for their customers. But every location also has unique qualities. In this section, we catch a glimpse of what makes India so special.



“ We have a very rich and positive culture, and learn to take care of each other from early childhood onward. This is why we take such good care of our customers.”

Jayant Gujar
General Manager, Expediting and Quality Control



“ Indians are very tolerant due to the many languages spoken in the country and the plurality of religions. We are also very caring and have many tradition-rich festivals.”

Rajendra Kharade
Deputy General Manager, Quality Control

I can, you can, we can.” The kind of humor found here might be a bit outlandish for some, but it does drive home the point that the initiative is trying to make.

“Your family needs you. Work safe for yourself,” reads another one of the workers’ drawings. Studying it, I get the feeling that in a way the entire staff at the Turbhe location is very close to being a big family in its own right—a family not by birth but by choice. Mishra confirms my impression: “Absolutely, this is a very family-like workshop with very high safety standards, well maintained, and with a medicare facility on site. We look after each other here, and we take good care of the workshop in general.”

READY FOR THE DIGITAL FUTURE

Mishra and I now head back to the conference room for a final discussion. I wonder what best to ask him to find out more about the outlook for the location, and I

settle for digitalization as a keyword. How will the trend toward Industry 4.0 impact the workshop? “All of our production machines are already fully automated,” Mishra says. “Aside from that, and speaking more strictly about digitalization, we are currently conceptualizing what changes we will be making to optimally support the steel industry in this development. These changes mostly concern us on a plant level rather than on a product level. They might take some time, but in the end they will greatly improve our operations.”

Does he think that there will be job losses in the steel industry—and potentially in his workshop—due to intelligent machines taking over? His answer is one of the smartest and to-the-point statements I have come across on the subject matter. “I am pretty fearless in this regard,” he says. “Job loss has never happened because of advancements in technology but because of a lack of training. Here, we have to be strong and »



“ I am really fond of our national anthem. Also, I like the numerous regional festivals—such as Maharashtrian, Gujrati, and Punjabi. They make India so unique.”

Aarti Warang
Procurement Manager, Supply-Chain Management



“ I am proud of the diversity of the Indian people, with the different castes, different regions, and different religions.”

Vaibhav Amrute
Operator, Vertical Machining Center



“ We have unity in diversity—from food to regional festivals to languages. India also has great potential to grow economically. Other strengths are our beautiful scenery and our history, which goes back millennia.”

Abhijit Deherkar
Head of Human Resources, Primetals Technologies India



GUIDING INNOVATION IN INDIA AND BEYOND

Suraj Arumughan has been with Primetals Technologies since 2010 and has decades of experience in the construction of guides.

What invention are you most proud of?

Suraj Arumughan: I come up with new solutions when the need arises. With guides, not everything is standardized. So I engineered a lot of customized guides, and am proud of them all.

How important was your training in preparing you to come up with unique, new solutions?

Suraj: I did a lot of hands-on work, and learned in a very immediate way—on the job—what will work and what won't.

Do you work systematically toward new ideas, or do they just come to you “out of the blue?”

Suraj: Whenever a new challenge is posed to me, I can't stop thinking about it, be it day or night. I then think of different potential solutions and try them out in my head before implementing them for real. The ultimate goal is to find the most simple and straightforward solution, because it is usually the most satisfactory one to our customers.

Can you describe one of your main sources of inspiration for your work?

Suraj: Working with people from different cultures has extended my world view and my perception of the steel business in particular, and it has been of great inspiration to me. I have, for instance, worked with people from Nigeria, Ukraine, Qatar, Bangladesh, Sri Lanka, and Egypt—all with different cultural backgrounds and different technical standards.

“**Job loss has never happened because of advancements in technology but because of a lack of training.**”

think ahead. And we will.” He certainly has me convinced that the Turbhe staff will rise to the challenge.

THANK YOU, INDIA

After three days at the Turbhe workshop, my visit comes to an end. I have learned a lot about the place—not just about the company location but the Mumbai area as well. I have learned not to interpret the kindness of strangers as deception (a taxi driver tried to trick me, and I had a hard time trusting hotel staff with my luggage afterward); I have learned about the benefits of vegetarian cuisine; I have seen just how much even the poorest of us are capable of enjoying the moment—for instance, teenagers dancing in the rain, making music, celebrating life as it comes. Most importantly, I have learned to surrender my intellect when I notice that something is simply beyond my understanding. India's culture is without equal, and with one week's worth of experience, I have barely scratched the surface.

Waiting at Mumbai airport for my 3-am flight to start boarding, I wonder what role India might play in the coming decades. Its people made a huge impression on me: Not only were they extremely friendly and open, they were also prepared to see the world around them with a clarity I have not encountered anywhere else. They were ready to take their future at face value. And no matter what role someone played, major or minor, they knew where they fit in—in the larger scheme of things. In the many interviews I did in Turbhe, I found that everyone had an acute sense of what was around the corner, technologically, economically, and politically.

I enter the plane, and just as it takes off and leaves the monsoon behind, I decide to conclude my story with a prediction: I'd be willing to bet that by the time our still nascent century ends, some of its greatest visionaries, innovators, and pioneers will have come from India. I have seen the country's potential, I have felt it, and I must say that I profoundly believe in it. I only hope that those future greats will stay in their home country—and make India the essential player on the world stage it deserves to be.

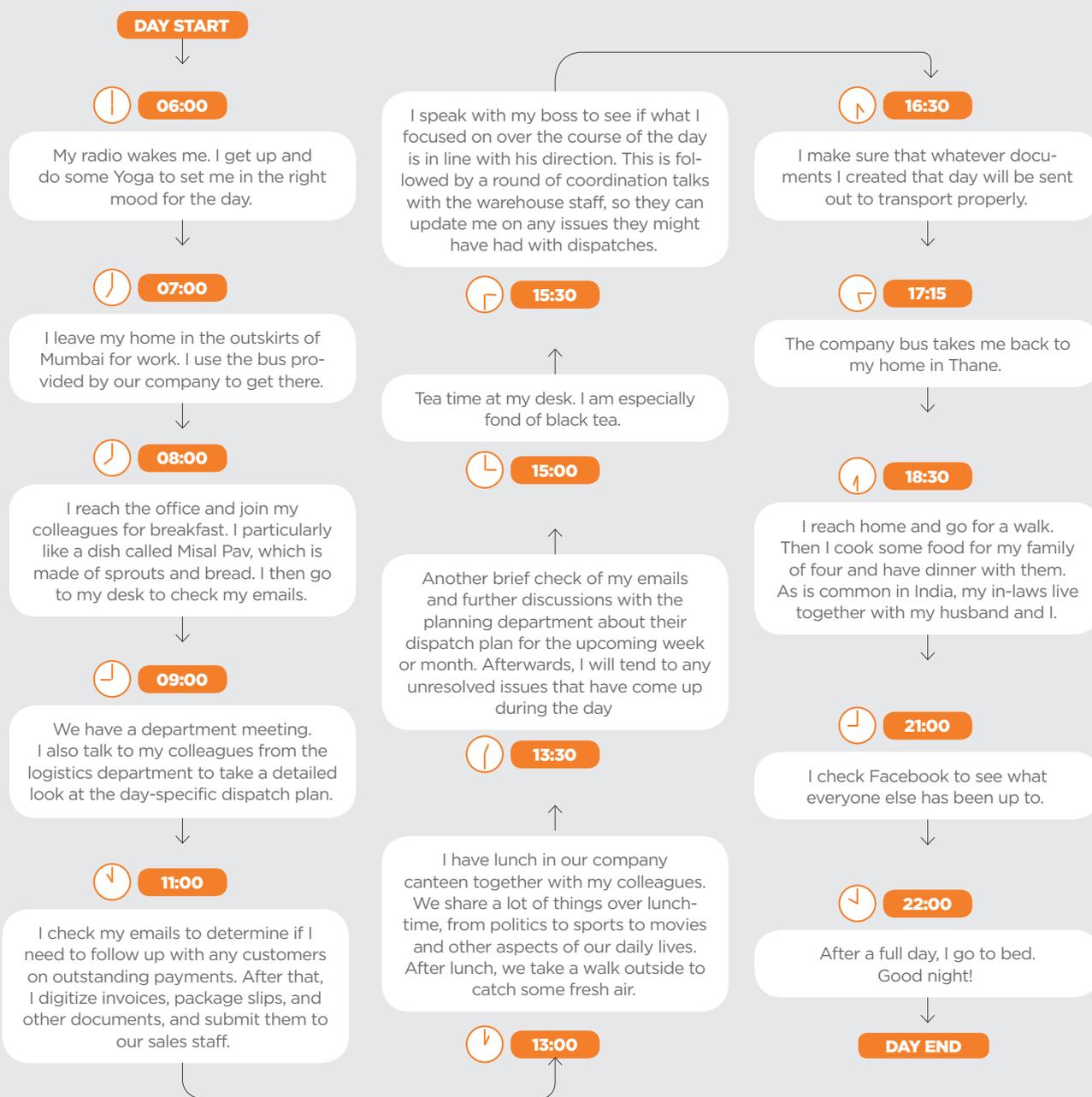
A DAY IN THE LIFE OF RUTUJA GOLHAR

As part of the series "Visiting the Company Locations of Primetals Technologies," the editorial team of Metals Magazine sits down with one employee of the respective location—with the aim of illustrating what a regular work day is like for them.



RUTUJA GOLHAR

We asked Rutuja Golhar to tell us what a typical day in her life is like.





1



2



3a



3b

EXPERIENCING THE COMPANY LOCATION AND THE GREATER MUMBAI REGION

1. WORKER SAFETY

In order to raise awareness among the staff that safety has to come first, the management at the Turbhe location initiated a drawing contest. Everyone working in the factory was invited to create an illustration of what a safe working environment meant to them, and what they felt they could contribute to enforcing it. If they wanted to feature writing as part of their sketches, employees had the option to either use English or Hindi as the base language. The results are highly creative and range from quite serious to very humorous. "Safety starts with me," claims one poster; "Our goal must be zero accidents," states another. One revisits ancient Roman wisdom: "Healthy minds at work," ensuring equally healthy bodies.

2. COCONUT TREES

On the margins of the premises of the Turbhe location, you will find what you might first identify as palm trees. In actual fact, they are nothing less than coconut trees, even bearing fruit. According to the workshop staff, so far no coconuts have fallen at unfortunate times. Equally, they rarely provide additional nourishment to the workers, as they seem to disappear by themselves—it is likely that passers-by take them as soon as they've dropped. Regardless, coconut is one of the favorite ingredients of Indian cuisine in some parts of the country. The canteen at the Turbhe location of Primetals Technologies offers the staff a wide variety in terms of food, and sometimes makes dishes with a distinctive coconut taste.

3. THE KARLA CAVES

There are several historic caves to be discovered in the Mumbai region, and the Karla Caves are among the most beautiful and impressive ones. The oldest of the Karla Caves dates back as far as 160 BC, and further work was done until the 5th century AD. Accessibility to the Karla Caves is limited, particularly during monsoon season, due to road-quality issues and the fact that a steep 20-minute walk is involved. Once you've reached the caves, you can walk barefoot inside the impressive halls, which were made not of stone but carved out of it. A Buddhist monastery dating back to the 2nd century AD used to be part of the caves, but was replaced by a smaller temple to the goddess Ekveera, who is much worshiped in Mumbai.



A PARTNER TO STEEL PRODUCERS IN ALL OF INDIA

Sharad Budhia is Head of Metallurgical Services at Primetals Technologies India. He joined predecessor Morgan Construction Company India in 2001 as a sales manager and took the role of Head of Operations at the Turbhe, Mumbai, location a few years later. He has since devoted his energy to promoting excellence in metals production in India by providing world-class metallurgical services to local steel producers.

How has the metallurgical services business developed in India over the last few years?

Sharad Budhia: It is currently evolving. We have seen a 50% growth over the last few years. India is a particularly price-sensitive country, and we have worked hard to maximize the value we provide to our customers. We have also extended our ability to support our customers locally. Whenever one of our customers is facing a challenge, we go there, study the situation in detail, create intimacy with the customer, and then deliver a solution based on that.

I understand that the Turbhe location of Primetals Technologies will be playing an even more central role in terms of the company's Metallurgical Services business segment. What are the plans?

Budhia: The Turbhe workshop is already exclusively dedicated to our Metallurgical Services business. In the future, the workshop's portfolio will be extended, and we will emphasize exports even more than we do today. I see a great opportunity here, because we can make use of the lower labor costs in India and support our company locations in other regions with the products we manufacture here.

Are long-term partnerships important in the metallurgical services business?

Budhia: Yes, long-term partnerships can last for many years and will help our customers to get critical spare parts on time, thereby reducing plant downtime. Contracts for the supply and repair of critical equipment as well as for predictive maintenance are also enhanced by a longer timeframe. We regularly visit our customers to ensure their operations are going well, which is much appreciated by them.

What are the top 3 services requested by Indian steel producers?

Budhia: The top 3 metallurgical services that our customers ask for are original spare parts at competitive prices and delivered in a timely manner, immediate technical support when a breakdown occurs, and expert services during scheduled maintenance activities.

Are there any specific areas you will be focusing on more closely in the coming years?

Budhia: Yes, we will be emphasizing the transfer of metallurgical know-how to India to expand our product portfolio, offer more repair and reconditioning services, and introduce e-services.

How has digitalization—the shift toward “Industry 4.0” solutions—impacted the metallurgical services business?

Budhia: To be frank, many discussions on digitalization are just the talk of the time. But we are truly spearheading the change toward new digital technologies such as predictive maintenance, which is in the process of replacing traditional reactive maintenance. Artificial intelligence based solutions will enhance a steel producer's ability to anticipate any deterioration of their equipment.

How can Indian steel producers best prepare for expected future developments?

Budhia: I think that Indian producers are quite good at adapting to new technologies. To me, the key to being future-proof is to be prepared. I think that the Indian steel industry by and large is in a very healthy state. Of course, it can't hurt to have a close relationship with Primetals Technologies to enjoy future success. ●

TAPPING HOT SLAG FOR ENERGY

HOT BLAST FURNACE SLAG IS A SOURCE OF ENERGY THAT HAS GONE LARGELY UNTAPPED. DRY SLAG GRANULATION IS ABOUT TO CHANGE THIS.

Tapped at 1,500 degrees Celsius, blast furnace slag retains a staggering 1.7 Gigajoules of energy per ton—enough to sustainably power an electric car for months. Currently, this precious resource mostly just goes to waste. An R&D project led by Primetals Technologies is developing a method that involves dry granulation and air cooling to recover a great deal of this energy. A pilot plant at voestalpine Stahl in Linz, Austria, is rapidly approaching industrial maturity.

DRY SLAG GRANULATION

A pilot plant has been constructed in Linz, Austria.





Blast furnaces produce roughly 400 million tons of slag per year worldwide at a tapping temperature of around 1,500°C. Generally, wet granulation plants are used to cool down and process the material, using large quantities of water—it can take more than eight tons of water to treat one ton of slag. As of now, there is no industrial-scale method to recover the heat energy retained in the slag—amounting to roughly 1.7 GJ per ton. In fact, cooling and treating the water used in the process requires a large input of additional energy.

STARTING A DRY RUN

As early as 2011, Primetals Technologies launched an R&D project involving several partners: Austrian steel producer voestalpine Stahl, the FEHS Building Materials Institute (Germany), and Montanuniversität Leoben (Austria). The goal was to develop a dry atomizing technology using air to cool the liquid slag and recover as much of the contained heat energy as possible, delivering high-quality slag sand as a result.

A lab-scale plant was set up initially, which proved the feasibility of the concept. Recently, the project passed another milestone with the start-up of a semi-industrial pilot plant on the premises of voestalpine Stahl in Linz, Austria. The plant is intended to operate in batch mode, processing slag from a single blast furnace, and allowing engineers to optimize the process, collect data, and build know-how. The results are promising.

RECOVERING HEAT WITH AIR

The basic setup of the plant is pretty simple: slag is fed from the blast furnace tap hole through a slag runner and a vertical, refractory-lined pipe. Entering the granulator, it hits the center of a rotating cup, is forced outwards and atomized. The droplets, at a grain size of 0.5 to 3 mm, are hurled against the inclined, water-cooled walls and finally bounce into the fluidized granulate bed beneath. This is where most of the cooling takes place: large amounts of air are introduced from below, removed above, and cleaned in two parallel cyclones for dedusting. The target temperature of the air leav-

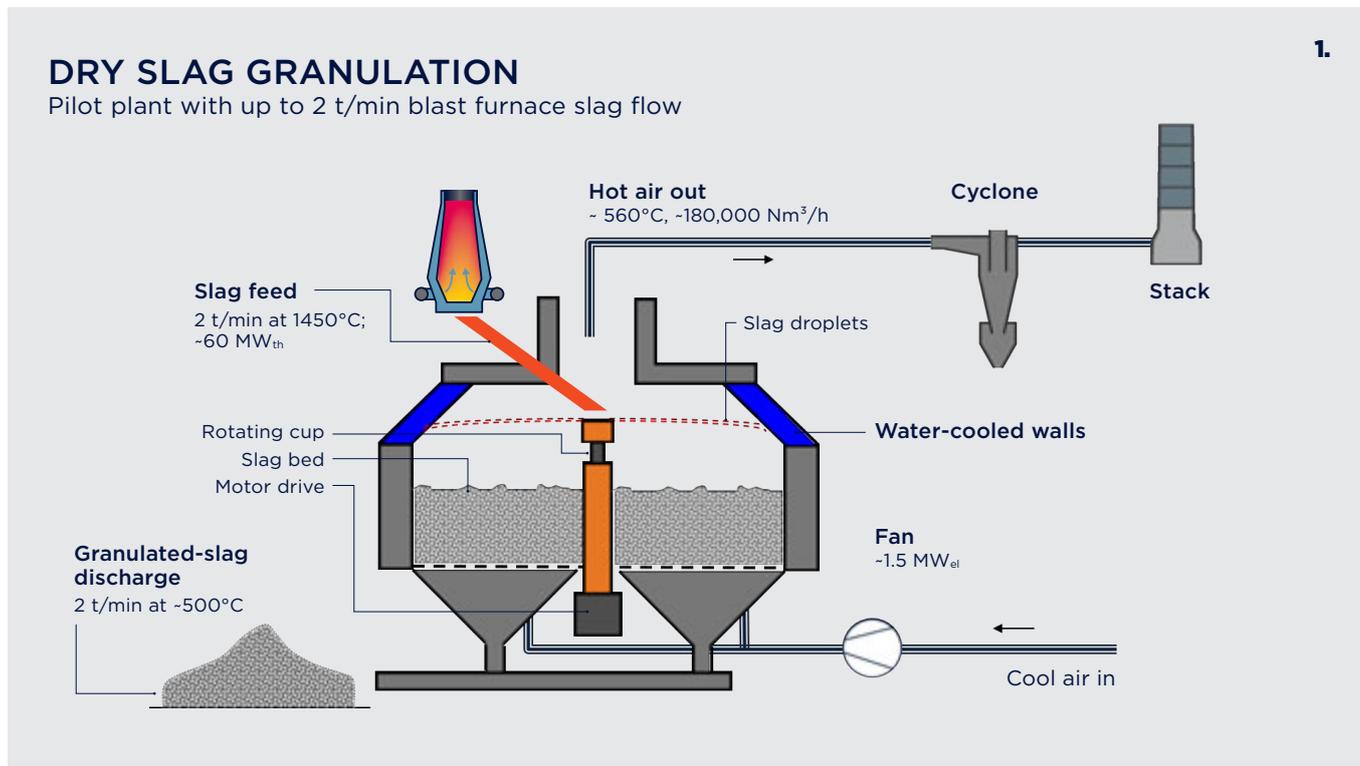


FIG. 1: Process scheme of the dry slag granulation pilot plant at voestalpine Stahl

FIG. 2: A look into the dry slag granulator: Slag enters from above, hits a rotating cup at the center and is atomized. Granules are cooled down with air.

FIG. 3: The final product: dry slag sand with a glass content of 94–97% can serve as a premium-quality substitute for cement clinker.

ing the granulator is 560°C. The final product is discharged with conveyors from the bottom of the vessel.

THE MAIN CHALLENGE

The focus of the project at this stage is the core process—perfectly atomizing the slag on the rotating cup. The set-up involves several visual imaging devices to monitor, control, and evaluate the granulation process. These devices make it possible to optimize rotation speeds and dynamically adapt them to parameters such as slag flow and temperature in order to ensure consistent process conditions and product quality. Another related challenge in the process is the speed at which the slag granules need to be cooled down to achieve the right properties in the resulting slag sand.

MAXIMIZING GLASS CONTENT

A key parameter for the quality of slag sand is glass content, which must be above 95% in order for the material to qualify as an additive in cement production. It directly impacts the latent hydraulic reactivity and »



2.



3.



PIONEERING TECHNOLOGY FOR GREEN IRONMAKING

Thomas Fenzl, a process technologist at Primetals Technologies, has been working on dry slag granulation for several years.

Recovering energy from slag seems like an obvious thing to do. Why hasn't this been tried sooner?

Fenzl: Research on dry slag granulation processes actually started decades ago, but without the focus on energy recovery. With energy prices on the rise and regulations on efficiency getting tougher, the steel industry was looking for possibilities to recapture energy that was being wasted in its processes. Blast furnace slag has some of the highest potential in this regard.

What part of the dry-granulation process is the toughest to crack?

