

ISSUE 02 | SEPTEMBER 2016

# METALS MAGAZINE

INNOVATION AND TECHNOLOGY FOR THE METALS INDUSTRY

**THE FUTURE**  
OF METALS

A photograph of the Aurora Borealis (Northern Lights) in shades of green and blue, viewed through the branches of snow-covered evergreen trees at night. A large, semi-transparent orange circle is overlaid on the center of the image, containing a quote.

**“ The best way  
to predict your future  
is to create it.”**

Abraham Lincoln, 16th president  
of the United States (1809-1865)

# EDITOR'S COLUMN



LAWRENCE GOULD

## DEAR READER,

*The ancient Finns believed it was sparks from a fox's tail. The Chinese thought it was a celestial battle between good and evil dragons breathing fire across the sky. Superstitious Europeans in the Middle Ages were shaken by the sight and saw warnings of illness, plague and death. And when red-hued northern lights astonishingly appeared throughout much of Europe on the night of January 25, 1938, my wife's grandfather immediately knew its significance: "War is coming," he said.*

The steel industry today is faced by an unprecedented crisis. Never before has there been such a gap between excess global steelmaking capacity and actual demand. According to a report from the Organization for Economic Cooperation and Development (OECD), the world's installed steelmaking capacity is projected to increase to 2.36 billion tons by 2017, which is 760 million tons more than the 1.6 billion tons of steel consumed in 2015. To put it bluntly, steelmakers will soon be able to produce nearly one-third more steel than the world actually needs. The reality is already oversupply, deteriorating prices, financial losses, bankruptcies and plant closures – which is not only limited to steel manufacturers. Despite the best intentions by key steel-producing countries to reduce excess capacity, these efforts will certainly be accompanied by job losses, social instability, trade wars and maybe even worse.

However, all is not necessarily doom and gloom. It's well worth remembering that the steel industry historically has always been cyclical. At the end of the tunnel there is the light. And after the darkness follows the dawn. The current pessimistic situation may last longer than previous downturns, and it may be far more painful, yet it is pragmatic to take a longer-term view. What is important is that the right decisions be made today by policymakers, producers and suppliers, and that future steps are carefully charted. By doing so, the groundwork can be laid today for a more prosperous tomorrow.