Fenzl: The rotating disc that atomizes the slag. This is a component that is spinning at high speeds and has to endure the impact of hot, liquid slag at 1400°C. Many fluid-dynamic effects develop on the disc that we did not expect in this form. We are testing different designs to find a construction that allows high slag-flow capacity, granulation quality, and durability.

How do you view the chances of this being adopted widely in the coming decade?

Fenzl: We are very excited about bringing this technology to the next level. Our goal is to start working on an industrial-scale plant with energy recovery in 2019, reaching out to partners in the industry. From there, I expect the technology to spread swiftly.



FIG. 4: The slag runner that feeds the pilot plant at voestalpine Stahl in Linz, Austria

Dry slag granulation recovers energy, saves water, and produces high-quality cement clinker substitute.

thus the strength of the resulting concrete. Glass content is also the main challenge for dry granulation with air cooling: the particles have to be cooled down ultra-fast in order to achieve it, which is easily done with water in the traditional wet granulation process, but hard to do with air.

Analysis of the resulting sand from the pilot plant shows a proportion of glass content of about 94–97%, which is in the range of conventional, wet-granulated slag and high enough to be considered premium quality in the cement industry. Extensive cementitious tests have confirmed this.

TAKING THE NEXT STEP

In its current form, the pilot plant at voestalpine Stahl is set up to handle a maximum of two tons of slag per minute, delivered from a single tap hole. In the near term, there are plans to increase slag flow to 60 tons per hour, extensively monitoring the equipment for wear and sticking behavior. At the same time, trials will be run to maximize off-gas temperature.

When the project enters its next phase, an upgraded plant will allow for the treatment of the full slag flow from multiple tap holes on the blast furnace, feeding hot air into a waste-heat recovery plant downstream to harness the energy.



FIG. 5: The slag resulting from the dry slag granulation process is extremely high in quality, with a glass content of about 94–97%.

THINKING BIG

If only half of the blast furnaces operating today were to switch from wet to dry-type granulation of their entire slag output, the energy recovered and saved would be enough to supply more than 3.5 million households with sustainable energy all year. To take another example: the energy from the slag, currently wasted almost entirely, would be enough to power 6.5 million electric cars (assuming typical mileage). At European emission intensity, this scenario would translate into a reduction of 8 million tons of carbon dioxide emissions per year.

In addition, plant owners would end up with large amounts of first-class clinker additive that is dry, highly glassy, and easy to handle. Considering its excellent carbon footprint, this material is easily marketable.

We are convinced that dry slag granulation technology, if deployed widely, would mark a significant step toward the green future of steelmaking. ●

Dr. Alexander Fleischanderl,

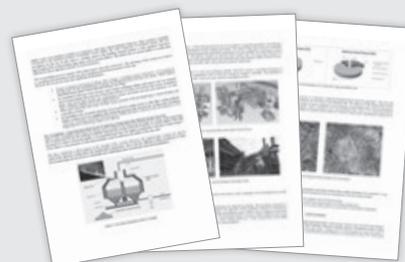
Technology Officer Upstream and VP of Iron- and Steelmaking

Thomas Fenzl, Process Technologist

Robert Neuhold, Process Technologist

(All with Primetals Technologies Austria)

LEARN MORE



READ THE FULL ARTICLE

Fleischanderl, A.; Fenzl, T.; Neuhold R. (2018): Dry Slag Granulation - the Future Way to Granulate Blast-Furnace Slag. In: AISTech 2018 Conference Proceedings

meta.is/dryslag



MIND THE GAP

20 YEARS OF DYNAGAP SOFT REDUCTION

TWO DECADES AGO IN RAAHE, FINLAND, PRIMETALS TECHNOLOGIES USHERED IN A NEW ERA OF QUALITY IN CONTINUOUS CASTING WITH THE FIRST INSTALLATION OF DYNAGAP SOFT REDUCTION—NOW ACTIVE IN 300 CASTING STRANDS WORLDWIDE.



FIG. 1: Where it all began: the SSAB (former Rautaruukki) steel plant in Raahе, Finland.

The first fully automatic strand-guide system: looking back and into the future.

The town of Raahе, founded in 1649 by an emissary of the Swedish crown, is located on the shores of Finland's Northern Ostrobothnia region. It has a busy port, a healthy amount of tourism and a well-preserved wooden Old Town.

This description might fit many other northern towns—but Raahе has something special going for it: It has long been home to a steely-eyed industrial avant-garde. As part of a strategic-development program, the Finnish government had decided in the late 1950s to strengthen economic development in the country's central and northern regions by establishing a steel industry there. The goal was to meet growing demand for steel in Finland's flourishing shipbuilding industry and to lure professionals from the country's south to better populate the north. As one of the first steelmak-

ing operations worldwide, the Raahе plant achieved a continuous casting rate of 100% on its vertical casters in 1967. Two bow-type casters were added at a later stage. And in 1997, the plant was again the site of a world first: The start-up of a new continuous caster with a fully dynamic strand guide system, allowing operators to adjust the roll gap at the push of a button and increasing slab quality at the same time. It was the first installation of Primetals Technologies' DynaGap Soft Reduction technology, which has since been continually refined and is now a part of almost 300 casting strands worldwide.

MEETING THE OLD CREW

In the fall of 2017—exactly 20 years after completing that pioneering installation—some of the men from the original teams sit down at a table in the plant's day »»

room to celebrate the anniversary. Over a cup of coffee, they introduce themselves in turn, talking about their current occupations. There's Jarkko Matkala, the site manager, Jarno Pirinen, the head of steelmaking at Raahe, and Michael Stiftinger, now in charge of Mechatronics at Primetals Technologies. "My name is Tauno Haapakangas. I work in the forest now—with my Husqvarna", says the last of the men with a smile, as the group cracks up laughing. Mr. Haapakangas has been out of the steelmaking game for quite a while now, spending some of his newfound spare time cutting spruce and birch trees for timber with his chainsaw. Back in the day, he managed the caster replacement project for the state-owned Rautaruukki corporation, which was undergoing privatization in the 1990s and is now part of Swedish SSAB. Across the table sits his counterpart from Primetals Technologies, Karl Pirner. He, too, retired a few years ago, but vividly remembers the years he spent in Finland, living in a brightly colored wooden house not far from the plant and working long hours in the short Finnish winter days, where at

times the sun would set while his team was still having lunch.

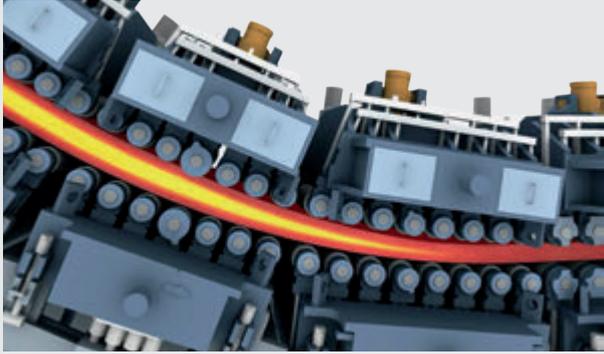
LOOKING BACK: THE ORIGINAL PROBLEM

In 1995, Rautaruukki had decided to begin replacing its three vertical casters with a new one featuring a straight mold and liquid core bending and straightening. The driving force behind the decision was not so much the desire for higher-quality slabs—although that was a factor, too. Rather, it was the plant's just-in-time production schedules: They demanded that the casters produce slabs of up to eight different thicknesses, requiring manual adjustment of the roll gap several times a day. Each one of these changes meant up to two hours of standstill and onerous labor for the crew. Rautaruukki quite simply needed something to take that pain away.

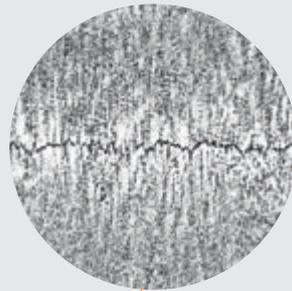
As it turned out, this "something" was at the very same time being cooked up in a university mechatronics lab in Linz, Austria.



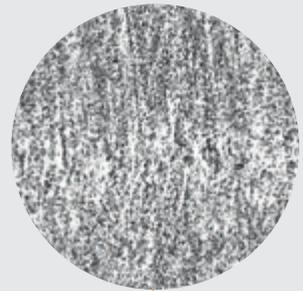
FIG. 2: Re-united after two decades: Tauno Haapakangas from Rautaruukki / SSAB and Karl Pirner of Primetals Technologies celebrate their achievements in Raahe, Finland.



DynaGap Soft Reduction adjusts the roll gap to exactly the right setting at the point of solidification.



WITHOUT
SOFT REDUCTION



WITH
SOFT REDUCTION

WHAT IS DYNAGAP SOFT REDUCTION?



Since steel does not solidify at a fixed temperature, but over a temperature interval, slabs in the casting process have a “mushy region” at the center, where the steel is neither entirely liquid nor solid. If conditions aren’t exactly right, “segregation” occurs in this center part of the slab: Because of thermal contraction near the point of final solidification, there is a flow of residual melt toward the center. And since that residual melt often contains high levels of carbon, sulfur, and other kinds of impurities, the center segregates from the rest of the material, creating undesirable material properties in the resulting product. One way to minimize center segregation is to compensate the thermal contraction by intentional thickness reduction

near the point of solidification. This method is called soft reduction.

Minimizing center segregation

The genius of DynaGap Soft Reduction is that the technology calculates the ideal roll-gap set points with online process models, taking into account the temperature field in the strand and employing a steel-grade dependent gap practice. Even in varying casting conditions, the pressure is always applied just at the right point by hydraulically adjustable SMART segments in the casting strand. Since its pioneering first application in 1997, DynaGap has been continually refined, culminating in today’s DynaGap 3D and Single-Roll DynaGap, which takes precision in soft reduction to the next level: from the segment to individual rolls.

DIRECTLY FROM THE MECHATRONICS LAB

Up until that point, hydraulic adjustment in the roll gap had only been possible using servo hydraulics—a technology far too costly and way too prone to malfunctioning in dusty environments to be employed in regular continuous casting plants. Researchers and engineers in Linz, working with continuous casting experts from Primetals Technologies (at the time VAI), realized that a simpler setup involving more robust on/off valves could do the job just as well—and prove to be a lot more durable in the environment of a casting facility. Combining this hardware with position sensors would dramatically reduce the need for manual labor and downtimes when adjusting the roll gap. Thickness could be changed remotely at the push of a button. And the system would have a huge, additional benefit: adding advanced automation and process

models, the dynamically adjustable roll segments would significantly increase internal slab quality.

A BOLD MOVE

When Rautaruukki engineers learned of the technology in the run-up to a continuous casting conference (CCC) in Linz, they were convinced on the spot: This was the solution to their long-standing problem. After a short process of negotiations, the Finnish steel producer placed the order in a bold move and a grand gesture of trust. After all, the hydraulic setup had until that point hardly been tested outside of the lab.

The new, highly flexible continuous caster was to replace three individual vertical casters, operating at different casting thicknesses. In addition to the pioneering dynamic strand-guide system, it would also »



FIG. 4: Continuous-Casting Machine No. 6 at the SSAB Raahе (former Rautaruukki) plant today. This is where the fully dynamic strand-guide system with DynaGap Soft Reduction had its world premiere in 1997.

include the first hydraulic oscillator in Scandinavia. And because the caster had to be integrated into a tight existing structure, the order also included new ladle and tundish turrets to fit into the available space. “Some of the documentation of pre-existing equipment was available only in Russian,” recalls Karl Pirner, the Primetals Technologies project lead, “A testament to Finland’s long-standing friendly relations with its eastern neighbor.” Work started in 1996 and was concluded successfully when the caster was started up on December 15, 1997—right on schedule. Performance and availability were excellent from the start, as the

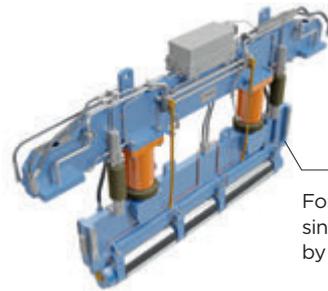
machine cast slabs first in three, then four different thicknesses per day, drastically cutting the amount of manual labor required for the roll-gap changes. Careful inspection of numerous slabs by the Rautaruukki quality department showed internal quality to be excellent from the get-go. With news about the success in Finland spreading, new installations of DynaGap at other sites were soon to follow: ILVA, voestalpine Stahl, Bethlehem Steel, POSCO, and Outokumpu were among the early adopters. Today, DynaGap Soft Reduction is operating in close to 300 casting strands all over the world.

THE NEXT STEP: SINGLE ROLL DYNAGAP

Automating changes in the roll gap with hydraulically adjustable SMART segments was a giant leap forward in terms of efficiency and product quality in continuous casting. But quite naturally, segment-level control of the roll gap allows only one gap setting across all the rolls contained in a segment. Consequently, it hits the point of solidification only by some measure of approximation. For sensitive steel grades, this might not be enough.

That is why Primetals Technologies has developed the Single Roll DynaGap (SRD) segment. Each individual roll is controlled by its own dedicated hydraulic cylinders. With high-quality data from the DynaPhase and Dynacs 3D secondary cooling models, the SRD segment can hit the exact point in the strand where dynamic soft reduction has to be applied for maximum

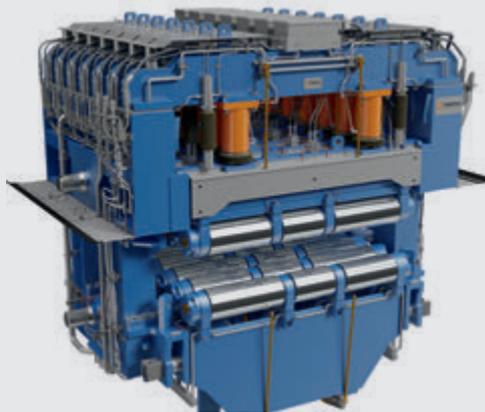
center quality. The segment is interchangeable with DynaGap SMART segments as well as with other segment designs and can thus easily be integrated into existing setups. SRD segments have already been deployed in production—at the Ternium integrated steel works in Santa Cruz, Brazil. In light of the excellent results, the company recently decided to equip an additional strand with the technology. ●



For maximum precision, every single roll is individually controlled by hydraulic cylinders.

THE SINGLE ROLL DYNAGAP (SRD) SEGMENT

As an upgrade solution for casters producing sensitive steel grades, the Single Roll DynaGap segment can replace conventional segments as well as regular SMART segments. It offers a number of advantages.



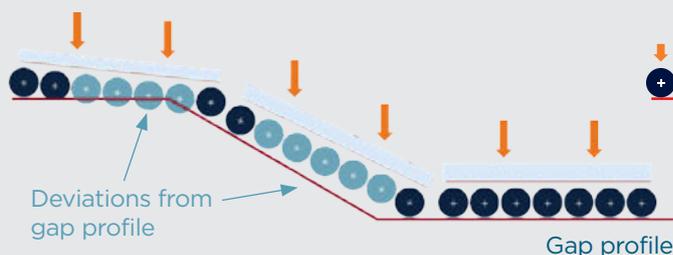
- Individual gap adjustment on each roll
- Backlash-free operation
- Suitable for any kind of roll-gap profile
- Optimum application of cylinder forces and minimized roll deflection
- Potential for high reduction rates
- Dry-casting capabilities



PERFECT SOFT REDUCTION

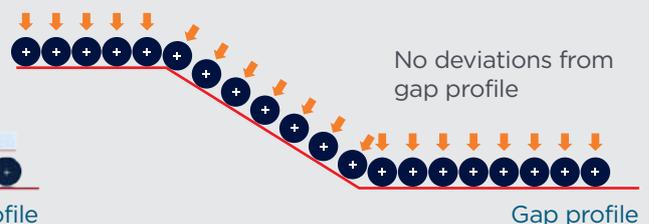
Regular SMART segment

Roll-gap optimization constrained by the length of one segment



SRD segment

Roll-gap optimization without constraints





THROUGH THICK AND THIN **WITH ARVEDI ESP**

ARVEDI ENDLESS STRIP PRODUCTION (ESP) PROVIDES STEEL PRODUCERS WITH CUTTING-EDGE TECHNOLOGY FOR THE MANUFACTURE OF HIGHEST-QUALITY STRIP IN THICKNESSES FROM LESS THAN 0.8 TO 25 MILLIMETERS.

Since the latter part of the 20th century, it has no longer been a marvel for humans to be surrounded by high-tech computers. But back when the first pioneers developed their initial rudimentary circuit designs, public reaction toward their potential success was doubtful. Even Thomas J. Watson, Chairman and CEO of International Business Machines (IBM), stated in 1943, "I think there is a world market for maybe five computers."

Reactions were similar when Italian steel producer and inventor Giovanni Arvedi announced the installation of the first Endless Strip Production (ESP) line in 2006. The majority of the steel community was convinced that endless production would never work. But today, after the successful implementation of the patented Arvedi ESP technology in many plants worldwide, steel producers are opening their eyes to the potential of the still unparalleled technology. The ESP plants that exist today are producing more ultra-thin gauges than any other plants. And there's more to come: The revolutionary design of Arvedi ESP has not been standing still since its inception, it continues to lead the industry with new developments and additional capabilities.

INVENTED IN CREMONA, ITALY

When the initial Arvedi ESP project was started in Cremona, Italy, it seemed unrealistic to the public to run a combined casting and rolling plant in endless operation, but the project team had the proof of feasibility they required. Mass-flow tests had been executed on the existing ISP line of Arvedi steel, which operated with a heated coil box separating the first and second rolling steps. The main challenge to achieve endless operation was to always ensure the required mass flow from the caster.

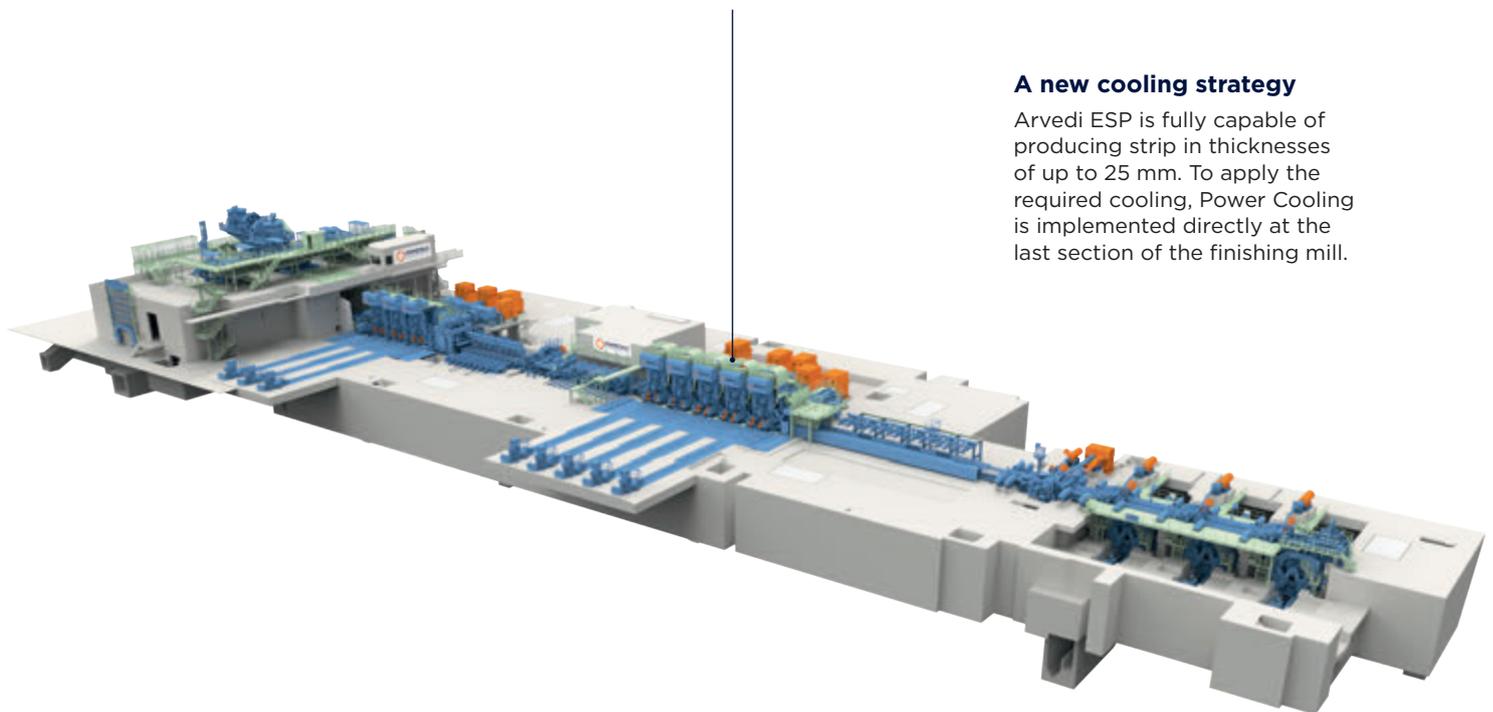
Everyone involved was determined to turn the entirely new concept into reality. After ISP upgrades executed by Arvedi and caster upgrades implemented by Primetals Technologies (at that time VAI), a casting speed of 7 meters per minute at the caster could be reached. The main target of the successful test was to verify mold stability as well as the mold- and strand-cooling capabilities of the setup. With the assurance that the caster would be up to the task and capable of providing sufficient mass flow and production stability, the full scope of the Arvedi ESP project, which would make true endless strip production a reality, could be started. »

ARVEDI ESP NOW WITH ULTRA-EARLY POWER COOLING

Ultra-Early
Power Cooling

A new cooling strategy

Arvedi ESP is fully capable of producing strip in thicknesses of up to 25 mm. To apply the required cooling, Power Cooling is implemented directly at the last section of the finishing mill.