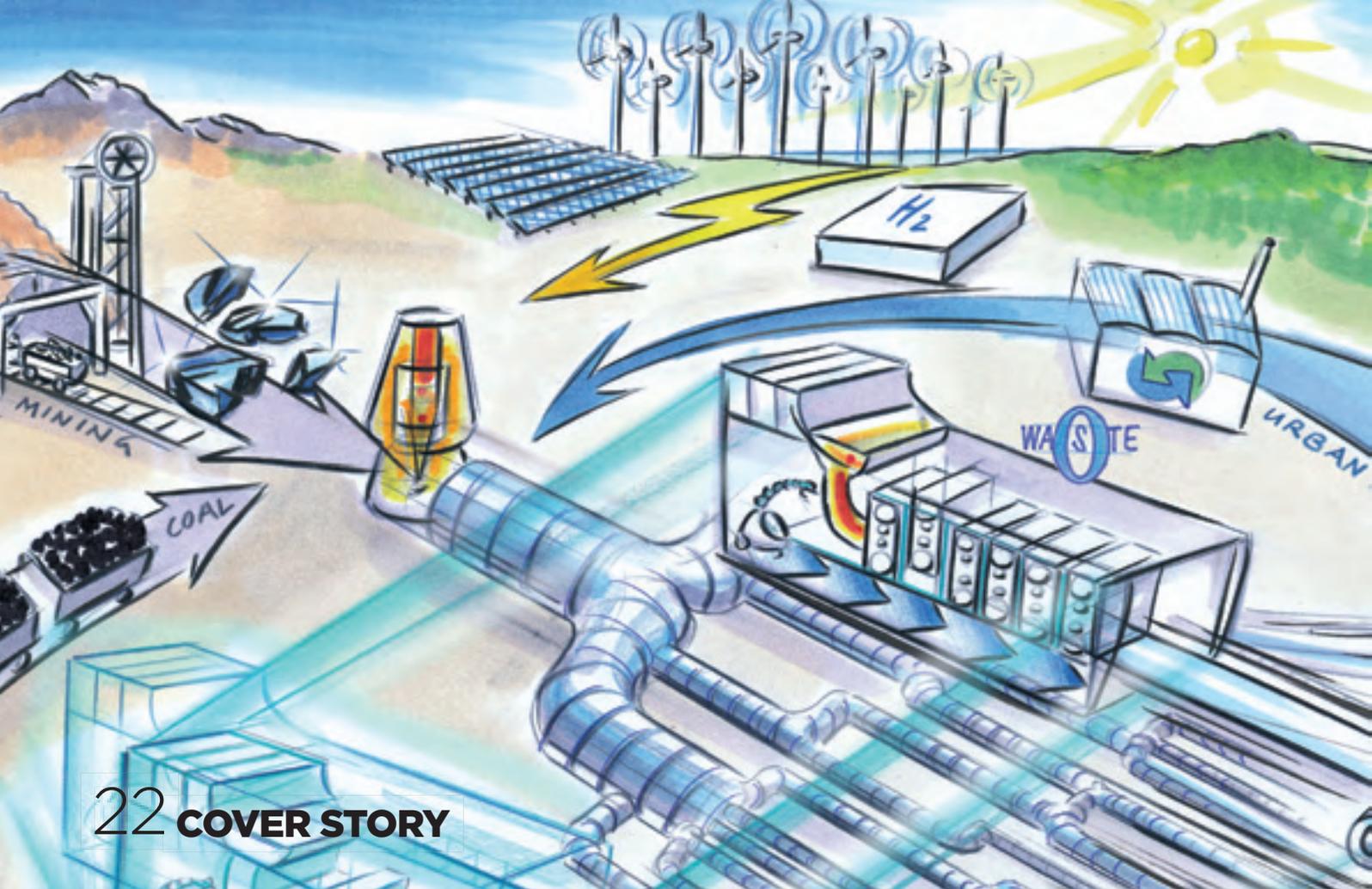
The future of metals starts by thinking about it. Primetals Technologies has therefore taken a long and hard look at the state of the metals industry, and has explored future perspectives and scenarios. We have conducted scores of interviews during the past four years with prominent figures, opinion leaders and technology specialists from the metals sector. The results have been compared and emerging trends identified. The quintessence of all this work is summarized in this issue of *Metals Magazine*. A common tenor in the interviews is a surprisingly optimistic outlook for the mid- to long-term future of metals.

*Of the hundreds of legends about the northern lights, most are enigmatic, ominous or foreboding. Yet a number of stories offer a positive or auspicious message indeed: In Chinese and Japanese cultures, it is still believed that a child conceived under the northern lights will be blessed with good fortune. And when Nanahbozho, the Algonquin creator of the Earth, finished his task of creation, he traveled to the far north where he built large fires – the celestial lights – to remind his people of his concern and lasting love for them.*

The pictures of northern lights used throughout this issue thus symbolize either a positive or negative outlook for the future of metals. Primetals Technologies has contemplated the future and is optimistic for the metals world to come. To safeguard a bright tomorrow, we continue to develop the technological solutions and processes needed to meet the challenges that lie ahead.

**Yours sincerely,**

**Dr. Lawrence Gould**  
Managing Editor of Metals Magazine  
Primetals Technologies, Limited



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How will the metals industry look in the decades to come? Which developments, innovations and technologies will prevail? Primetals Technologies is asking questions like these today so that the company, together with its customers and partners, can play a key role in “creating the future of metals as one” – the company’s slogan.

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#### **METALS MAGAZINE IS ALSO AVAILABLE FOR TABLET COMPUTERS**

For selected magazine topics, readers can access additional content with the new magazine app for tablet computers. The app offers an interactive alternative to the print version of Metals Magazine and can be downloaded at the magazine newsstand of Primetals Technologies.

For iOS



For Android





**YASUKUNI YAMASAKI,**  
CEO and Chairman of  
Primetals Technologies

**“ An open innovation culture within our company accelerates the introduction of new ideas into our portfolio of metallurgical solutions and services. This allows us not only to predict the future, but to create it.”**

Yasukuni Yamasaki

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# MESSAGE

# FROM THE CEO

## DEAR CUSTOMERS,

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What does the future of metals hold? This is a highly important question, and it is the main focus of this issue of Metals Magazine. It is also a central question that I, as the CEO of Primetals Technologies, do my best to answer every day. I rely on both my own judgement and the support and insight of our leadership team, company employees and other sources of information. Detailed planning is essential for short- and mid-term developments and also for the long-term outlook. Each of these time frames requires careful consideration of what lies ahead, and each demands an action plan that is backed by the necessary support and implementation procedures.

First of all, short- to mid-term prognoses are vital for defining annual and multi-year goals and strategies as well as to ensure coordinated efforts by our workforce to take advantage of market opportunities to identify and schedule promising metallurgical plant projects. Also, our various company locations throughout the world require central planning guidance in order to focus and channel their local engineering and service activities as part of the overall business strategy.

Secondly, long-term projections that extend over decades are necessary to steer our company into an uncharted future. Forecasts about developments and trends in the metals business are based to a large degree on the recognition of global driving forces and their potential impact on society and the industry. These forecasts also incorporate the feedback of our customers with their tremendous experience, which allows us to make an even better assessment of future developments.

Since January 2015, I have had the privilege to serve as CEO of an international and multi-cultural company with an outstanding reputation for technological excellence. During this time, I have spoken with scores of customers

throughout the world. I have carefully listened to their needs and concerns. The leadership team as well as the engineers and technicians of Primetals Technologies have also been continuously involved in intensive discussions with customers, suppliers and industry management – both from the metals sector and from other fields. The input from our global network of approximately 30 company locations, spread over several continents, is crucial for improving the accuracy of what we believe the future may bring. Each of these locations, with its own unique expertise and local knowledge, is situated in close proximity to metals producers and caters to their specific requirements. This feedback allows us to “walk in our customers’ shoes.” In this way, we can offer producers the right solutions to address the existing and ever-changing market requirements.

Primetals Technologies has brought together the best and the brightest in their respective fields who apply their intelligence and creative energy to continually improve equipment design, optimize production processes and introduce potentially disruptive technologies with far-reaching implications. Not only are internal sources accessed, but also in close cooperation with customers, business partners and research and development institutes, the creative potential of outside specialists is utilized to push the limits of technology. Furthermore, an open innovation culture within our company accelerates the introduction of new ideas into our portfolio of metallurgical solutions and services. This allows us not only to predict the future, but to create it.

The future is not something that just happens. Rather, it is something that we all contribute to. Let us therefore work together for a positive future – one that we can be proud of, and one that will have a lasting impact on society for the benefit of future generations.

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# PRIMETALS TECHNOLOGIES

## RECENT PROJECT AND COMPANY NEWS

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- |                                   |  |
|-----------------------------------|--|
| 1. Monclova, Coahuila, Mexico     | 7. Beihai, Guangxi Zhuang Autonomous Region, China |
| 2. Genk, Belgium                  | 8. Rizhao, Shandong province, China                |
| 3. Bolzano, Italy                 | 9. Huzhou, Zhejiang province, China                |
| 4. Abinsk, Krasnodar Krai, Russia | 10. Shanghai, China                                |
| 5. Dąbrowa Górnicza, Poland       | 11. Ningbo, Zhejiang province, China               |
| 6. Cherepovets, Russia            | 12. Quezon City, Philippines                       |



Processing of the first plate in the normalizing line of Mexican steel producer Ahmsa

## AHMSA COMMENCES OPERATION OF A NORMALIZING LINE FOR PLATES

**1. MEXICO:** In May 2016, the first steel plate was processed on a normalizing line supplied by Primetals Technologies to Mexican steel producer Altos Hornos de México S.A.B de C.V. (Ahmsa). The line, which was built at the Monclova works of Ahmsa, is designed to treat up to 300,000 tons of plates per year. Plates can be processed with lengths between 3 meters and 6 meters, at widths from 1,500 mm to 3,048 mm, and at thicknesses between 4.5 mm and 50.8 mm. Normalizing results in a homogenous, finely grained steel structure for an improved tensile strength, ductility and weldability of the plates.

Primetals Technologies engineered the normalizing line, supplied all plant components and equipment, and rendered advisory services for construction and line start-up. The supply scope also included electrical equipment, the energy distribution system, basic automation (Level 1) and process optimization (Level 2).