INVENTOR GIOVANNI ARVEDI

Giovanni Arvedi pioneered Endless Strip Production in Cremona, Italy, in the early 2000s. Today's ESP technology is still based on his original invention and is second to none in terms of efficiency and process stability.

“ I could not be more proud of Arvedi ESP. The technology was revolutionary from the start, and we never stopped refining it.”

Giovanni Arvedi
Chairman at Acciaieria Arvedi S.p.A.

Arvedi's operation and maintenance experts as well as the technology and design specialists from Primetals Technologies worked together to start the world's first endless strip production in 2009. First, the casting and high-reduction mill sections were started up. After the production of a number of test plates, the first mini-coil was produced after fine-tuning and by use of the finishing mill, with the line being coupled to enable endless production.

This startup principle remained the same for subsequent ESP installations, but in all of those cases, the startup time was significantly shorter. Today, it takes only six days after the first cast for endless rolling operation to be fully implemented, and while achieving 0.8 millimeters in endless mode took several months at the first plant, this gauge is achieved on current start-ups within weeks.

As further fine-tuning in the facility progressed, the first Arvedi ESP plant in Cremona evolved from a test and showcase site into an industrial production plant for very desirable high-quality steels. The most important steel grades had to be developed within a very short timeframe in order to serve a market that was interested in coils with uniform material properties from head to tail. A wide variety of low carbon and HSLA steels were developed during the first year of operation. Silicon steel was tested in the second year. After three years, API and dual-phase steel production were implemented.

RIZHAO STEEL'S BOLD STRATEGY

In a project that involved the installation of no fewer than five Arvedi ESP lines at one location, Primetals Technologies customer Rizhao Steel of China took the opportunity to become a key manufacturer of uniform ESP material. While it was risky for Rizhao to make the associated investment during an economic crisis with vast overcapacity in China, the project was also a highly attractive future-oriented proposition. It was essential that construction would be executed very swiftly, and Rizhao Steel, together with Primetals Technologies, managed to start up the first line after only 20 months.

Rizhao Steel were aware of the fact there would not be any substantial market for cold-rolled substitutes in China before 2015, but they had a clear strategy. They defined a plant setup with five ESP lines followed by pickling and galvanizing lines, completely omitting cold-rolling plants. The ultra-thin cold-rolled-strip substitute is a highly welcome premium product today—not only in China but also in the rest of the world.

The new Arvedi ESP lines installed at Rizhao Steel are exhibiting stable performance, providing Rizhao Steel with an ideal basis for rapid product development. The new production setup will enable the company to



Coils of 0.8-mm thin strip, produced at the Arvedi ESP plant in Rizhao, China. The plant is currently using five ESP production lines.

enter the market with some of the most relevant steel grades. Currently, a wide range of products is already being produced on ESP lines, and more grades are being tested and further refined.

PROCESS STABILITY IS KEY

Extraordinarily high process stability is a consequence of fewer production interferences and less frequent setup changes across the full production chain—from the caster down to the laminar-cooling section, which comes ahead of the coiling of the finalized hot-strip product. The endless production mode serves to ensure higher process controllability and increased homogeneity of the final products' properties, and it maintains stable production windows for all products.

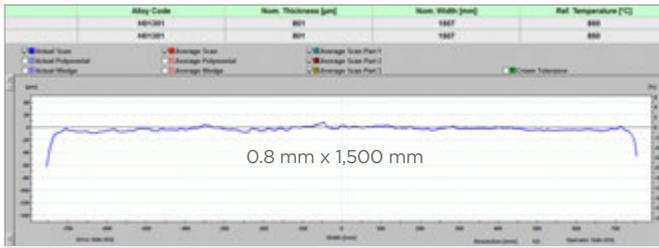
GREATER WORK ROLL LIFETIME

Producing very high quantities of ultra-thin gauges puts high demand on the work rolls. A work roll exchange routine in an Arvedi ESP line is structured in such a way that after every sequence the work rolls at finishing mills F3-F5 are exchanged. The work rolls of F1-F5 are replaced after every other sequence, and high reduction mill rolls are swapped after three completed sequences. Sequence lengths at Rizhao Steel currently go up to 15 ladles' worth of steel, resulting in 4,500 tons of coiled strip. In sequences comprising

large quantities of ultra-thin material, 150-170 kilometers of rolled strip have become a common usage factor on F5. This exceptionally long work roll life is supported by the fact that in an ESP line, crown and wedge shaping already takes place at the high reduction mill, which directly succeeds the caster and makes use of the benefit that the core of the strand is still very hot and therefore highly malleable. The Level 2 work-roll-wear model is crucial in optimizing work-roll usage. It distributes excessive edge wear by utilizing work-roll shifting up to ± 250 millimeters. This results in sequences with final strip thicknesses below one millimeter for more than 50% of the strip produced.

INLINE WORK-ROLL CHANGE

To further refine the concept of endless rolling with maximum yield at lowest conversion costs, the Inline Work Roll Change (patent pending) was implemented for Arvedi ESP Line 4 at Rizhao Steel and made available to other steel producers, as well. Although production data from Rizhao Steel demonstrated that impressively high yields had already been achieved, it proved possible to extend cast-rolling sequences and increase yields even more. This new advancement is based on the fact that the main factor that impacts sequence length is work-roll lifetime, which had been pushed to 170 kilometers of produced strip. The »



ADJUSTABLE CROWN SHAPE

In an Arvedi ESP line, crown and wedge shaping takes place in the high-reduction mill, directly after the caster, when the core of the strand is hotter and thus easily formable. This setup enables full control to form the final shape. End customers can order products with C40 target-crown values of as little as 1% of the strip's thickness. Also, flat target crowns can be produced as shown in the graph. This allows for the slitting of narrow cold-band-substitute products while retaining a good symmetric crown without compromising wedge-related issues at downstream aggregates. The figure above shows the strip profile of a 0.8-millimeter strip with remarkable consistency in terms of strip shape.

new design changes allow for the work rolls at the last stands to be changed inline, and thanks to the resulting increase in sequence length, the refractory material (submerged entry nozzle) in the mold is optimally used.

THICKNESSES BELOW 0.8 MM

While other steel-plant builders are experimenting with plant concepts to promote 0.8-millimeter strip production in endless operation, Primetals Technologies is raising the bar by targeting ultra-thin production at even less than 0.8 millimeters. For further quality improvements and to comply with the market demand for ultra-thin hot-rolled strip, Primetals Technologies developed a new control concept for the finishing mill based on their experience in hot and cold rolling. With the newly developed "Ultra-Thin Rolling" (UTR) controller, the focus is on improving thickness quality during the "flying gauge change" as well as on active compensation of work-roll eccentricity. This feature is already implemented at Rizhao Steel's new ESP line No. 4.

NEXT STEP: API GRADES

The market for line-pipe steels is currently changing and so are the production routes for manufacturing the respective steel grades. The requirements in terms of mechanical properties are steadily increasing as pipelines must be able to support higher transport capaci-

ties and be more lightweight at the same time. Over the past few years, API 5L X70 and X80 have become the quasi-standard grades. These advanced steel grades can not only be made using the traditional plate-based production route but also by hot-strip mills, which have seen a major technological evolution. They are now capable of facilitating the processes required for thin-slab casting and rolling.

A design convenient for the application of thermomechanical treatment is characterized by either a split rolling-mill setup that corresponds to the conventional roughing and finishing-rolling steps or by plate-rolling strategies. Both approaches can realize the split between recrystallizing and non-recrystallizing rolling, which provides important levers for controlling the microstructural evolution during processing.

If severe deformation is applied immediately after casting—as is the case with the Arvedi ESP endless production process—the tight link between casting and rolling provides optimal conditions for the activation of recrystallization in the critical center regions of the cast steel. This is due to the characteristic inverse temperature profile after casting, which promotes a fast start of the recrystallization in the hotter center of the cast steel, resulting in a more homogenous grain structure throughout the full thickness of the products. The effective deformation (reduction in thickness in conjunction with shear deformation) that is often observed in near-surface regions with conventional roughing is successfully shifted from near-surface regions toward the center of the slabs.

As is common for all thin-slab casting and rolling processes, micro-alloying elements—with the exception of titanium—remain as a solid solution before finishing rolling. Due to the absence of a tunnel furnace and »

Arvedi and Primetals Technologies are once again raising the bar, by targeting ultra-thin production at even less than 0.8 millimeters.

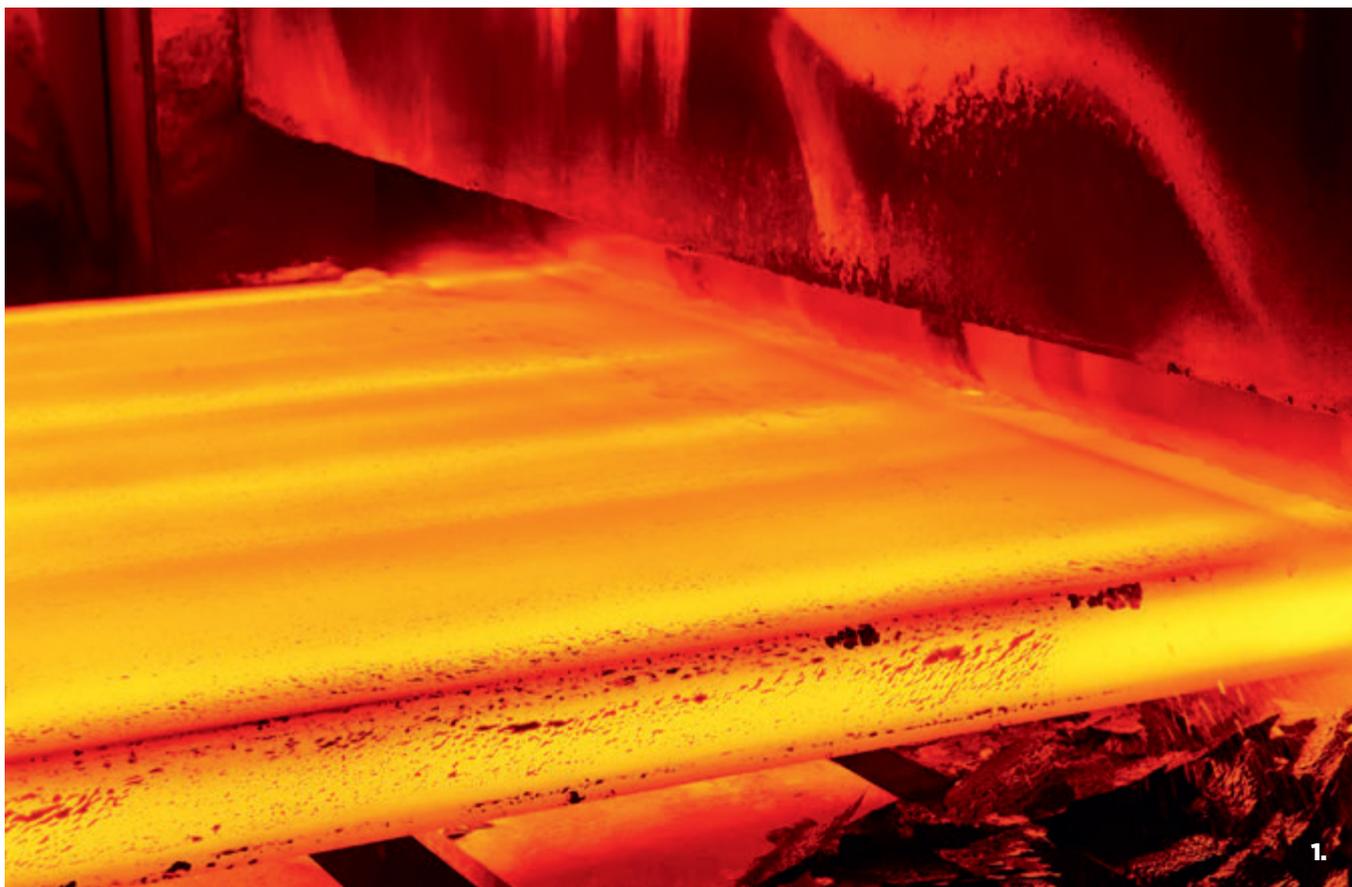
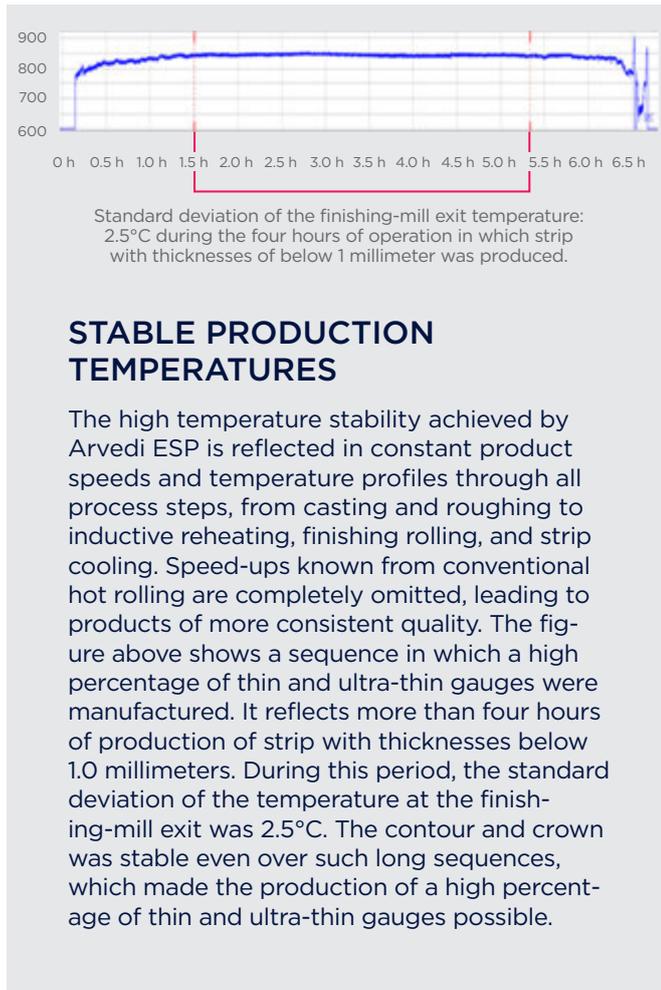


FIG. 1: Hot strand exiting the thin-slab caster for the first rolling step. No additional heating is required thanks to the ESP layout.

FIG. 2: Fully automated plant technology for smooth and safe operation with reproducible high-quality results

FIG. 3: The hot strand is rolled immediately while its core is still hot for perfect strip shaping and significant energy savings.

FIG. 4: Endless operation leads to stable plant conditions—due to the omission of speed-ups known from conventional hot rolling—and to uniform strip quality from head to tail.



STABLE PRODUCTION TEMPERATURES

The high temperature stability achieved by Arvedi ESP is reflected in constant product speeds and temperature profiles through all process steps, from casting and roughing to inductive reheating, finishing rolling, and strip cooling. Speed-ups known from conventional hot rolling are completely omitted, leading to products of more consistent quality. The figure above shows a sequence in which a high percentage of thin and ultra-thin gauges were manufactured. It reflects more than four hours of production of strip with thicknesses below 1.0 millimeters. During this period, the standard deviation of the temperature at the finishing-mill exit was 2.5°C. The contour and crown was stable even over such long sequences, which made the production of a high percentage of thin and ultra-thin gauges possible.



the short time spent in the induction heater, alloying with titanium to limit grain growth is optional and in most cases not necessary. The direct link between an induction heater and finishing-mill train, in conjunction with a properly chosen cooling strategy, permits precise microstructure engineering for niobium-prone steels. The start of the rolling operation under the non-recrystallization regime can be shifted between the second and fifth rolling step by making corresponding adjustments to the power of the induction heater and to the pass-schedule setup.

ULTRA-EARLY POWER COOLING

Findings show that the cooling relevant for ferrite formation should take place as soon as possible after the final deformation at the last active rolling step. Therefore, Primetals Technologies invented a solution called "Ultra-Early Power Cooling," which employs the Power Cooling system directly after the finishing stage of the rolling section. This setup provides extremely high cooling rates as early in the process as possible.

In order to minimize the distance from the last operating rolling stand to the cooling equipment, which is

placed along the run-out table, and to avoid the resulting delays, Ultra Early Power Cooling is implemented directly at the last section of the finishing mill, which is set to be inactive for the rolling of heavy gauge products. The cooling capacity is dimensioned to support a temperature drop down to the point where the final phase of the transformation from austenite to ferrite is complete. This ensures extraordinarily fine ferrite grain sizes and forces the thermomechanical effect to unfold its full potential.

Arvedi ESP is no longer a miracle today. The technology has become the state of the art in modern thin slab casting and rolling.



The compact plant layout unites the caster, high-reduction and finishing mills, as well as the cooling and coiling sections at a length of just 180 m.

The space in between the two last stands—and potentially more stands—can be used for the implementation of intensive inter-stand cooling devices. For maximum impact of this novel cooling solution, the work rolls of the final stands can also be replaced by Power Cooling headers. The combined cooling capability of these measures can create a water flow so powerful that it equals that of a full-fledged Power Cooling installation. Based on the well-known physical principles that govern metallurgical effects and the well-proven layout of the ESP production line, Arvedi and Primetals Technologies have created a solution that enables the high-quality production of thick-gauge thermo-mechanically rolled material.

Probably surprising to some, Arvedi ESP is also capable of producing thicker strips. To facilitate this, ESP lines can be equipped with a second endless shear, extending endless-operation principles to strip thicknesses of up to 25 millimeters. Thick-strip production on ESP lines benefits from absolutely stable production conditions, which contribute to uniform strip quality from head to tail for every strip, from 0.8 to 25 millimeters.

ARVEDI ESP KEEPS ADVANCING

Having firmly arrived in the 21st century, most of us have come to appreciate that there is a vast worldwide market for computers, and for much more than five of them. Similarly, many steel producers have become interested in the revolutionary production setup that is Arvedi ESP. Endless Strip Production is no longer a miracle but a tried-and-tested solution, and has become the state of the art in modern thin slab casting and rolling.

With inline work-roll change now possible, productivity and production flexibility have now been brought to an even higher level. Yet the most decisive benefit of Arvedi ESP remains the stable production, which is second to none in the industry and already known to deliver thin gauges of remarkable quality. With the Ultra Early Power Cooling feature, ESP-based operation has just been extended to make production of thick gauges of up to 25 millimeters a reality. ●

Andreas Jungbauer, General Sales Manager, Endless Strip Production
Bernd Linzer, Head of Technology, Endless Strip Production
 (Both with Primetals Technologies Austria)



A COMMON VISION **FOR EXCELLENCE**

PRIMETALS TECHNOLOGIES AND PARTNER THYSSENKRUPP STEEL EUROPE HAVE DEVELOPED A NEW AND GROUNDBREAKING VISION-BASED STRIP-STEERING CONTROL SYSTEM FOR HOT-ROLLING MILLS.



FIG. 1: The hot-rolling line at thyssenkrupp's Duisburg plant that saw the first installation of the new Vision-Based Strip-Steering Control.

The controller developed by Primetals Technologies as well as the respective measuring equipment is now in regular use at thyssenkrupp Steel Europe's WBW1 Duisburg plant.

In an effort to further increase the production quality of advanced steel grades at thyssenkrupp's Duisburg plant in Germany, the engineers of Primetals Technologies have devised a groundbreaking strip-steering method for the hot-rolling stage. This new solution was created in close collaboration with both thyssenkrupp Steel Europe and Johannes Kepler Universität Linz, Austria, and uses custom-built optical sensors in conjunction with an elaborate strip-threading, strip-guidance, and strip tail-out control system. Following conclusive results during the testing phase—particularly in terms of cobble rate and thickness wedge quality—, thyssenkrupp decided to make the technology an integral part of its regular production setup.

Prompted by the rising demand for high-quality strip, the steel industry has begun to use recent advances in control theory, measuring techniques, and machinery equipment to improve production capacity, efficiency, and product quality. The main quality parameters of the rolled strip are the dimensional tolerances of the material, essentially the strip's thickness and width tolerance, shape, and flatness.

Usually, the shape (i.e. the thickness profile) of the rolled material is first set by the process automation system and then more finely adjusted in the hot-strip mill. The downstream stages are then focused on maintaining the shape and controlling the flatness of the strip. Any change in shape over the length of the strip can cause strip-run and flatness problems. Therefore, it is crucial that the produced strip exhibits a constant shape over the full length.

Another challenge facing plant operators involves preventing the build-up of camber, which can arise from

numerous uncontrollable factors (temperature profile, non-uniform thickness profile, etc.). Since the occurrence of camber can cause process interruption and even equipment damage, solutions geared towards counteracting camber build-up are highly sought after in the industry.