**The upgrade was carried out within only three-and-a-half weeks, followed by a fast production ramp-up.**



Modernized bridle area of the annealing and pickling line of Aperam in Genk, Belgium

## SUCCESSFUL MODERNIZATION OF ANNEALING AND PICKLING LINE AT APERAM GENK

**2. BELGIUM:** An annealing and pickling line was recently modernized by Primetals Technologies for Belgian steel producer Aperam Genk. The project comprised the supply of new electrical equipment, automation components, motors, bridle rolls and pinch rolls. Furthermore, the drive technology was upgraded and the strip-tension control system optimized. The capacity of the three loopers was also increased by extending their length and installing new dolly cars and winches. These measures allowed the processing line speed to be increased from 100 meters to 120 meters per minute. For this turnkey project, Primetals Technologies was responsible for engineering, procurement and supply as well as for construction work and commissioning. The upgrade was carried out within only three-and-a-half weeks, followed by a fast production ramp-up.

## CONTINUOUS BILLET CASTER MODERNIZATION AT VALBRUNA

**3. ITALY:** A 3-strand continuous billet caster is being modernized by Primetals Technologies for the Italian steelmaker Acciaierie Valbruna S.p.a. at the company's Bolzano site. Primetals Technologies originally installed the billet caster in 1992, which was designed with a nominal casting capacity of 200,000 t/a. A key objective of this project is to modify the caster so that it will be capable of casting stainless steel and special alloy bars with cross-sections up to 180 mm. The machine radius of the plant will also be increased from seven to nine meters to allow even larger cross sections to be produced at a later date.



The 3-strand continuous billet caster in operation at the Bolzano site of Italian steel producer Acciaierie Valbruna



Abinsk Electric Steel Works, Russia

## MINIMILL MODERNIZATION AT ABINSK ELECTRIC STEEL WORKS

**4. RUSSIA:** Abinsk Electric Steel Works Ltd. (Abinsk), a Russian long-product producer, signed a contract with Primetals Technologies for the modernization of an electric arc furnace (EAF), a ladle furnace and a 6-strand billet caster at its minimill. The EAF will be equipped with new components and systems, including an oxygen-injection system that will allow Abinsk to produce additional high-quality steel grades such as high-carbon steel for wire and spring steel. Plant availability will be increased and maintenance costs lowered. Furthermore, the energy requirements of the EAF are expected to decrease from 410 kWh to 370 kWh per ton of tapped steel. Conversion costs will be reduced accordingly.

A key target of the billet caster modernization is to increase the production output of billets with cross sections of 130 mm and 150 mm from 950,000 tons up to 1.5 million tons per annum. A number of sophisticated technological packages will be installed in the caster to improve casting operations, allow high casting speeds and ensure high internal and surface quality of the cast billets. The modernized meltshop is scheduled to come into operation at the end of 2016, and the continuous billet caster in the first quarter of 2017.

## TWO LD (BOF) CONVERTERS TO BE REPLACED IN DĄBROWA GÓRNICZA FOR ARCELORMITTAL POLAND

**5. POLAND:** ArcelorMittal Poland S.A. placed an order with Primetals Technologies for the replacement of the LD (BOF) Converters No. 1 and No. 3 at its Dąbrowa Górnicza steelworks. The existing converters, which have reached the end of their service life, will be removed and substituted with new 325-ton converters.

The project scope comprises the supply of new trunnion rings, converter bearings and housings, and the maintenance-free Vaicon Link 2.0 converter suspension system. The suspension system minimizes stresses caused by thermal deformation of the vessel and is characterized by its long service life. The order also includes dismantling of the existing vessels, as well as pre-assembly and installation of the new equipment. The work will be carried out by ZKS Ferrum S.A., the Polish consortium partner. The new Converter No. 1 is scheduled to be brought into operation at the end of 2016, and Converter No. 3 in mid-2017.

## INSTALLATION OF A LADLE FURNACE IN THE CHEREPOVETS CONVERTER STEELWORKS

**6. RUSSIA:** Russian steel producer PAO Severstal placed an order with Primetals Technologies for the supply of a new twin-ladle furnace for its Cherepovets converter steelworks. The ladle furnace will be capable of treating 375-ton charges of liquid steel within 45 minutes, which enables an annual steel-treatment capacity of 4.8 million tons to be achieved.