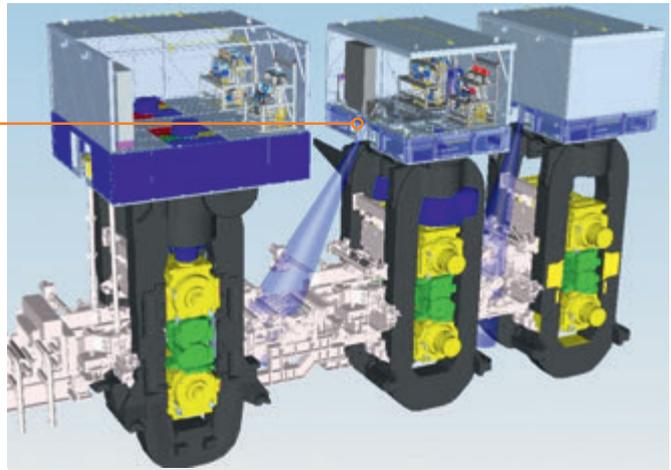
CONTROLLING THE SHAPE

The main actuators for controlling the shape in the hot-strip mill are the leveling and bending of the work rolls. Leveling is used to influence the thickness wedge, whereas work-roll bending and shifting affects the strip's thickness profile. However, for strip that is not under tension, changing the leveling of the work rolls determines whether or not there is camber build-up.

The strip-steering control solution developed by Primetals Technologies in collaboration with its partner thyssenkrupp uses Primetals Technologies' latest vision-based measuring equipment in combination with advanced control technology for automatic



FIG. 2: The optical sensors are mounted on top of the mill stands for optimal vision.



THE SENSOR OF CHOICE

The engineers of Primetals Technologies decided to use a specific optical sensor (left photo) to obtain the strip data necessary for the new control system. Placement is equally important as the sensor itself: all involved sensors are positioned on top of their respective stands, which protects the measuring devices from the harsh steel-mill environment. The schematic above illustrates the sensor arrangement, with the blue cones of light indicating the sensors' measuring area.

threading, in-bar control, and thread-out. The new control solution's main targets are to improve mill availability and increase productivity by reducing the cobble rate. An additional goal is to increase the quality of the material in respect of the thickness wedge.

CUSTOM-DESIGNED SENSORS

Reliable sensors are essential to any dependable control system. In the finishing-mill section of a hot-strip mill, the environment is heavily impacted by dust and cooling water, which puts substantial strain on sensor operation. Additionally, the strip surface is affected by unpredictable scale spots and temperature variations, which mostly affect the head and tail end but also the edge regions over the full length of the strip. All of these factors make it exceptionally difficult to utilize any sensors close to the strip in the hot-mill environment.

To meet these challenges, Primetals Technologies chose to install a highly specific optical sensor that

would be able to withstand the harsh surroundings. This type of device combines camber and center-line-measuring techniques and can simultaneously assess strip width. The advantages of this method are the low number of components, the simple arrangement, and the sufficiently large distance between strip and sensor. Thanks to its operating principle, this sensor ensures high reliability combined with almost zero maintenance.

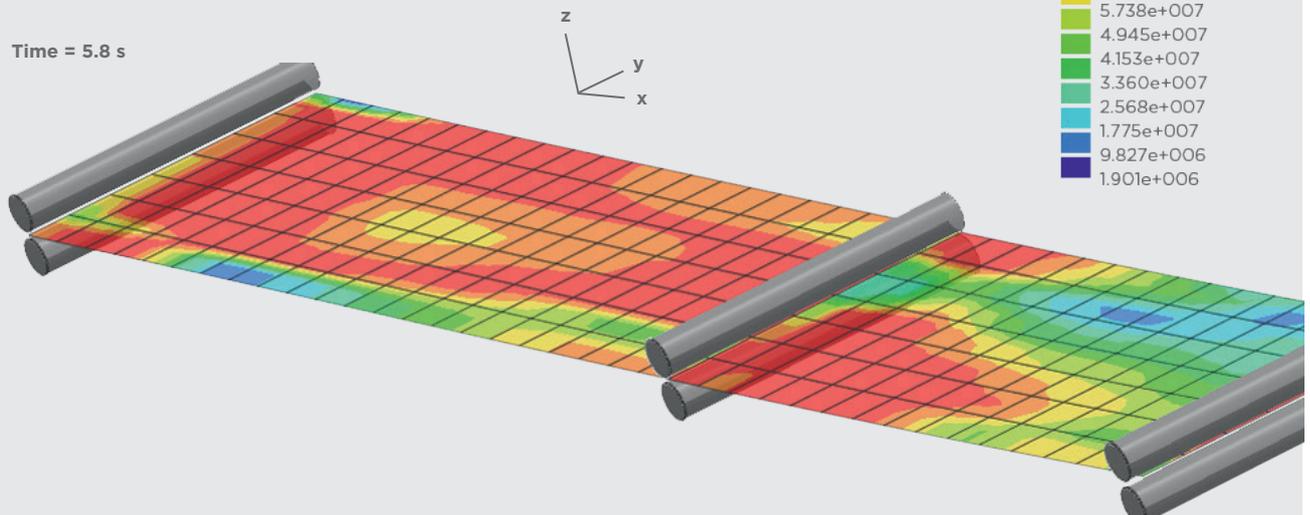
TWO SETS OF CONTROLLERS

Since the hot-rolling process needs to be controlled differently depending on whether or not the strip is under tension, two sets of controllers—each with their own particular objective—had to be developed.

The strip-threading control regulates strip threading at the first three stands and relies on strip-position measurements taken by the vision-based measuring equipment, which is located after each of the stands. Its purpose is to support the automatic threading of »

STRIP SIMULATION IN HOTINT SOFTWARE

Time = 5.8 s



SIMULATING THE STRESS ON THE STRIP

Prior to its implementation at the real plant, the new control strategy was rigorously tested by means of numerous simulation-based studies. For this purpose a new computer-simulation model of the overall strip run was developed. The respective model consists of two coupled sub-models: the “Free Strip Model,” implemented through the

framework of the HOTINT software, and the “Roll Gap Model,” implemented in a separate, dynamically linked library. The software tool not only allows for autonomous studies of the overall strip motion to be performed, it also provides an interface to MATLAB/Simulink, through which the controller is implemented.

STS
ON

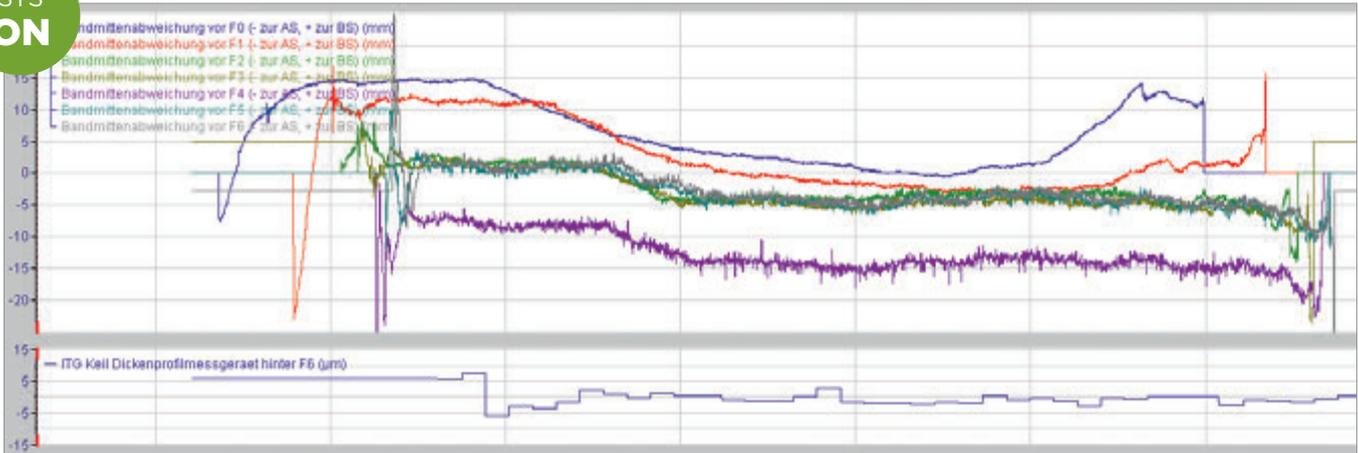


FIG. 3: Lateral displacement of the strip in successive stands, and thickness wedge of the rolled product with active strip-steering control.

WITH AND WITHOUT STRIP-STEERING CONTROL (STS)

The figures shown in the graphs above compare data from a strip rolled where strip steering control is active (left) and inactive (right). The upper parts of the charts show the lateral displacement of the strip at each roll stand. Without steering control, there is a strong correlation between lateral displacement

and the evolved thickness wedge after the finishing mill section outlined at the bottom of the charts. This is not the case when steering control is active, and even where lateral displacement of the strip occurs, there is no effect on the rolled product's thickness wedge thanks to the strip-steering control.

the strip from one stand to the next with a nonlinear model that describes the movement of the strip at the time it is threaded. This model, the simulation environment, and the respective controller were developed in cooperation with Johannes Kepler University in Linz, Austria.

The goal of automatic strip threading is to prevent camber build-up by introducing a combination of measures, namely the prevention of wedge change and wedge reversion over the length of the strip; adherence to a maximum leveling value; keeping the strip-head position within the operating width of the side guides; and consistent performance in conjunction with all possible material grades, at all temperatures, and for all thicknesses.

STRIP-GUIDANCE CONTROL

The second control handles the strip when it is under tension. The objective of the control is to maintain a

parallel-loaded roll gap so that no wedge is formed even under asymmetric rolling conditions. The traditional solution is to level the work rolls of the mill stand according to the measured differential roll force multiplied by a constant differential stand modulus. Without camber control in the roughing mill of the hot-strip mill, the shape of the transfer bars is inconsistent, and there is the possibility that lateral movement might occur in the finishing-mill section.

There are several factors that influence wedge thickness, but the effect is dominated by the material's lateral movement. When strip is rolled off-center in the roll stand, it undergoes asymmetrical reduction to shape the roll-gap profile, which results from thermal crown and roll wear but also from gap actuators (shifting, bending, pair-cross), including roll grinding. Therefore, the feed-forward pathway, including the lateral displacement of the strip, was added to the closed loop between the differential roll force and the

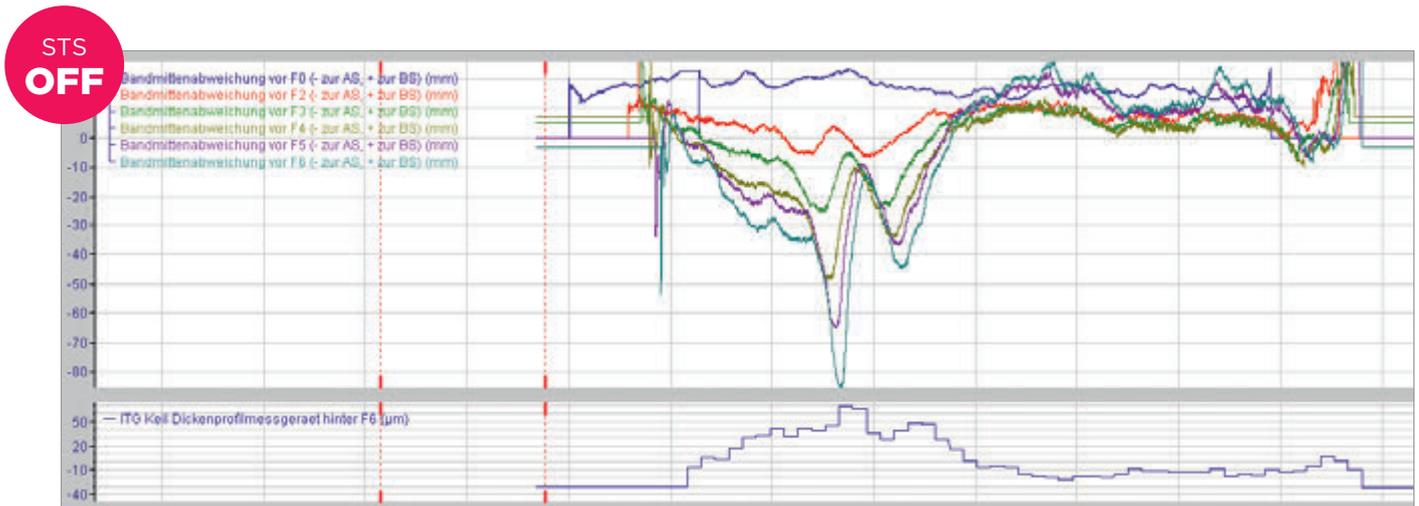


FIG. 4: Lateral displacement of the strip in successive stands, and thickness wedge of the rolled product without strip-steering control.

During the performance-test phase, no cobbles were detected that would have been caused by strip-run failures or during threading—in contrast to the previous cobble rate of 0.1%.

amount of leveling. With active feed-forward control, the lateral displacement of the strip is measured and accounted for—before it can affect the system and create a disturbance.

EXCELLENT RESULTS

In 2016, the strip-steering control system was implemented and tested at thyssenkrupp's Duisburg-based WBW1 plant. Initial tests were performed for common rolled products, subsequent tests targeted special steel grades. Directly after completion of the pilot phase, further tests with approximately 18,000 rolled coils were run to statistically validate the new strip-steering control method.

Results showed that the absolute mean of the thickness wedge remained largely unchanged, but the standard deviation of thickness wedge over the strip length could be significantly decreased. This improvement was achieved for all of the mill's rolled products, inde-

pendent of their particular material grade. During the performance-test phase, no cobbles were detected that would have been caused by strip-run failures or during threading. This was in stark contrast to the cobble rate of 0.1% that was previously common for the mill.

The newly developed control as well as the respective measuring equipment is now in regular use at thyssenkrupp Steel Europe's WBW1 Duisburg plant. Based on the success of the project, further installations at other plants and for other steel producers are expected. ●

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¹⁾ Primetals Technologies

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ON COURSE FOR MADE IN CHINA 2025

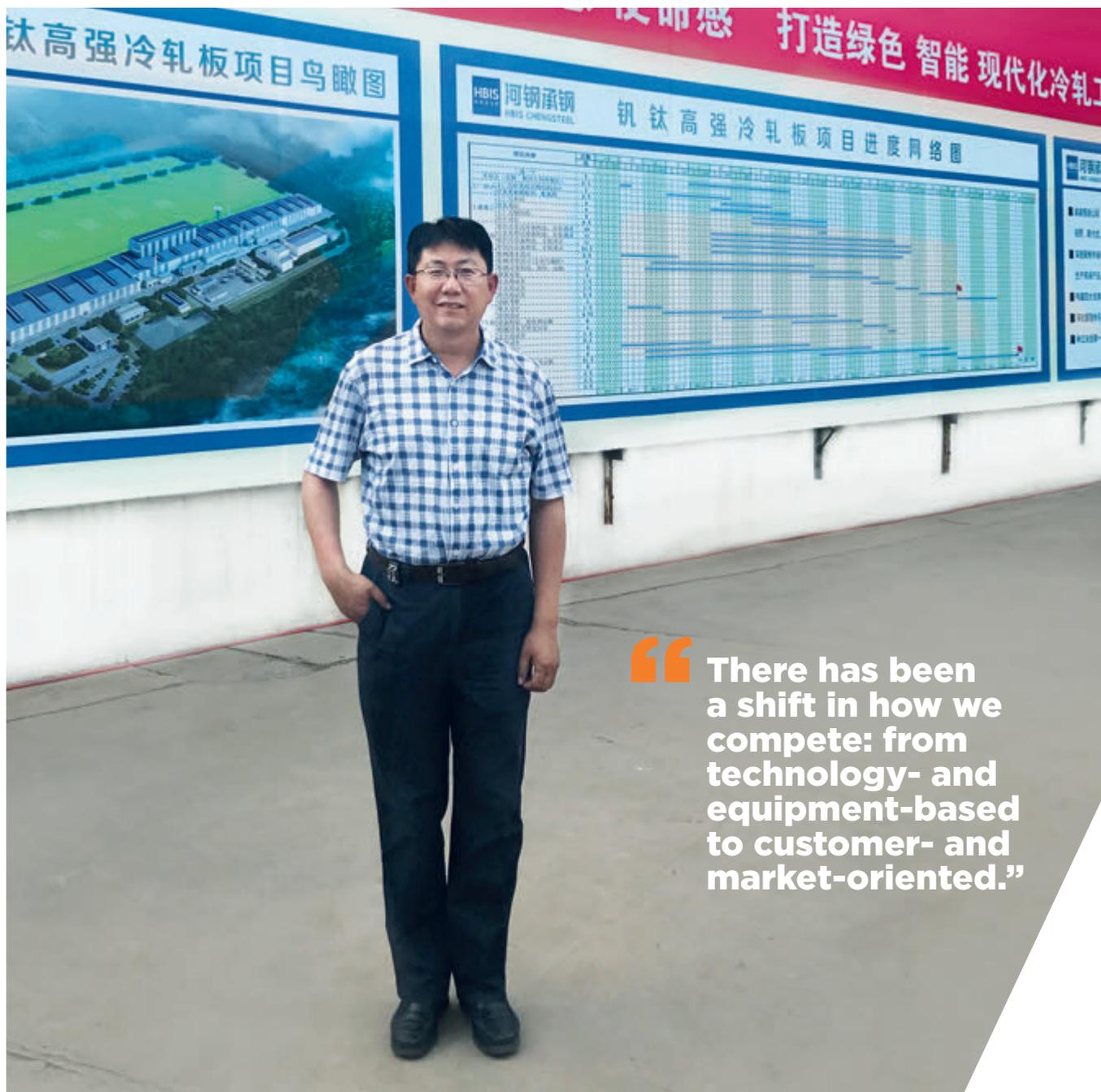
**INTERVIEW WITH LI WEI, GENERAL MANAGER
OF CHENGDE VANADIUM AND TITANIUM
COLD-ROLLED SHEETS CO., LTD.**

Primetals Technologies Communications Officer Deng Yang spoke with Li Wei on the site of HBIS Chengde's future cold-rolling-mill complex—a project that was recently initiated jointly by the two companies. HBIS Chengde, established in 1954, is seen as the birthplace of vanadium-titanomagnetite smelting in the blast furnace and of the vanadium-extraction process in China. It is regarded as the “vanadium capital of northern China” and a worldwide leader in the development, utilization, and commercialization of vanadium and titanium resources.

HBIS Chengde recently ordered a continuous pickling line and a hot-rolling galvanizing line from Primetals Technologies, which will be used for the production of vanadium-titanium high-strength cold-rolled steels. Why did HBIS Chengde choose Primetals Technologies as its partner?

Li Wei: There are three reasons for our choice: First, HBIS Chengde had already successfully collaborated with SVAI, one of Primetals Technologies' predecessor companies. Both parties enjoyed a very good relationship in terms of project implementation, technical exchange, and R&D. All of that combined laid very solid foundations for this partnership today. Second, the

local market has increasingly opened itself up to newly developed forms of hot-rolled strip that can be used as a cold-rolled strip substitute. This change is largely due to the success Shangdong Rizhao have seen with their Arvedi ESP lines. We are aware of the significant impact of state-of-the-art rolling technologies on conventional solutions and have continually updated our knowledge in rolling. Third, the Chinese government is encouraging intelligent manufacturing and green manufacturing, which makes it even more critical for us to implement technological upgrades and extend the production chain. We were impressed by Primetals Technologies' excellence in mechanical manufacturing



“ There has been a shift in how we compete: from technology- and equipment-based to customer- and market-oriented.”

and automation control and saw them as the leading equipment supplier and service partner. This is also why HBIS group signed a comprehensive strategic-partnership agreement with Primetals Technologies in February 2018, which will benefit both parties.

What are the main areas on which HBIS will be focusing?

Li: The business strategy of HBIS Chengde is to “refine iron and steel, enhance vanadium and titanium, and enlarge the non-steel sector.” To refine iron and steel, we need to focus on the following aspects without increasing production capacity: First, updating and

optimizing existing equipment and software so as to reduce failure rates and improve accuracy and availability. Second, strengthening R&D capabilities by establishing a qualified R&D team, investing in new products, optimizing new product R&D and production processes, and improving benefit levels. Third, extending the existing production chain to increase the ratio of value-added products, expanding our customer base in the high end, enhancing product competitiveness, and diversifying our service portfolio.

How can you further strengthen the position of your company in China?

»



Li: In the current economic climate, the foundation of our core competitiveness is shifting from a technology- and equipment-based to a customer- and market-oriented direction. Since 2017, HBIS Chengde has been doing a lot of work on market matching, market development, and structural readjustment. We have established a professional marketing team to further improve our customer services and meet requirements for customization.

What are the new technologies in environmental innovation?

Li: HBIS Chengde will produce cold-rolled products for automotive light-weighting. While exhibiting the same dimensions as their equivalents, our products will have better strength and elongation. We will replace existing products with thinner sheets, which will not only reduce vehicle weight and consequently emissions but also optimize quality and performance. This is our biggest advantage. In September 2017, we founded HBIS Chengde Research Institute for Vanadium and Titanium Industrial Technology with the goal of focusing on the efficient and clean utilization of vanadium and titanium resources as well as on R&D and the commercialization

of new vanadium- and titanium-based high-tech materials. It is our intention that these efforts will be to the benefit of not just HBIS Chengde but also of our province and our country as a whole.

How advanced are Chinese steel producers today compared to the industry worldwide?

Li: The rapid growth of the Chinese steel industry in recent years has had a significant impact on the global steel industry, but we still have a long way to go before we catch up with more advanced producers in terms of intelligent manufacturing and high-end products. Our products are mainly low- and medium-end, typically automotive steel. On the other hand, the quality of locally produced cold-rolled products is constantly improving, as are the related services. Also, the government regulations on production-capacity control and environmental protection have encouraged steel companies to develop high-quality and value-added products. This is also the philosophy adopted by HBIS Chengde.

What do you see as the main industry trend over the next 10-15 years?



The Chengde steel plant will be further upgraded to play a central role within the HBIS group.

“We are confident that steel will maintain its strategic position and play a key role in the development of the world economy.”