Furthermore, the ladle furnace installation will allow the maximum annual converter steel output to be increased from its previous maximum of 9.5 million tons to almost 10.3 million tons.

Primetals Technologies is responsible for engineering the twin-ladle furnace, the alloying system and the dedusting system, and for supplying key components. The scope of supply additionally encompasses the associated electrical and automation equipment. The project is scheduled to be completed by the beginning of 2017.

## This was the second order for an X-HI mill and the third order received by Primetals Technologies for the supply of a continuous TCM for stainless steel in China.

### POWER X-HI STAINLESS STEEL TANDEM COLD MILL PRODUCES FIRST COIL AT BEIHAI CHENGDE

**7. CHINA:** In December 2015, a continuous tandem cold mill (TCM) for rolling stainless steel produced its first coil at Beihai Chengde Stainless Steel Co. (Beihai Chengde) in Guangxi province. The cold-rolling mill, which was supplied by Primetals Technologies, features the installation of five Power X-HI-type mill stands, the associated high-tension bridles, a rinsing section to remove emulsion from the strip surface, and a heavy laser welder. Primetals Technologies was also responsible for the supply of the strip looper, the mill exit section, an inspection station, a rotary shear, scrap- and coil-handling equipment as well as Level 1 basic automation and Level 2 process optimization.

The rolling facility has a rated capacity of 600,000 tons of strip per year, and it is designed to produce AISI grades series 200 and 300. This was the second order for an X-HI mill and the third order received by Primetals Technologies for a continuous stainless steel TCM in China.



Power X-HI mill assembly in the French workshop of Primetals Technologies



Twin-strand continuous slab casters will be supplied by Primetals Technologies to Chinese steel producer Shandong Iron & Steel Group Rizhao Co., Ltd.

## SHANDONG IRON & STEEL ORDERS TWO TWIN-STRAND CONTINUOUS SLAB CASTERS

**8. CHINA:** Chinese steel producer Shandong Iron & Steel Group Rizhao Co., Ltd. ordered two twin-strand continuous slab casters from Primetals Technologies. They will be built in a new, high-quality steel-production plant that will be erected in the Rizhao coastal region of Shandong province. The casters are designed to produce 4.6 million tons of slabs per annum. A number of sophisticated technology packages will be installed in the casters to ensure high surface and interior strand quality – even under unstable production conditions. They will also support flexible casting operations. Equipment and technology packages will be designed according to the "Connect & Cast" principle of Primetals Technologies, which means that plant functions and systems are ready for use right from the start of casting operations. The two slab casters are scheduled to go on stream in June 2017.



Two pouring reels and a transfer mast from Primetals Technologies for bar-in-coil products

## SUPPLY OF COMBINATION MILL TO YONGXING FOR ROLLING STAINLESS STEEL LONG PRODUCTS

**9. CHINA:** To expand into the market for higher-grade stainless steel products, Yongxing Special Stainless Steel Co., Ltd., selected Primetals Technologies for the supply of a new combination mill for the rolling of bars, bar-in-coil and wire rod at the company's plant in Huzhou, China. The project scope for the mill includes a reversing sliding breakdown mill, a mill train with 14 Red Ring stands, a straight-bar rolling facility with a cooling bed, bar-in-coil machinery and the bar-outlet section. Furthermore, Primetals Technologies will supply a 10-stand Morgan Vee No-Twist Mill, a 4-stand Morgan Reducing/Sizing Mill, Morgan water boxes, a Morgan high-speed laying head, a 4-zone Morgan Stelmor-controlled cooling conveyor, a stepless coil-reforming station, a vertical-stem pallet-coil-handling system, a vertical coil compactor, and an inline annealing furnace for wire rod products. The new mill will have an annual production output of 250,000 tons of stainless valve steels, nickel-based alloy steel and various stainless and special steel grades such as austenitic, ferritic, dual-phase and hardening steels. Steel products will find use in the most demanding downstream applications such as in the aerospace, energy, medical, automotive and petroleum industries.