Li: We are confident that steel will maintain its strategic position and play a key role in the development of the world economy. As one of the basic industrial materials, steel is irreplaceable, and as one of the supporting industries, the steel industry is indispensable for the development of the world economy. The Chinese steel industry will focus on improving quality and efficiency, and will support the development of both the Chinese and world economies through continual transformation and upgrading, low-carbon development, and open business development.

In order to strengthen China’s high-end manufacturing industry, the Chinese government devised the “Made in China 2025” development strategy. What is your contribution to the program?

Li: HBIS Chengde has been building a modern reference plant that promotes green manufacturing and intelligent manufacturing. We are set to continue this path and will be in a perfect position to support the “Made in China 2025” program once our new project for the production of vanadium and titanium high-strength cold-rolled sheet has been completed. For example, we will install a manufacturing-execution system that will enable our

clients to query the current status of their order: whether the products they ordered are in the planning stage, being processed, or have been shipped, and which port they have been transported to. We are building a product-tracking system, so that products can be automatically tracked by clients via the Internet. The system has been put into operation with basic functionality, and it will be further improved.

Sounds like a fascinating solution. Can you give me another example of an intelligent-manufacturing technology you will be using?

Li: Certainly. We, for instance, plan to install a deslagging robot and automatic unpacking equipment in addition to the existing automatic packing machine, automatic-banding machine, and unmanned crane, so that we will have a fully intelligent production line. The unmanned-crane system is an in-house design by HBIS Chengde, which will facilitate the application of an automation concept and the implementation of a new approach and new technologies in production-line operation, maintenance, and management. After some further refinement, it will be rolled out gradually to the whole HBIS Group. ●



FIG. 1: Camera used to measure bar height in "Industry 4.0"-compatible long rolling plants

THE IMPACT OF INDUSTRY 4.0 ON **LONG ROLLING**

TODAY'S TREND TOWARD INCREASED DIGITALIZATION IN STEEL PRODUCTION IS HAVING A MAJOR IMPACT ON THE AREA OF LONG ROLLING AND IS CHANGING IT FOR THE BETTER.

Communication will occur seamlessly within a plant, allowing mill managers to instantly respond to data from all sensors, machines, and processors.

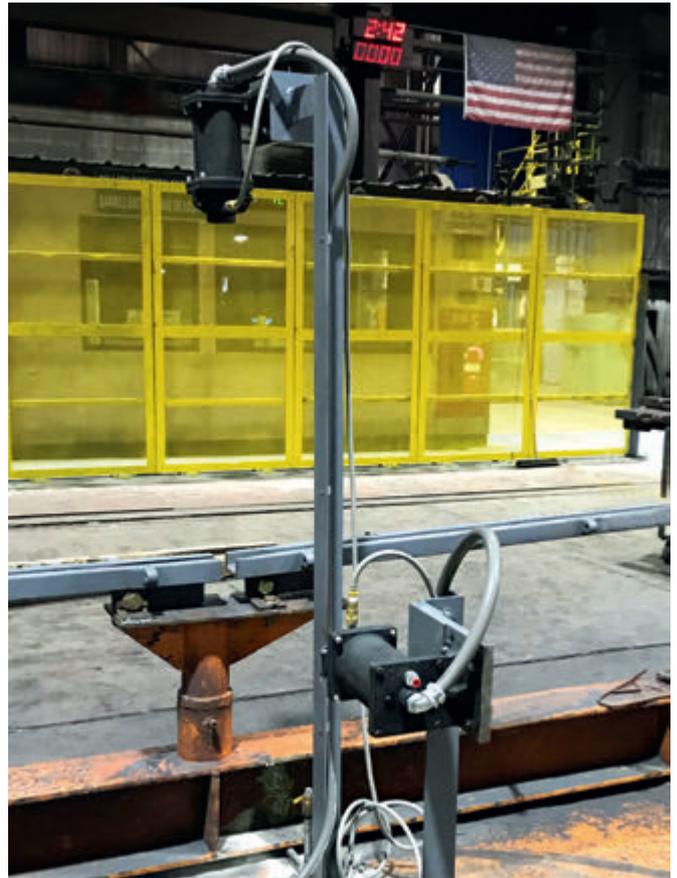


FIG. 2: Test arrangement of bar-height-gauge sensors

Today's steel producers face the dual challenge of ensuring on-time delivery and meeting ever-demanding product requirements, while also running a lean operation. The day-to-day management of a long-rolling plant requires continuous optimization of both operating and business practices.

Imagine a long-rolling facility designed to address these competing demands, a plant where individual pieces of equipment communicate with each other, where sensor information can be used not only for control purposes but also to monitor the condition of the equipment, where models are used to verify the process remains within working limits, and where the equipment alerts operators whenever maintenance is required.

Every mill owner's goal is the highest utilization possible for their investment. New data from devices such as smart sensors, advances in predictive maintenance, and condition monitoring systems can take a long-rolling mill a step closer to that goal. Imagine stand no. 1 informing stand no. 2 about the product's status, and then specifying the actions required from stand no. 2 based on the rolling condition of stand no. 1.

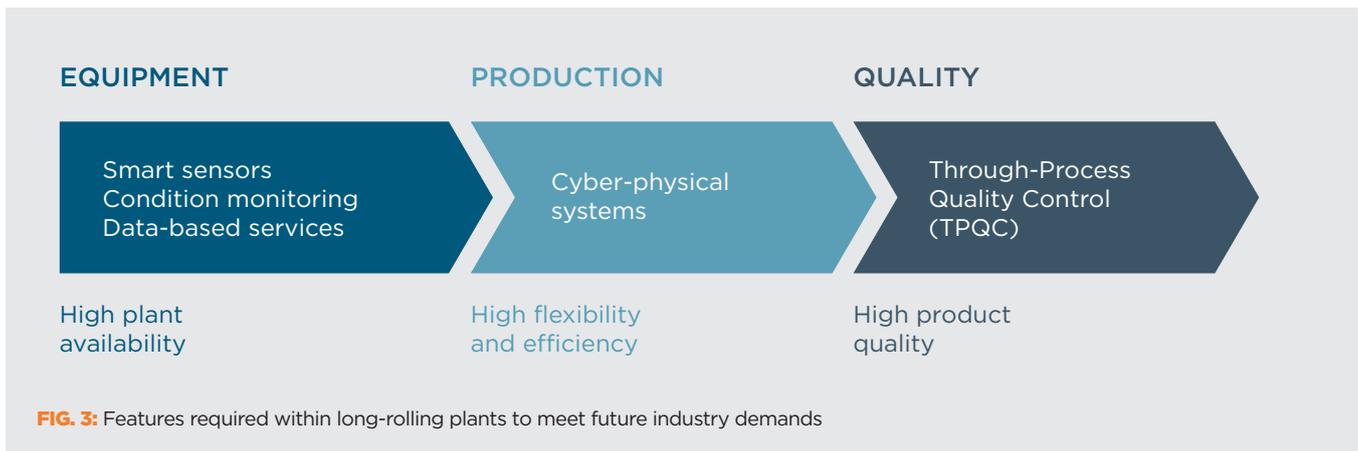
Imagine the roughing mill communicating with the intermediate mill.

REVOLUTIONARY DEVELOPMENTS

This ideal long-rolling operation may be possible in the not-too-distant future. The ongoing evolution in technology through data collection, communication, Internet of Things, control techniques, and smart sensors is generating more information than ever before. Acting on informed data analysis will initially advance both control and monitoring of plant performance. In the longer term, however, it will revolutionize long-rolling mills worldwide and optimize their entire value chain, enabling improved and more flexible production.

Today, there is a traditional horizontal and vertical integration of mill-control and supervisory systems. But with these future changes in technology, communication will occur seamlessly within a plant, allowing long-rolling-mill managers to instantly respond to data supplied by all sensors, machines, and processors, using the Internet of Things as a major pathway.

There is a great deal of interest within the long-rolling industry in what has been labelled Industry 4.0, »



digitalization, or the Smart Factory. While the specifics of each plant's requirements differ from one long-rolling mill to another, the packages supplied within the Industry 4.0 portfolio range from smart sensors, mechatronics solutions, and robotics, to cyber physical models, maintenance systems, and full plant production. Designed to present immediate customer value generated from improved productivity, quality, and flexibility, the portfolio elements access the information available through sophisticated real-time data analysis to understand and optimize a mill's process.

A BUNDLE OF NEW TECHNOLOGIES

It is important to recognize that Industry 4.0 is not one product but a group of technological, process, and maintenance packages to support the transition of a

long-rolling plant so that it can meet the future requirements of plant digitalization.

Digitalization started years ago and will not end anytime soon. Suppliers will actively assist plant operators in the digital transformation of their production plants by developing a roadmap of portfolio elements and services based on each plant's short- and long-term requirements and strategy. Implementation will most likely occur through phased, small modernization projects, to minimize impact on ongoing production.

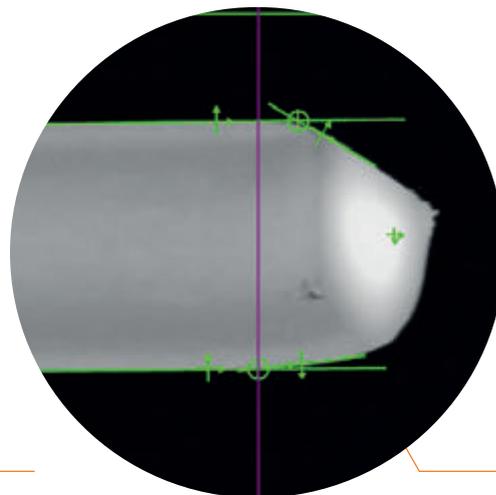
As a partner and supplier to the steel industry, Primetals Technologies continuously develops new technological functions and packages for long-rolling mills in close alignment with key customers, to increase overall

A SELECTION OF SMART SENSORS DEVELOPED FOR LONG-ROLLING APPLICATIONS



Non-contact speed measurement

- Crop optimization
- Pinch-roll control
- Tension control
- Dynamic mill setup



Imaging technology

- Bar counting
- Product measurement
- Billet positioning
- Coil positioning

It is important to recognize that Industry 4.0 is not one product but a group of technological, process, and maintenance packages to support the transition of a long-rolling plant.

productivity and to improve quality, mill flexibility, and mill efficiency. These relationships enable development teams to understand the challenges mill owners face, so that they can provide the tools to support the anticipated growth in technological possibilities and the advancements in future long-rolling plants. Elements of this vision already exist. The long-rolling “Smart Factory” will include numerous components to generate data, as well as systems to analyze the new information.

SMART SENSORS

As a general category, smart sensors provide additional information on the state of equipment or the production process itself. They either directly measure physical values or use existing measurements to indi-

rectly calculate additional information. They enable the implementation of advanced automatic functions, process models, and condition monitoring—and they can communicate this information to anyone at any time.

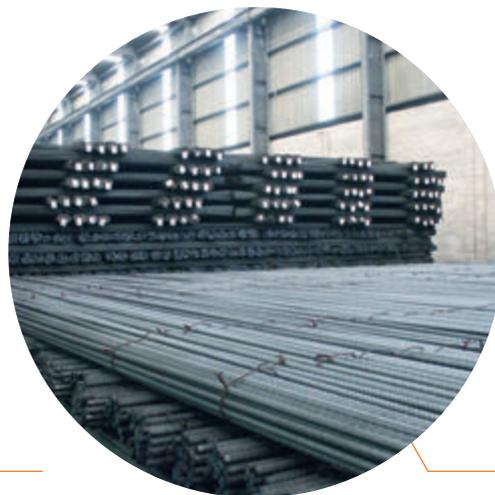
For long rolling, Primetals Technologies offers a portfolio of sensors capable of measuring and supporting process improvement. To name just a few: vision systems and non-contact laser gauges used to measure product height, length, and speed, which are all measurements previously unavailable from the roughing and intermediate mills; and RFID technology for product tracking and logistics control.

Vision systems can monitor “what the eye can’t see,” as these cameras can be positioned in mill areas that »



Intelligent temperature measurement

- Thermomechanical rolling control
- Control of product-transition point
- Enhanced temperature control



Finished product tracking and logistics

- Coil tracking
- Bundle tracking
- Coil- and bundle-yard logistics
- Shipping logistics



FIG. 4: The cooling bed of a long-rolling mill supplied by Primetals Technologies

would be unsafe for operators. They relay continuous images for real-time analysis and dynamic control of the process. Installing the cameras in hazardous areas increases the safety of the operation, in particular for mill personnel.

Laser gauges measure “true product speed.” Having this information along the mill line not only enhances the mill-control system and mill setup but also increases the cut-length accuracy of shears.

When vision systems are combined with non-contact laser gauges, the mill-control system can dynamically monitor product height and width throughout the mill line. Laser gauges track product speed from the furnace exit through to the finishing end. These systems alone lead to a consistent mill setup with dynamic control, which improves yield, product tolerance, and quality. It also increases the flexibility of the operation, and reduces operating costs.

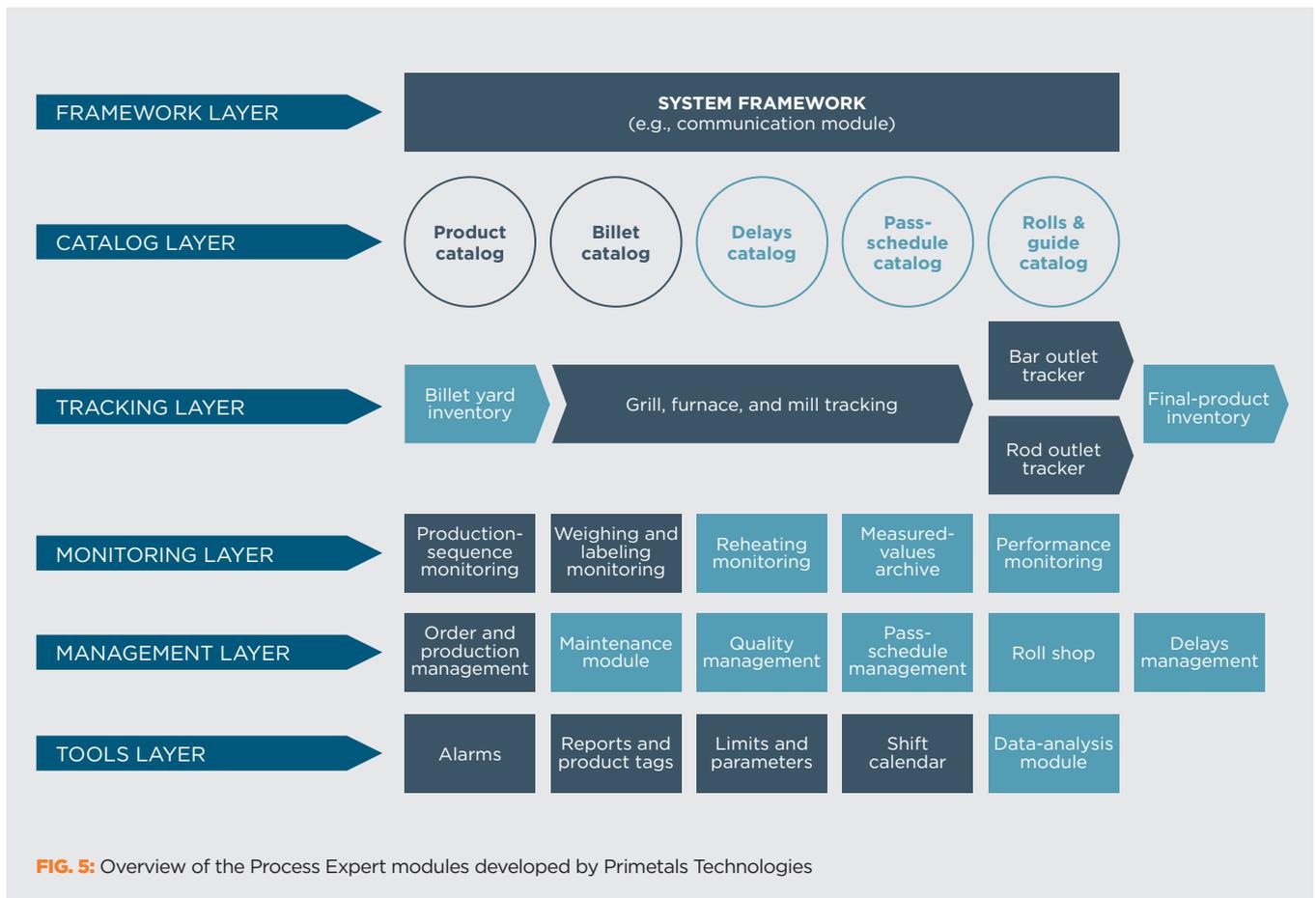
PROCESS EXPERT SYSTEM

Data from new sensors is only useful when it can be analyzed to adapt mill processes. Meeting today's demands for flexible and economic production of long products requires production process, electrical, and

automation solutions that are based on precise process modeling, high-performance control systems, and an in-depth understanding of long-rolling technology. These tools for long-rolling mills can all be considered part of Industry 4.0 packages.

Process Expert is a result of close cooperation between long-product manufacturers and Primetals Technologies engineers. The system enables continual improvement by examining a plant's manufacturing operations as one system, rather than many small systems contributing to a single operation. Mill owners shared what was missing in their existing process-

When a mill is running well, plant managers want the assurance that it will perform just as well in weeks to come.



automation systems. Primetals Technologies engineers met with specialists in basic automation, process automation, and technological and process management to develop a system to represent that missing link.

Through a communication module, Process Expert monitors and collects data from the raw-material stage through to the finished product. Its domain extends from the enterprise-resource planning, through manufacturing-execution systems, to control systems down to Level 1 devices. Tracking usually covers areas such as grill, furnace, and mill, and then—depending on the line configuration—bar outlet or rod outlet. A final module weighs and labels the mill's end product, but outside of the plant, the system can also support billet and product-yard inventory. The system delivers mill reports to operator staff and facility managers, enabling them to assess a plant's performance and optimize production. Not limited to one plant, this system supports plant-to-plant performance evaluation at the corporate level.

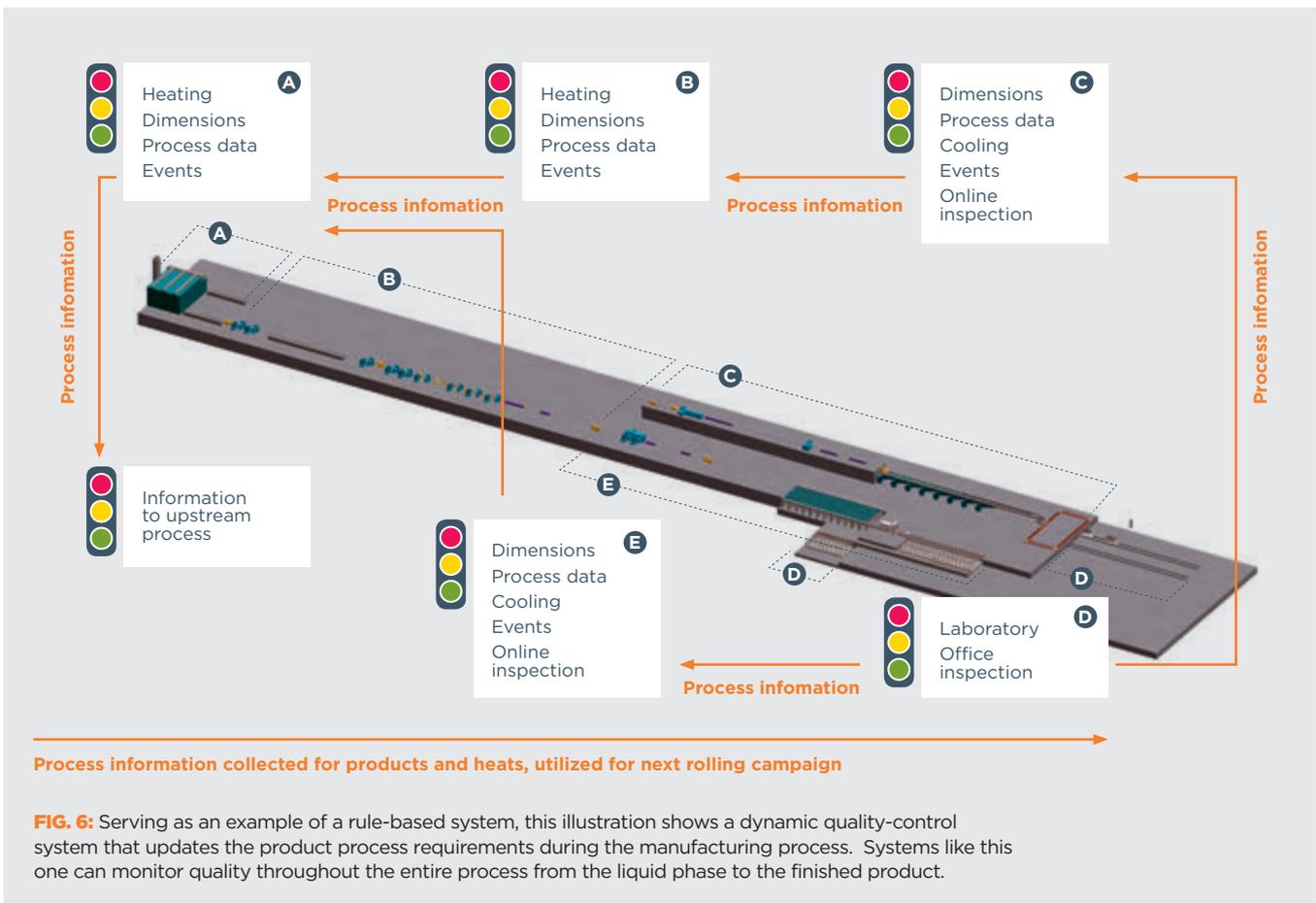
CONDITION MONITORING

How is your mill feeling? When a long-rolling mill is running well, plant managers want the assurance that it will roll just as well in weeks to come. Suppliers can guarantee recognition of all elements contributing to

plant operation, particularly when applying mechanical and electrical knowledge of the equipment and the process to monitor the condition of the entire plant—not just the rolling-mill equipment but also upstream and downstream components. Used to establish a predictive-maintenance schedule, this data ensures that any downtime or shutdowns are scheduled for maximum efficiency, thereby alleviating pressures on the maintenance staff.

As part of the Industry 4.0 shift toward data gathering, a rolling mill's process is constantly assessed and logged to ensure that its process is within acceptable limits. If it falls out of the limits, the control system will use this information and feed it into the control algorithm to bring the process back into limits.

Equipment-condition data is acquired at each plant level, then processed and evaluated against known operating standards, and finally reported back at the plant level. Utilizing the equipment knowledge among suppliers, the system can process the data and issue alerts whenever maintenance is required. Knowing the status of the equipment throughout the full process line helps to maintain quality as well as improve plant productivity. »



The system automatically produces work instructions for maintenance personnel (including any spares required), together with any additional information necessary for execution of the respective maintenance project. It may supply data obtained through 3D interactive models on tablets, which further minimizes downtime.

CYBER-PHYSICAL SYSTEMS

Another element of the Industry 4.0 portfolio for long rolling mills is cyber-physical systems. Used to verify

Cyber-physical systems are based on virtual models: digital representations of the real physical plant or process.

the consequences of changing the plant conditions, cyber-physical systems are based on virtual models—a digital representation (“digital twin”) of the real physical plant or process, formed from integrations of computation, networking, and physical processes. Embedded computers and networks monitor and control the physical processes with feedback loops, illustrating where physical processes affect computations and vice versa.

Long-rolling producers require flexibility and high efficiency in their production cycle. Advancements in software and powerful network systems provide the tools to collect, sort, and analyze large amounts of data. When used within cyber-physical systems, these tools enable offline production simulation with the ability to monitor, analyze, and measure against designated key performance indicators to evaluate whether the planned production will meet higher standards.

Representing the future of process automation, cyber-physical systems can model an individual process, such as a cooling module, to calculate the temperature equalization in a rail mill, the water-box setup in a conventional rod or bar mill, or a mill setup and roll-pass calculations.

Utilizing cyber-physical systems in the future, mill operators and supervisors will be able to understand the effects of a change in setup of a certain process or piece of equipment before the change is made, and make those changes with confidence. On a broader scale, the use of cyber-physical systems will be a critical factor in optimizing the entire value chain, evaluating new business models, and integrating new business partners.

THROUGH-PROCESS OPTIMIZATION

Already in use in long-rolling mills, this additional Industry 4.0 package, Through-Process Optimization (TPO), helps mill operators achieve intended product specifications, and supports quality management. It accomplishes this through the identification of non-conformities, determination of the related root cause, and provision of corrective and compensational actions throughout the entire steel-production chain.

This system integrates the quality know-how of a product with the real-time production process. A rule-based system checks the resulting data at each process event. Based on these rubrics, it decides whether product quality is within the defined limits. The system then determines corrective dynamic adjustments to both upstream and downstream processes. This consequently enhances overall product quality by both preventing further quality issues from occurring and rectifying those detected.

PRODUCTION- AND MAINTENANCE-MANAGEMENT SYSTEMS

Production- and maintenance-management systems for long-rolling mills provide yet another source of data for the Industry 4.0 portfolio. To ensure production facilities are fully utilized, a Production-Management System can dynamically plan and track a facility's production to optimize each step in the process—from the first product order to final delivery. Armed with this data, a plant manager can respond to customer requests with greater flexibility and run a leaner operation.

For ongoing plant maintenance, a computerized maintenance-management system works in parallel with the Production-Management System to manage and execute maintenance activities by flagging tasks and other scheduled action items for greater efficiency. The system incorporates built-in knowledge of a facility's overall maintenance strategy and production system, and maps that against data points supplied by onsite sensors.

REVOLUTION OR EVOLUTION?

Is Industry 4.0 a revolution or evolution of technology for the long-rolling industry? From a technical point of view, it is an evolution that needs to be implemented not just in long rolling but across the metals industry as a whole. Once the analytical drivers of Industry 4.0 merge with the production process, it will turn into a revolution.



Solutions are now available to enable the digitalization of long-rolling mills, from the liquid phase to the finished product.

In many ways, Industry 4.0 is no longer a vision of a distant future, as much of it has already arrived. Elements of this approach are already being developed, installed, and tested globally. By implementing the measures outlined in this article, long rolling mill owners can, utilizing the expertise of suppliers, manage the digital transformation of their production plants. They can establish both their short- and long-term goals in a phased approach, optimize the implementation of these ever-evolving technologies, and harness the full power of Industry 4.0.

Where does all this lead? Some say that it will promote the development of a fully automated factory. Solutions are now available to make possible the digitalization of an entire long-rolling mill, from the liquid phase all the way through to the finished product. Steel producers who plan to implement these new technologies in the near future will find great support in the counsel and collaboration with expert partners—such as Primetals Technologies' engineers. ●

Paul Riches, Vice President, Electrics and Automation, Long Rolling, Primetals Technologies U.S.A.

Allison Chisolm, Principal, Choice Words/Chisolm & Co.

BUILDING INFRASTRUCTURE **FOR KAZAKHSTAN**

PRIMETALS TECHNOLOGIES HAS PARTNERED WITH AKTOBE RAIL AND SECTION WORKS TO BUILD AN INDUSTRY 4.0-COMPATIBLE ROLLING MILL FOR RAILS AND STRUCTURAL SECTIONS IN KAZAKHSTAN.



The rolling mill for rails and sections of Aktobe Rail and Section Works LLP (ARBZ) is the first rail-manufacturing facility in all of Kazakhstan. Considered one of the world's benchmark manufacturers of rails, it is based in the town of Aktobe, from where it caters to the growing demand of the domestic market and neighboring countries. Rails of up to 120 m in length are pre-certified according to the GOST standard, and are sold on the domestic market and exported to the Russian Federation as well as to CIS countries.

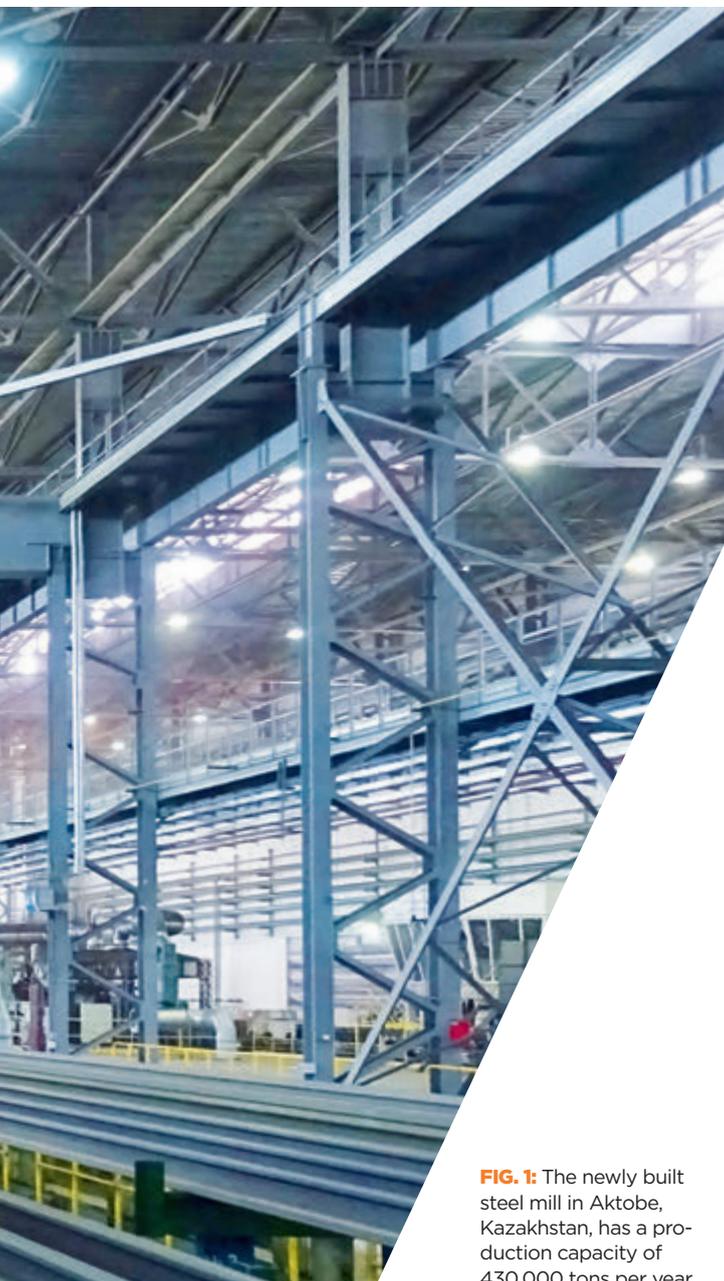


FIG. 1: The newly built steel mill in Aktobe, Kazakhstan, has a production capacity of 430,000 tons per year.

Under the auspices of Kazakhstan Temir Zholy JSC, the national railway company, the ARBZ venture was first established in 2012 and a decision was made to build the first rail manufacturing plant outside the city of Aktobe in the north-west part of the country, about 100 kilometers from the border with the Russian Federation. Aktobe is in a strategically favorable location, with easy access to markets in Europe, Russia, the CIS, and Middle East.

Primetals Technologies was awarded the main contract in 2013. Engineering, automation, and manufacturing took place in 2013 through 2014, and construction started in 2014. Hot commissioning started in September 2015, and the certification process was initiated in February 2016. The final plant acceptance certificate was signed in August 2017.

PLANT LAYOUT AND PRODUCTS

The ARBZ steel mill in Aktobe has a nominal production capacity of 430,000 tons per year. The overall footprint of the production area of the plant is 650 by 150 meters, remarkably compact for a facility designed to process long rails. In addition to some 200,000 tons per year of rails (P65 65 kg/m) in lengths of up to 120 meters, the product mix comprises 230,000 tons per year of structural medium sections, including beams and channels of up to 300 millimeters and angles of up to 200 millimeters. ARBZ is therefore able to flexibly react to changing market trends.

As the basic material, rectangular blooms with sizes of between 160 and 350 millimeters are used, with lengths ranging from 5 to 12 meters. The way in which the plant layout and equipment are configured allows for the expansion of the product mix to include additional rollable sizes, and for beam blanks to be used as the basic material. The re-heated bloom is rolled in a reversing breakdown mill and transferred to a reversing

finishing mill for final rolling. Depending on requirements, rails may be head-hardened by Primetals Technologies' patented Inline Injector Dual-Phase Rail Hardening System (idRHa+) before being deposited on the cooling bed. Cold rails and sections are straightened and then subjected to non-destructive tests before final handling and dispatch. Other included packages are the descaling systems, inline profile measurement, rail stamping unit, hot and cold saws for cutting and web drilling, laboratories, and a maintenance workshop.

REVERSING BREAKDOWN MILL

The breakdown mill is a 2-high, reversing, housing-type machine with a roll-barrel length of 2,200 millimeters. The housing design provides the stiffness required to withstand the high separating forces with minimum deformation. The machine is equipped with automated lineals and tilters located at both entry and exit, which translate and rotate the bar in between the rolling passes and guide it into the selected groove.

Hydraulically balanced, the top roll is vertically positioned by a screw-down system, driven by two independent servo-controlled motors that automatically compensate possible asymmetries. The screw-down system is made of compound material with anti-friction coatings for increased wear resistance.

Hydraulic capsules are installed at the bottom of the machine to:

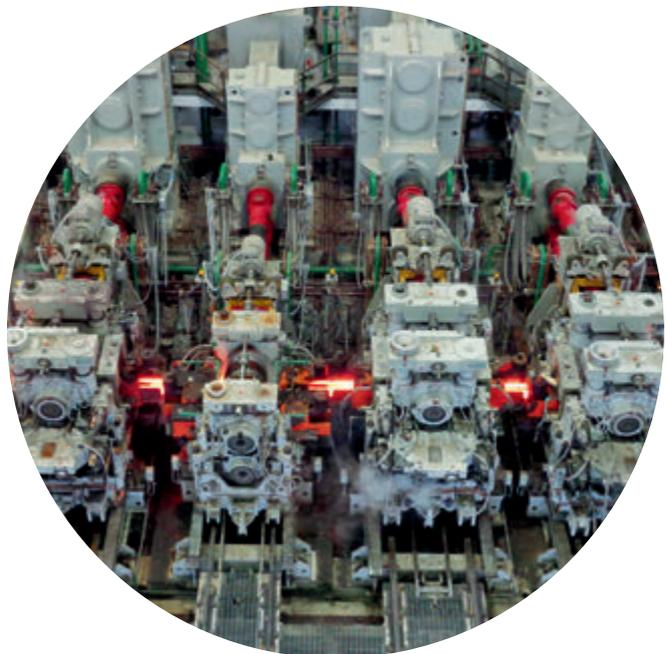
- adjust the centerline position of the bottom roll
- provide anti-jamming release functionality
- automatically position the bottom roll at the start of a roll replacement
- automatically control the rolling force

The innovative symmetrical open-pass calibration for rails ensures consistent dimensions of stock over the full bar length and reduces the risk of fin and wrinkle formation. At the same time, the guiding system is simplified and axial loads are reduced. The closed-pass calibration traditionally used for rails requires complex rolling sequences and bulky guide equipment with side collars that limit usable barrel length. By relying on symmetrical open-pass calibration instead, the rolling sequences are simplified and the bar is simply and effectively guided by the lineal noses and shoe plates. The full roll-barrel length can thus be utilized and rolls with smaller barrel and diameter can be used. Uniform groove wear is ensured, while roll lifetime is increased and redressing times are reduced.

When manufacturing the P65 rail from a 360 by 300 millimeter bloom, the breakdown mill applies nine rolling passes to the bloom and shapes it to a leader sec-



The reversing breakdown mill uses a rigid housing-type design to minimize stand deformation even when great pressures are applied.



The 3+1 finishing mill requires less maintenance than comparable mill setups with more conservative designs.

tion. The first six passes are high-reduction box-type and guarantee the desired metallurgical properties in terms of grain size and core soundness; the final three passes are shape-type and allow for the precise leader pass required to feed the finishing mill.

UNIVERSAL FINISHING TANDEM MILL

After the breakdown mill, the bar is cross-transferred to separate the rolling between roughing and finishing, and to limit the plant's footprint. The universal finishing tandem mill is made up of four stands of the fourth-generation housingless Red Ring type, with solid and compact construction for high load capacity, wear-resistance, and ease of maintenance.

The stands can be quickly converted from universal to horizontal configuration and vice versa. The universal configuration is used for rolling rails, beams, and channels, while a full horizontal configuration is used when rolling angles.

Whenever spare units that have been prepared in the roll shop are used, total downtime can be kept below 30 minutes. Offline in the workshop, the stand parts (horizontal rolls, vertical rolls, chocks, baseplate) are disassembled and reassembled with dedicated automated jigs.

The 3+1 finishing mill uses a particular sequence with three reversing runs to process the leader pass prepared by the symmetrical calibration of the breakdown mill. The reversing runs allow precise control of the bars' temperature and of the temperature's head-to-tail gradient. During the first two reversing runs, the fourth finishing stand stays open and is not used. It is only closed during the third run, once on each bar, applying a small finishing reduction.

In comparison to a traditional 3-stand finishing mill, the rolls at the fourth stand of the 3+1 mill are subjected to lower stresses and will show reduced wear. They need to be serviced less frequently, which makes changes largely unnecessary: one roll set can typically be used for a full campaign. Available hours and productivity are thus increased, and the return on investment for the fourth stand is short. The small-reduction finishing pass improves surface smoothness and size accuracy, which is especially beneficial when special-class products are rolled, e.g. X-class rails.

IDRHA+ INLINE RAIL HARDENING

In order to produce rails with a high resistance to rolling-contact fatigue and wear, the mill at ARBZ is equipped with Primetals Technologies' patented Inline Injector Dual-Phase Rail Hardening System (idRHa+).



The cooling bed is 125 meters in length to accommodate for rails that are 120 meters in length.



The horizontal straightener for rails can run at speeds of 2 meters per second, straightening the head and foot of the rails.



CERTIFIED TO THE HIGHEST STANDARDS

National certification in line with Kazakh standards was completed in a very short time, as the project scope included the in-house certification laboratory. ARBZ then began the multi-year certification process according to the Russian GOST standard, and pre-certification was obtained in November 2016 after a rigorous six-month testing protocol at the All Russian Railway Research Institute (VNIIZhT). VNIIZhT operates a railway loop where the rails are tested and a variety of operating conditions are simulated, such as train composition, load distribution, time, acceleration, speed, braking, and gradient.

ARBZ and Primetals Technologies have begun a long-term partnership for the supply of spare parts, which will maximize plant availability.

idRHa+ is based on a software suite that comprehensively simulates the production process by modeling the transfer of thermal energy to the rails, as well as the change of their mechanical properties and the transformation of their metallurgical structures. The application of idRHa+ leads to required hardness distribution across the full rail section, as well as to a consistent microstructure.

The heating zone is equipped with a set of high-power induction modules for immediate heat transfer. The heating action equalizes the temperature of the rail along its length and applies the desired temperature gradient over its cross-section.

The cooling zone contains several independent modules, each equipped with a set of interchangeable cooling devices that apply the required cooling protocols. Mist-water atomizers and air-jet blades are used. Modules are independently operated to remain flexible in terms of changing the optimum cooling protocol application. Cooling speeds can range from 0.5°C/s to 40°C/s. Rails processed with idRHa+ are then brought into a head-up position and sent to the cooling bed, where they are not prone to bulging.

THE COOLING BED

The mill is equipped with a 125-meter walking-type cooling bed, capable of handling rails with a maximum length of 120 meters. The cooling effect is by natural air flow. On the cooling bed, non-hardened rails tend to bulge inward on their head side due to differential cooling gradients in the section. In order to prevent distortion and internal stresses, Primetals Technologies installed a pre-cambering system at the bed inlet table that applies a controlled outward bulge on the rail. 3-meter-spaced hydraulic grippers are mounted on independently traveling cars to apply the desired pre-camber according to a calculation model.

STRAIGHTENING SYSTEMS

The combined effects of the mechanical work from rolling and of inhomogeneous cooling result in considerable internal stresses on the product at the cooling-bed exit. International standards dictate acceptable limits for the internal stresses in order to prevent any distortions in the final product. Inline roll straightening is the last process of plastic deformation along the chain of production. The straightening process involves the application of calculated and controlled plastic deformations along the bar length. During straightening, the internal stresses are reduced to within an acceptable range, while precise straightness tolerances are achieved.

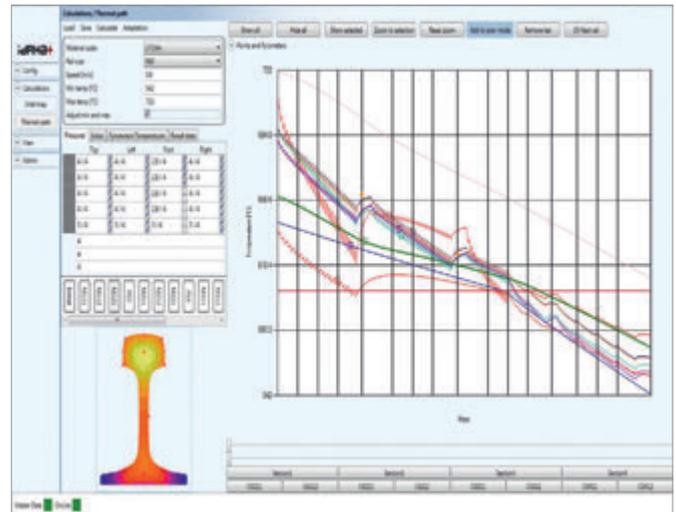
For structural sections, there is a horizontal multi-strand straightener with nine double-supported staggered rolls. For rail straightening, one horizontal and one vertical machine are used, which act on the rail head and foot, and on the rail web, respectively. The



RAIL TRANSPORT ON THE RISE

The role of rail transport, both passenger and freight, is becoming increasingly important throughout the world. The global rail market posted an annual growth rate of 3% in 2013 through 2015, and is forecast to continue growing steadily until 2021, when the market is expected to reach 218 billion dollars.

To meet the demands of higher speeds and high loads, all the major national rail material standards were updated in the period from 2010 to 2015. Quality must be raised to much higher levels than was considered adequate at the end of the 20th century. Manufacturing units are expected to efficiently produce rails in a wide range of grades, sizes, and lengths, with mechatronically assisted setup procedures and self-adapting operations governed by process control. These are the tenets of Industry 4.0 that will promote digitalized manufacture, with considerable benefits in terms of product quality, shorter start-up times, lower running costs, greater operational flexibility, and the efficient use of resources.



THE INDUSTRY 4.0 SOLUTION OF PRIMETALS TECHNOLOGIES FOR RAIL HARDENING

idRH⁺ stands for “Inline Injector Dual-Phase Rail Hardening System” and is based on an advanced software package that comprehensively simulates the production process. The suite integrates with the equipment’s advanced sensors and mechatronics, thus implementing Industry 4.0 production management solutions. The models allow for the prediction and real-time control of the rail properties along the length and across the section, such as YTS, UTS, hardness gradient, microstructure transformation, and deformation behavior. The cooling protocols provided by the models are applied by the equipment modules, which are located inline with the finishing rolling operation, so that productivity is not affected. The real-time measured values are used to dynamically adjust the process and the equipment. As a result, the desired microstructure and hardness distribution across the rail section is kept consistent.

horizontal straightener, with nine individually driven rolls, is equipped with hydraulic capsules with digital pressure and position transducers. The mechatronic control precisely adjusts roll position under load and in real time.

SUCCESSFUL PROJECT EXECUTION

Primetals Technologies completed the rolling-mill project in August 2017, when the final acceptance certificate for the rolling mill was signed. However, the partnership between Primetals Technologies and ARBZ is set to continue: the two companies have since

entered into a long-term agreement for spare-part supply in order to maximize plant availability. This will ensure that ARBZ will optimally contribute to the improvement of Kazakhstan’s rail infrastructure for many decades to come. ●

Alberto Lainati, Head of Long Rolling, Primetals Technologies Italy

Francesco Toschi, Head of Technology and Innovation, Primetals Technologies Italy

A TECHNOLOGICAL LEADERSHIP ROLE

INTERVIEW WITH ANDREY ANATOLYEVICH KUZMIN, GENERAL DIRECTOR OF AKTOBE RAIL AND SECTION WORKS LLP AT THE TIME OF THE RAIL AND SECTION WORKS PROJECT

A native of the Kazakh city of Aktobe, Andrey Kuzmin graduated with honors from the regional State University. After a career in the energy sector, he established himself within the construction industry in 2006 and headed a branch of a domestic company. He led the ARBZ project from its very beginning in 2012 until 2018. In 2014, he was the recipient of the “Altyn Sapa” accolade, which was awarded to ARBZ by the president of Kazakhstan in the category “Best Industrial Project.”

What prompted your company’s decision to invest in 2013, in spite of the worldwide recession in the steel industry that was still ongoing at the time?

Andrey Anatolyevich Kuzmin: There is a multi-year plan for the modernization of Kazakhstan, which requires investments to be planned based on a long-term vision. Within the framework of the “Industrialization Map” of Kazakhstan, the development of railway infrastructure is among the country’s top priorities. This has led to the decision to build the first plant in Kazakhstan for the production of rails. ARBZ is now among the most modern rail producers in Eurasia. It is one of only a few sites in the CIS region that manufacture premium rails using state-of-the-art technologies for rolling, thermal hardening, cambering, straightening, and inspecting. A fully automated platform integrates these technologies, guaranteeing the quality of the final product.

What were the key challenges that had to be met during the project?

Kuzmin: As the project had been initiated under the auspices of Kazakhstan Temir Zholy, the national railway company of Kazakhstan, there was significant pressure from all shareholders to complete the on-site construction work within the shortest-possible time-

frame. Although tight, the project schedule was sound and rational, and all parties collaborated to meet the targets.

Was it possible to keep the project on schedule?

Kuzmin: Yes, a lot of work was done during the design, installation, and commissioning of the plant, which significantly sped up the plant’s startup. In the first year of operation, we were already producing about 140,000 tons of rails. I believe that there are no other cases anywhere in the world in which a plant was built from scratch in just 2.5 years, with rail production being mastered after only 6 months. In order to keep to this schedule, a great number of highly qualified specialists from several companies worked in unison.

Why did ARBZ choose Primetals Technologies as the main partner for this project?

Kuzmin: The original commitment from the stakeholders was very clear: to build a facility that would take a technological leadership role and would be capable of manufacturing top-quality products. Therefore, once the investment strategy had been outlined, ARBZ investigated which cutting-edge equipment and processes were available for rail manufacturing. The



“ We established a positive relationship with Primetals Technologies early on, and it remained this way during the entire undertaking.”

results from this investigation convinced us that the portfolio of Primetals Technologies had all the technologies, processes, and competences we required. Primetals Technologies was also chosen due to its reputation for being one of the most knowledgeable and reliable plant suppliers, with both technical proficiency and sound contract management. For example, Primetals Technologies' inline-controlled hardening process "idRHa+" has proven to be very effective in obtaining high productivity levels in premium-rail manufacture.

How would you characterize the relationship with Primetals Technologies?

Kuzmin: A positive relationship was established between ARBZ and Primetals Technologies in the early phases of the project, and it remained this way over the course of the entire undertaking. Both parties showed eagerness to quickly resolve any problems, which greatly enhanced the teamwork. Of course, some situations with conflicting interests did occur, but they could be overcome thanks to the open-minded cooperation. Our mutual trust has always been solid, and the respective responsibilities were professionally met.

The mill is capable of manufacturing both rails and medium sections. What are the current percentages of these two product groups?

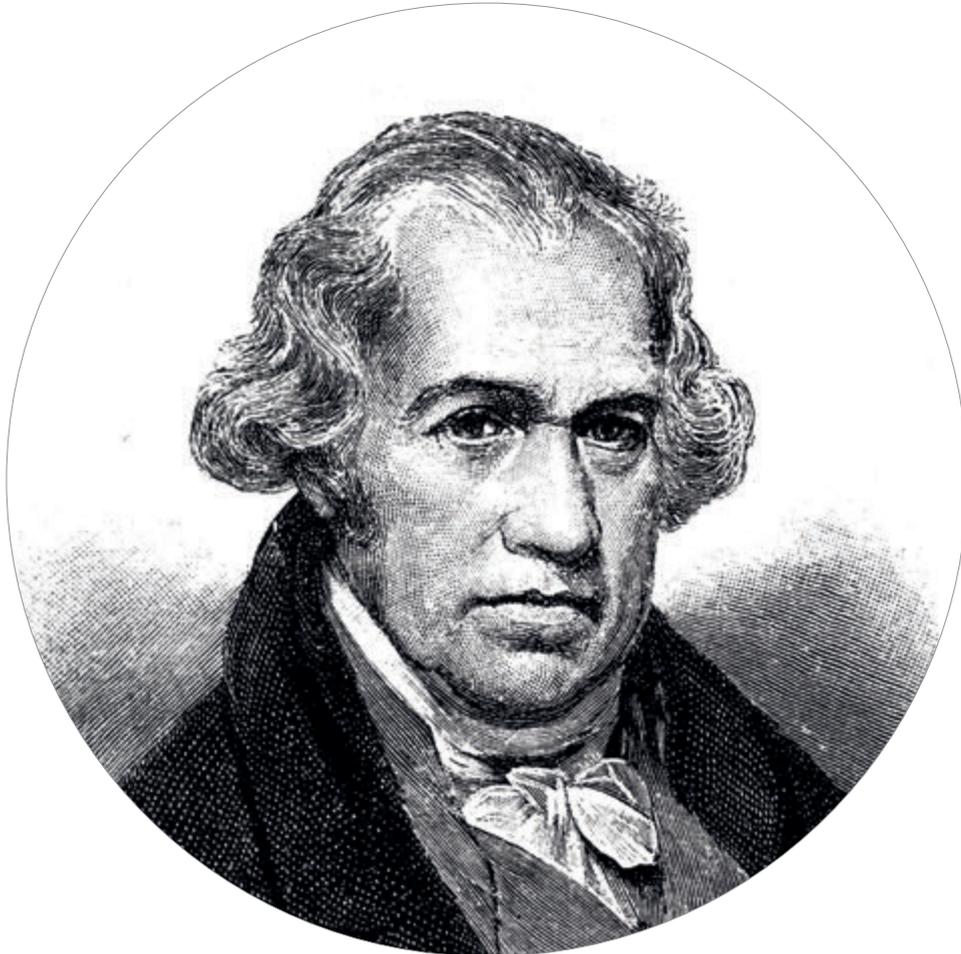
Kuzmin: Because of our long-term agreement with Kazakhstan Temir Zholy, rails represent the majority of our production. Aside from selling our products on the domestic market, our rails are currently exported to the Russian Federation and to CIS states. However, our equipment was designed for a quick changeover from the production of rails to that of structural sections, which gives us a great flexibility to adapt to different market conditions as they arise.

Could you comment on the state of the steel industry in the CIS region? What are its main challenges right now?

Kuzmin: In Kazakhstan and other CIS countries, the demand for steel products for both construction and engineering applications is set to moderately increase over the next few years. The main challenge is the imports from China and other countries. In order to remain competitive, it is crucial to constantly raise product quality, to conduct product research, and to focus on cost optimization. ARBZ will be continually improving the rail grades it can produce and will develop new ones, with the goal of enhancing rail performance, especially in terms of the rails' resistance to wear and flaking. In order to increase our market share, we strive to foster excellent relations with our customers, as well as to widen our customer base. Geography is one of ARBZ's biggest advantages: located right in the center of Asia, we are in the perfect position to serve Europe, Russia, the CIS region, and the Middle East. ●

GREAT PIONEERS

THAT INSPIRE US



At Primetals Technologies, we constantly strive to pioneer new and groundbreaking solutions for the steel industry. We work with passion, inspired by our close partnerships with steel producers from all around the world. Another source of inspiration are the great pioneers that have come before us—innovators who have made a profound impact on the way we live and changed the course of history. In this series, we look at the lives, the challenges, and the achievements of some of the most outstanding pioneers of all time.

TIMELINE**1736**

Watt is born in Greenock, Scotland.

1765

Watt invents the separate condenser.

1781

Watt invents the sun-and-planet gear.

1782

Watt patents the double-acting engine, where the piston both pushes and pulls.

1784

Watt invents the parallel motion: "One of the most ingenious, simple pieces of mechanism I have contrived."

JAMES WATT

THE FATHER OF THE INDUSTRIAL REVOLUTION

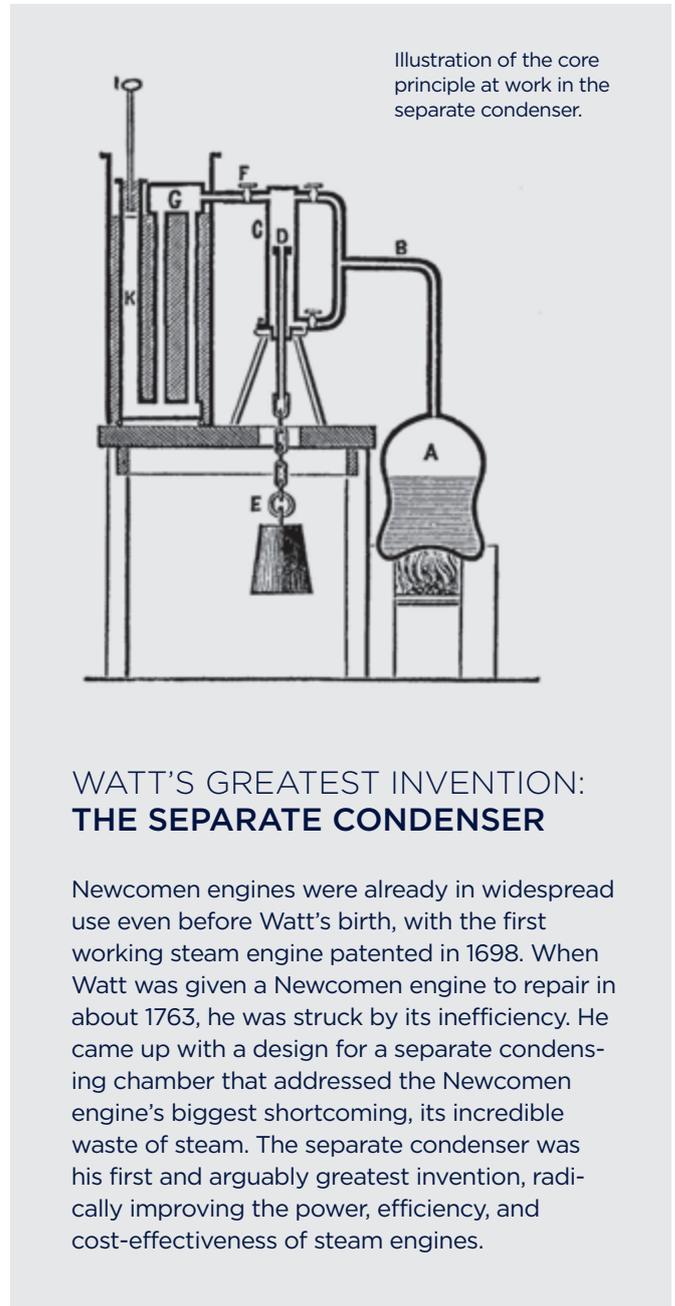
Scottish inventor and mechanical engineer, best known for his improvements in steam-engine technology

Newton and gravity, Roentgen and X-rays, Mestral and Velcro, Plunkett, and Teflon; some of history's defining scientific discoveries have been accidental, and fifteen-year-old James Watt's incident with a kettle is no less momentous. Young James is said to have sat at his aunt's tea table for over an hour, watching the lid on a kettle rise and realizing the power of steam. Some dismiss the story as a myth, but James Watt went on to carry out many laboratory experiments using a kettle as a boiler to generate steam. His improvements to the steam engine sparked the Industrial Revolution, altered economies and laid the tracks for seismic social change.

THE ENGINE THAT DROVE A REVOLUTION

The young James Watt was described by his cousin, Marion Campbell, as a "sickly, delicate" but brilliant boy who would sit for hours poring over mathematical calculations and dismantling and reassembling his toys. James Watt's talent for observation and practical application saw him become the engineering virtuoso behind the Industrial Revolution. His contributions to science and industry eventually led to the adoption of the unit of power named in his honor. Watt did not actually invent the steam engine, but it was his pioneering work on steam power that culminated in his invention of a separate condenser that significantly improved the efficiency of the Newcomen engine. This was arguably the most important invention of the 18th century, and his steam engine became known as "the workhorse of the Industrial Revolution."

James Watt propelled us into the modern world, but it was his difficult early years and subsequent setbacks that defined him. The son of a shipwright and grandson of a noted mathematician, Watt was prone to bouts of ill health and was largely home-schooled by his well-educated mother, Agnes. At first, his father's business prospered and grew, and the young James would make models and repair nautical instruments in the workshop. But during Watt's teenage years, a »



WATT'S GREATEST INVENTION: THE SEPARATE CONDENSER

Newcomen engines were already in widespread use even before Watt's birth, with the first working steam engine patented in 1698. When Watt was given a Newcomen engine to repair in about 1763, he was struck by its inefficiency. He came up with a design for a separate condensing chamber that addressed the Newcomen engine's biggest shortcoming, its incredible waste of steam. The separate condenser was his first and arguably greatest invention, radically improving the power, efficiency, and cost-effectiveness of steam engines.

1785

Watt is elected fellow of the Royal Society of London.

1790

Watt invents the pressure gauge.

1794

Approaching retirement, Watt founds the firm Boulton & Watt, which built the Soho Foundry to produce steam engines.

1806

Watt becomes an honorary doctor of laws of the University of Glasgow.

1819

Watt dies in Heathfield Hall, near Birmingham, England.

series of commercial disasters struck and the business began to flounder. His father's health began to fail, and two years after his mother's death, 19-year-old James Watt was forced to move to London to study instrument-making. He mastered the craft in a single year.

An optimistic Watt returned to Glasgow in 1756, certain that as the only mathematical instrument-maker in Scotland he would have no problem finding work. His hopes were dashed by the Glasgow Guild of Hammermen, however, who blocked his employment because Watt had failed to put in the requisite seven years as an apprentice. So much for being a fast learner! It was a catch-22 for Watt: there was nobody for him to apprentice with, because there was no-one with his speciality. No-one said it was easy being a pioneer.

REVOLUTIONARY REFINEMENTS

Watt was thrown a lifeline by the University of Glasgow, who employed him privately to restore a range of astronomical instruments. He was then given the opportunity to set up a small workshop within the university. Though lacking in business acumen, he entered into a partnership with architect and businessman John Craig, and over the next six years, they manufactured musical instruments and toys.

It was while working at the university that Watt became increasingly intrigued by the technology of steam engines. Adam Smith, the father of modern capitalism, introduced Watt to John Robison in 1758, and Robison in turn introduced Watt to the science of steam. The moment that altered the course of history came in 1763, when Watt was asked by the university to repair a steam-powered Newcomen steam engine, originally invented by English engineers Savery and Newcomen.

**“ Raphael paints wisdom,
Handel sings it,
Phidias carves it,
Shakespeare writes it,
Wren builds it,
Columbus sails it,
Luther preaches it,
Washington arms it,
Watt mechanizes it.”**

Ralph Waldo Emerson,
poet, philosopher, and essayist



THE U.K. £50 BILL AN INNOVATION IN ITSELF

The current U.K. £50 banknote, first issued in November 2011, features Matthew Boulton and James Watt and is itself an innovation; the Boulton and Watt note is the first Bank of England banknote to feature two portraits on the reverse, and is also the first introduced by the Bank to feature a green “motion thread.” According to the Bank of England: “The motion thread on the £50 note is woven into the paper. It has five windows along its length, which contain images of the £ symbol and the number 50. When you tilt the note from side to side, the images move up and down. When you tilt the note up and down, the images move from side to side and the number 50 and the £ symbol switch.”

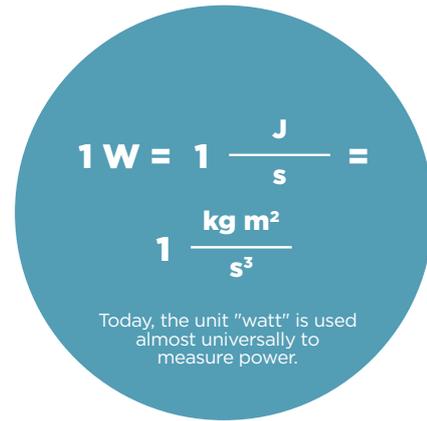
The Newcomen engine had already been widely used for decades to pump water out of mines, but it was very inefficient. Watt discovered that through repeatedly heating and cooling the cylinder, the engine wasted most of its thermal energy rather than converting it into mechanical energy. Watt's solution was to use a separate chamber to condense steam without cooling the rest of the engine. His invention effectively turned a machine of limited use into one that would power the Industrial Revolution.

Since Watt was broke at the time, he was glad to be given another break by British inventor John Roebuck, who took two-thirds ownership of Watt's invention. One major problem, however, was the lack of skilled labor needed to produce components with sufficient accuracy and precision. Meanwhile, the patent on Watt's invention was proving hugely expensive, so to supplement his income, Watt was forced to work for eight years as a surveyor and civil engineer. Eventually, however, Roebuck went bankrupt and Matthew Boulton, owner of the Soho Manufactory near Birmingham,



DID YOU KNOW ...?

... that James Watt came up with the concept of horsepower in 1783 to describe the power output of an engine. Having already adapted and marketed a steam engine for pumping water from underground mines, Watt was keen to introduce his “rotative” steam engine that he believed could outpace the horses used by brewery mills as the source of power. Despite his confidence in his engine’s potential to massively improve production rates, for marketing purposes, Watt knew he still had to convince the brewers by putting the steam engine’s specifications into a context they would understand: horsepower. Watt calculated that a horse was capable of lifting 150 pounds by almost 4 feet in one second (equivalent to 550 foot-pounds per second).



THE “WATT” (ABBREVIATION W)

The SI unit of power, equivalent to one joule per second, corresponding to the power in an electric circuit in which the potential difference is one volt and the current one ampere.

The “watt” was recognized by the Second Congress of the British Association for the Advancement of Science in 1889. In 1960, the 11th General Conference on Weights and Measures adopted it for the measurement of power into the International System of Units (SI).

acquired the patent rights. Boulton finally provided Watt with access to the precision boring and instrument making he needed, and The Boulton & Watt Company was founded in Birmingham in 1774 to manufacture Watt’s improved steam engine. With demand high, the pair became leading figures in the Industrial Revolution, and their partnership continued successfully for the next twenty-five years.

FULL STEAM AHEAD!

The Watt engine was a defining development of the Industrial Revolution because of its rapid incorporation into many industries. Boulton & Watt’s first customers came from the mines, but it was Boulton who saw the potential for other applications. Boulton encouraged Watt to convert the reciprocating motion of the piston to produce rotational power for grinding, weaving, and milling. Very quickly, paper, flour, cotton, and iron mills were all being powered by Watt’s engines. Boulton & Watt both retired in 1800 and handed over the business to their sons. Watt spent his remaining years carrying out further research and eventually died in 1819,

to be buried, fittingly, alongside his loyal business partner, Matthew Boulton.

Watt was a true pioneer of industrial modernity and his brilliance lay in an innate ability to apply his theoretical knowledge of science in practical ways. Cornish chemist and inventor Humphry Davy said: “His inventions demonstrate his profound knowledge of those sciences, and that peculiar characteristic of genius, the union of them for practical application”.

Watt’s improvements to the steam engine breathed new life into industry by making efficient and reliable motive power available for the first time, while also leading to large-scale urbanization as rural families flocked to the towns and cities. After a historic firsthand account of the young Watt’s kettle experiment surfaced in 2002, Sotheby’s director James Miller said: “Were it not for James Watt, the Industrial Revolution might never have happened. He was not only the most prolific innovator imaginable, he also possessed one of the greatest minds of his time.” ●

STRAIGHT FROM THE LABS OF **PRIMETALS TECHNOLOGIES**

ACOUSTIC EXPERT

The solution consists of a robust acoustic sensor, recording equipment, and advanced analysis tools.



ANNA MAYRHOFER

As one of Primetals Technologies' highly dedicated researchers, Anna Mayrhofer has worked hard to bring Acoustic Expert to life.



FIG. 1: Anna Mayrhofer closely collaborated with partner company voestalpine throughout the entire evaluation period.



FIG. 2: The microphone was installed to optimally capture the sound emitted by one of voestalpine's flip-flop screens.

The extensive R&D efforts of Primetals Technologies are an integral part of the company's larger strategy to continually promote innovation for the metals industry. In this series, we present new, remarkable solutions pioneered by Primetals Technologies' engineers—solutions that may still be in their infancy today but have the potential to change the way steel and other metals will be produced in the decades ahead.

ACOUSTIC EXPERT

DETECTING MALFUNCTION THROUGH SOUND

It is an integral part of the DNA of Primetals Technologies to pioneer solutions that will serve steel producers in the world of tomorrow. One such solution is Acoustic Expert, a technology that uses an acoustic fingerprinting method to detect common errors in a variety of steel-plant equipment.

A VERSATILE PIECE OF EQUIPMENT

Anna Mayrhofer is leading the R&D efforts behind this remarkable solution. To date, she and her team have developed several different applications for Acoustic Expert. They range from the assessment of material quality on conveyor belts to the monitoring of torch cutters in continuous casting machines to the supervision of cooling and lubrication nozzles. Based on the success of these applications, she was approached by one of Primetals Technologies' closest partners, Austrian-based voestalpine, about the possibility of implementing Acoustic Expert in their stockhouse—with the aim of observing the operation of flip-flop screens.

Mayrhofer first created a concept for how Acoustic Expert could be put to work in the stockhouse. The challenge was that her solution would be required to

register any tear-up or misalignment of the screen linings used for lump-ore treatment, as well as other potential problems. It was hoped that Acoustic Expert would help ensure that all lump ore would pass through the stockhouse as intended, and that any problems would be identified immediately.

DESIGNED FOR TOUGH ENVIRONMENTS

Mayrhofer constructed a mobile version of Acoustic Expert's monitoring equipment to make the installation a simple and straightforward process. She was able to make all of the core equipment fit into one rugged transport box that would withstand the dusty environment in the stockhouse. Both the box and a robust microphone were then installed at voestalpine's facility.

Over the course of six weeks, Acoustic Expert closely monitored one of voestalpine's flip-flop screens. Every deviation from perfect operation was recorded, evaluated, and made transparent. Anna Mayrhofer was able to demonstrate that her solution perfectly met all expectations. Acoustic Expert can now be used in yet another area of steel production—and it surely won't be the last one. ●

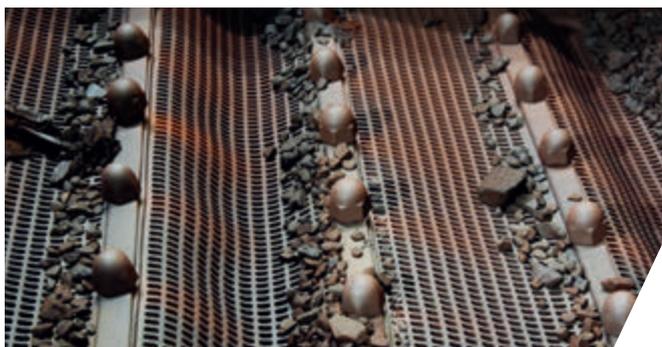


FIG. 3: The flip-flop screen's movement ensures that none of the lump ore parts become stuck in the screen lining, even when wet.



FIG. 4: Anna Mayrhofer designed a mobile unit of Acoustic Expert's monitoring and analysis equipment for the new site.

**DR. THOMAS PFATSCHBACHER**

Pfatschbacher has pioneered the development of Through-Process Optimization and other innovations at Primetals Technologies.

IN THIS INTERVIEW FORMAT, WE ASK ONE OF PRIMETALS TECHNOLOGIES' EXPERTS TO USE THEIR IMAGINATION.

Dr. Thomas Pfatschbacher is Head of Technology and Innovation for Casting & ESP, Rolling, Mechatronics, and Through-Process Know-How at Primetals Technologies. He is regarded one of the company's most experienced experts, and his vision for where the steel industry is going is valued by metals producers worldwide. We have asked him for his personal view on what if ...

“The steel industry is undergoing a transition that is similar to that of the automotive industry: from the human-controlled steel mill to the 'self-driving' plant.”



... SELF-DRIVING CARS BECOME THE NEW STANDARD FOR INDIVIDUAL TRANSPORT IN THE NEXT TEN YEARS?

Dr. Thomas Pfatschbacher: I am convinced that autonomous driving will become a reality sooner than some people realize. The automotive industry has been one of the driving forces in terms of innovation for a long time—in fields such as base-material treatment and coatings, mechanical engineering, sensor technology, environmental and safety solutions, as well as financial business models. Enormous sums of money are now being pumped into self-driving car research. Also, the processing power of our computers has exploded, and we now use sensor technology that provides high-resolution data in real time. If you add artificial intelligence algorithms to this equation, what you get is autonomous vehicles that can react to their environment within milliseconds. This development will prevent accidents caused by human error or tiredness. It will increase road safety and make driving much more economical. It will revolutionize the “idea of driving” on the whole. Aside from that, I would like to point out that the steel industry is now undergoing a similar transition—that from the traditional to the “self-driving steel plant.” At Primetals Technologies, we are promoting this development.



... THE AUTOMOTIVE INDUSTRY IS URGED BY GOVERNMENTS TO FURTHER REDUCE THEIR CARS' FUEL CONSUMPTION?

Pfatschbacher: I believe that we owe it to future generations to protect our environment and to safeguard it for the future. Minimizing energy consumption will therefore be at the heart of many innovations, not just from the automotive industry but also from its suppliers, from the recycling industry, and from ourselves at Primetals Technologies. Together with our customers, we are working on new solutions for the production of high-end steels with excellent material properties for the construction of lighter cars that require less fuel. Manufacturing these steels is highly challenging, but once a producer has upgraded their equipment and implemented the necessary know-how, they will be able to differentiate themselves on the worldwide market and take a leadership role. Electrical steel is just one example of a product that places high demands on the producer's capabilities. Generally speaking, it is factors like strength, low strip thickness, good formability and processibility, surface quality, and corrosion resistance that are important today. High-end steels will allow the automotive industry to build more lightweight and more energy-efficient vehicles that are at least as robust and safe as the ones made today.

Continuous casting is one of the areas of Dr. Thomas Pfatschbacher's expertise.



... EVEN MORE INFORMATION THAN IS AVAILABLE TODAY WILL BE AT OUR FINGERTIPS IN THE FUTURE?

Pfatschbacher: Never before has there been as much data available as today, and it is set to increase even further. This is true for many aspects of our lives, and it certainly extends to steel-production plants. But despite the effects of digitalization on metals production, only about 2% of all available data is currently used in the mill as a basis to make informed decisions. In the future, it will be even more relevant that the vast amount of information is preprocessed and a selection is made before it is presented to human operators. Otherwise it would just be overwhelming. Only with this preprocessing in place will it be possible for operators to interpret the data given to them and take the appropriate actions. This means that information needs to be intelligently customized and tailored to the actual needs of those who will be dealing with it. To give you an example, at Primetals Technologies, we have developed an IT system called "Through-Process Quality Control" (TPQC), which unites a large variety of data sources and uses smart algorithms and customizable rule-sets to determine what depth of information should be presented to whom—from plant operators to product-development managers.



... DATA ANALYSIS EVOLVES INTO ONE OF THE MOST ESSENTIAL TOOLS IN STEEL PRODUCTION?

Pfatschbacher: In my personal opinion, data analysis and data mining are clear growth areas and will play a central role in the world of tomorrow. Data analysis can be particularly helpful when we are dealing with complex situations and scenarios that involve several dimensions. However, there is one crucial measure that needs to be taken before any results stemming from data analysis are considered usable: all findings have to be thoroughly checked and verified by domain experts. The reason for this step is that someone has to ensure that there is always a proper physical basis to the conclusions drawn by data analysis. The problem is often a lack of clarity in how these findings correlate to what's actually going on in the physical world, and exactly where the events are happening. I am stressing this because I see a tangible risk that factors like insufficient data quality or an improper distribution of data points could lead to the creation of algorithms that only work correctly under very specific circumstances. Despite these reservations, I am convinced that data analysis will be used more broadly in the future, and that we will be able to derive smart and powerful algorithms from its results.



... AI-BASED TECHNOLOGIES MAKE MANY OF TODAY'S JOBS REDUNDANT, BOTH IN THE STEEL INDUSTRY AND BEYOND?

Pfatschbacher: I'm not a futurologist, but I would assume that we will be seeing a deep transformation on the labor market. I have little doubt that some jobs will disappear. However, at the same time, new competences will become essential and new opportunities will open up. Holistic and inter-disciplinary thinking will become more common in many fields, and programmers will effectively work as "intelligence designers" in many industries, including our own.

“ Holistic and inter-disciplinary thinking will become more prevalent in many fields in the future.”



... ULTRA-THIN STEEL STRIP WILL BE IN EVEN HIGHER DEMAND IN THE DECADES AHEAD?

Pfatschbacher: The capability of producing strip at lower thicknesses is a target that more and more steel producers are setting for themselves, and for good reasons. Let me explain why by using the automotive industry as an example: Lower strip thicknesses enable car manufacturers to build vehicles with a much more lightweight design. The core idea is to produce better and more energy-efficient cars with less yet higher-quality steel as the base material. Advanced high-strength steels can be used for many applications—end products range from individual specialized car components to strip for the entire chassis of the vehicle.

The trend toward lower strip thicknesses will have a positive impact on global CO₂ emissions, both directly and indirectly. The direct benefit is quite obvious: A lighter car requires less fuel and will emit less CO₂ over its lifetime—it's as simple as that. Of course, electric cars will also require less energy as long as they are lightweight models. The indirect benefit is at the steel-production stage: Since less steel is required to build the car, less of it has to be produced in the first place, bringing overall emissions per car down further. In this respect, the total CO₂ footprint of a lightweight car will be reduced simply by virtue of its base materials.

I would like to mention the Arvedi ESP technology in this context. Arvedi ESP enables the production of very high-quality hot-rolled steel that can substitute cold-rolled steel and requires 40% less energy during production. This is due to the innovative, streamlined process at work with ESP. You can tell efficiency is higher just by comparing the length of an ESP line to traditional continuous casting lines: it is much shorter. And since no cold-rolling or annealing is involved with Arvedi ESP, you can achieve further energy savings. Primetals Technologies is the exclusive supplier of Arvedi ESP worldwide, and we have seen increased interest in the technology recently. Just last July, we were awarded a contract by a Chinese producer for an Arvedi ESP line. ●



THE PIONEER'S GUIDE TO **BOOSTING CREATIVITY**

In this series, we look at different ways of getting the creative juices flowing. This time, we focus on physical exercise as a tool that promotes not just personal health but also intellectual capacity and the ability to solve problems creatively.



“If you don’t have answers to your problems after a four-hour run, you ain’t getting them.”

Christopher McDougall,
author and journalist

When it comes to being creative there’s no magic bullet, but exercise comes pretty close. We all know that exercise is good for you, but getting physical can also have an amazing effect on your mind and your mood. Sometimes it might seem like you were born without the “creative gene,” but nobody is born highly creative; creativity is a skill you have to develop through practice and hard work. And if we compare creativity to a muscle, then the inevitable result of sitting back and waiting for inspiration to strike is something akin to muscle atrophy.

A study in the journal “Frontiers in Human Neuroscience” claims that regular exercise is linked to improved divergent and convergent thinking, the two compo-

nents of creative thinking. “Exercising on a regular basis may thus act as a cognitive enhancer promoting creativity in inexpensive and healthy ways,” says cognitive psychologist Professor Lorenza Colzato of Leiden University in the Netherlands. She goes on: “Anecdotal literature suggests that creative people sometimes use bodily movement to help overcome mental blocks and lack of inspiration.”

GETTING ACTIVE MATTERS

A high percentage of the population leads a sedentary lifestyle, with the average person spending anywhere between 7 and a whopping 15 hours per day sitting down. We can easily spend all day working in front of the computer, drive or take public transport to and

from home, eat dinner and spend another couple of hours in front of the TV, reading or playing video games. Given the negative health influences—cardiovascular disease, weight gain, diabetes, cancer, back and neck pain, increased anxiety, depression—it seems a crazy way to live.

According to the World Health Organization (WHO), “Globally, about 23% of adults and 81% of school-going adolescents are not active enough.” The WHO also recommends that all adults aged 18-64 should be doing at least 150 minutes of moderately intense physical activity each week, or at least 75 minutes of vigorous activity throughout the week. So there’s every reason for us to get moving and increase our heart rates with some kind of workout.

WALK WITH ME

Studies suggest that people tend to be more creative when walking than sitting down, and one such study by Stanford University researchers found that a person’s creative output increased by an average of 60 percent while walking. Earlier research already showed that regular aerobic exercise can boost and protect cognitive abilities, but the Stanford study found that just a simple walk—either indoors or outdoors—could temporarily improve certain types of thinking. The study also found that people remained in the creative zone even after they had sat back down shortly after a walk.

A follow-up study also showed how people who take part in “walking meetings” tend to be more creative and engaged. Business leaders and entrepreneurs from several Fortune 500 companies are known for holding

meetings on foot, and their business practices outside of any conference rooms have yielded extraordinary achievements in many fields, arguably most prominently in that of personal technology.

So next time you find yourself struggling for an idea or wrestling with the solution to a problem, don’t sit back and wait for inspiration to strike, try going for a quick walk instead; it costs nothing, and the potential benefits can be huge. Philosopher Friedrich Nietzsche said over a century ago, “Sit as little as possible. Do not believe any idea that was not born in the open air and of free movement—in which the muscles do not also revel.” Authors such as Henry James and Thomas Mann also used to walk before starting to write, so why not take a leaf out of their book?

INSPIRED BY NATURE

Although the Stanford study found that the act of walking itself, and not the environment, was the main factor in boosting creative inspiration, there are also many arguments for getting outdoors. Aerobic workouts like running in particular stimulate something called Brain Derived Neurotrophic Factor, which encourages the growth of new brain cells in the hippocampus.

According to neuroscientist Wendy Suzuki, author of “Healthy Brain, Happy Life,” the exercise-induced brain changes that may be responsible for improving memory might also improve the imagination, and there are reasons to believe a long run, for example, could help strengthen the same parts of the brain people use while being creative. Suzuki says: “In addition to its stress-reducing, mind-focusing, productivity-inducing, and memory-enhancing properties, there seems to be some evidence supporting the idea that exercise could help make us more creative.” Exercise has also been shown to help with creative problem-solving.

CREATIVITY NEEDS TO BE NURTURED

Associate professor of education and of psychology Dr. Robert Keith Sawyer, believes that nobody is born creative, but everyone shares the cognitive processes needed to become creative. Sawyer says: “One myth is that if you’re a creative person it’s a trait and everything you touch turns to gold. That’s not the way creativity works. It’s not some magical trait. You have to work hard to be a more creative person. You have to be diligent.”

Which is to say, we have to work at it, to make time to develop creativity as a skill, to nurture it. Sawyer attributes the biggest difference between highly creative people and the rest of us simply to hard work and work habits. “Creative people work hard but they also work smart,” Sawyer says. “There is a certain way they structure their work habits. They structure their day so they alternate between hard work and time off. Researchers call it idle time.”

“Going for a run makes me sharper, it helps me to stay focused, to concentrate, and also you create endorphins, which makes you feel better.”

Guido van der Werve
artist and regular triathlon competitor

TOP 5 WAYS TO GREASE THE CREATIVE WHEELS



“When I’m still, the mind can race, but when I run, I can step out of the mind and watch the thoughts.”

Nathalie Provosty,
artist and passionate runner

Idle time allows people to frame their problems differently, to look at them from new perspectives. Exercise allows us to focus on a physical task rather than on more cerebral work, and by stimulating our brains through physical activity, we’re opening ourselves up to new ideas and approaches.

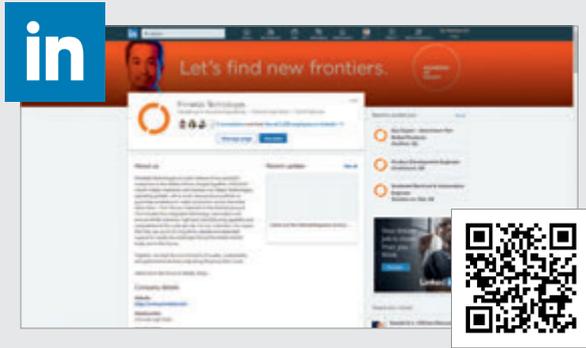
OPENING THE CREATIVE WINDOW

Depending on when you need to get creative, you might work out in the morning, taking time out during lunch for a walk, run, or bike ride in order to keep the window for inspiration open as long as possible. Or if your goal is to harness your creativity as soon as you walk through the doors at work, getting your heart rate up early in the morning might give your brain a much needed boost. If you’re saving your creativity for more

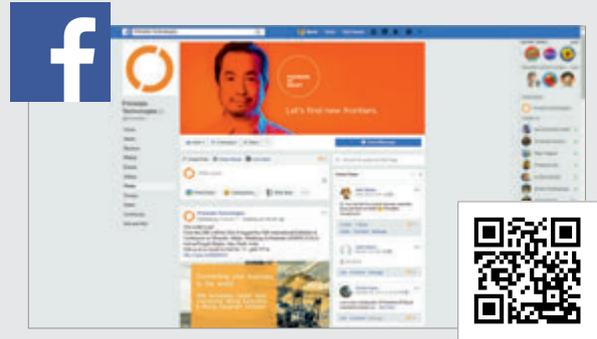
leisurely pursuits, then you might want to hit the gym after work so that you’re feeling inspired enough to tackle a do-it-yourself or arts project.

Ultimately we need to engage with our bodies, stimulating our brains through a good physical workout so that they remain in the creative zone afterward. Almost every cognitive process we are capable of improves from 30 minutes of daily exercise, and creativity is no exception. Studies have shown that the boost obtained from aerobic exercise can last for two hours or more; there is a prolonged positive effect largely independent of the kind of activity that was done. Bottom line: get moving—take a walk, bike to work, venture outside and go for a run. It’s the best recipe yet for getting the creative juices flowing. ●

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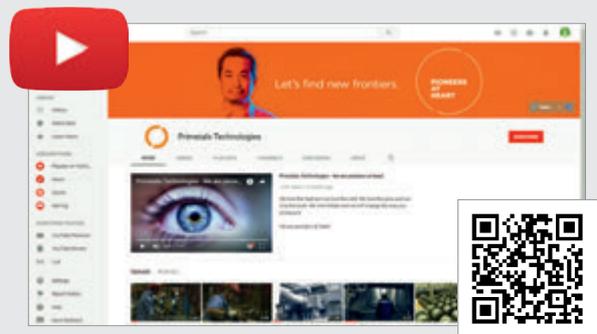
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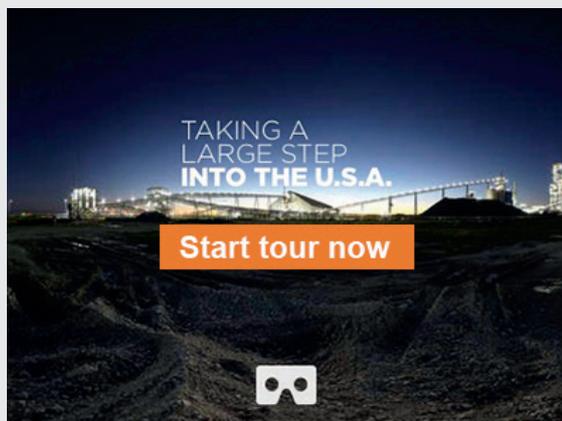


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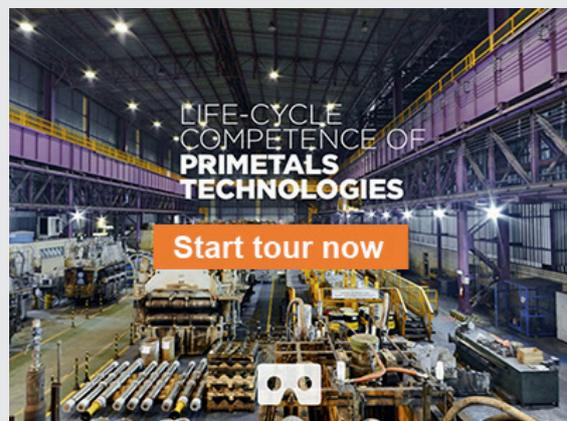
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 EXPERIENCE OUR SOLUTIONS IN 360°



A virtual reality tour through the direct-reduction plant of voestalpine in Corpus Christi, Texas, commissioned by Primetals Technologies and Midrex Technologies.

meta.ls/gowestvr



An immersive 360° experience of a fully equipped company service workshop, installed recently at the steelworks of Ternium Brazil in Rio de Janeiro.

meta.ls/riovr



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PIONEERS AT HEART



A PASSION FOR INNOVATION

At Primetals Technologies, we are naturally curious, always prepared to embark on a journey to explore new frontiers. We are ready to discover new solutions for our customers and partners in the metals industry worldwide. In this issue of Metals Magazine, we showcase some of the finest accomplishments of our technology specialists to date. And inspired by these, we focus firmly on the future—and on the innovations that are still to come.

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