150-ton twin electric arc furnace at Baosteel in Shanghai, China

**New air-cooled  
Fin-type anodes  
with a guaranteed  
anode lifetime  
of more than  
1,500 heats will  
be installed.**

## DC TWIN EAF TO BE MODERNIZED AT SHANGHAI STEELWORKS OF BAOSTEEL

**10. CHINA:** Primetals Technologies won an order for the modernization of a more than 20-year-old DC twin electric arc furnace (EAF) at the Shanghai plant of Baoshan Iron & Steel Co. Ltd. (Baosteel). The project involves redesigning the upper and lower vessels of both furnaces – each of which has a tapping weight of 150 tons of steel. New air-cooled Fin-type anodes with a guaranteed anode lifetime of more than 1,500 heats will be installed, in addition to new burner systems. Following the completion of modernization activities, the result will be improved power efficiency, greater flexibility in the use of input materials and lower operational costs. It will also be possible to operate the EAF with a hot-metal content of up to 90%.

## An inline PQS quenching system will impart the bars with a tempered martensitic case and a ferritic-pearlitic core, enabling Capitol Steel to produce ASTM A615 and A706 grades.

### NINGBO PLACES ORDER FOR NEW COPPER ROD MILL

**11. CHINA:** Ningbo Jintian Copper (Group) Co., the largest copper processing company in China, signed a contract with Southwire for an SCR 3000 copper rod mill, which will be supplied by Primetals Technologies. The new mill will be built in Ningbo, Zhejiang province, and will produce electrolytic tough pitch (ETP) copper for subsequent use in the construction industry as building wire and cables. Start-up is scheduled for the fall of 2017. Primetals Technologies is responsible for the engineering, manufacture and commissioning of the rolling mill and coiler equipment. The annual output of the mill will be 160,000 tons of rods with diameters ranging from 8 mm to 18 mm that will be coiled. The coils will weigh from one to four tons. Southwire and Primetals Technologies have worked together for more than five decades. During this time, Primetals Technologies has built more than 100 non-ferrous mills for Southwire customers, in addition to completing nearly 30 plant upgrades.



Example of a copper rod mill supplied by Primetals Technologies



Example of an inline PQS quenching system from Primetals Technologies

### SUPPLY OF BAR ROLLING MILL TO CAPITOL STEEL

**12. PHILIPPINES:** Capitol Steel Corporation (Capitol Steel) placed an order with Primetals Technologies – in cooperation with Automazioni Industriali Capitanio S.r.l. (AIC) – for the supply of a new bar-rolling mill for its steelworks in Quezon City, Philippines. The mill will produce around 500,000 tons of reinforcing steel (rebars) per annum. The starting material will be square carbon steel billets that will be rolled into rebars with diameters ranging from 8 mm to 50 mm. In order to increase the productivity of the plant, bars with diameters between 10 mm and 12 mm will be rolled in two-slit mode, and bars with a diameter of 8 mm in the three-slit mode. The rolling line will consist of a 7-stand roughing mill, an intermediate mill with six stands in HV arrangement, and a finishing mill with six stands in H arrangement. All rolling stands will be of the Red Ring Series 5 type. An inline PQS quenching system will impart the bars with a tempered martensitic case and a ferritic-pearlitic core, enabling Capitol Steel to produce ASTM A615 and A706 grades. The scope of supply also comprises a cooling bed; automatic bundling, binding, weighing and dispatch equipment; a water-treatment plant; and a workshop, laboratory, cranes and civil works. AIC is responsible for the design and supply of the electrical equipment and the Level 2 process-optimization system. Commissioning is scheduled to take place in the second half of 2017.

## NEWS FLASHES



Outdoor view of the secondary dedusting system at voestalpine Stahl, Linz, Austria

### **voestalpine Stahl GmbH**

Primetals Technologies received the final acceptance certificate for the secondary dedusting system of the secondary metallurgical facilities at voestalpine in Linz. The system is capable of cleaning up to 700,000 m<sup>3</sup> of offgas per hour. The clean gas dust content is now below 1 mg/N<sup>3</sup>, which is considerably less than the legally prescribed limit.

**Austria**

### **Gerdau Açominas S.A.**

Brazilian steel producer Gerdau issued the final acceptance certificate for a new Steckel mill supplied by Primetals Technologies at its Ouro Branco production site in the state of Minas Gerais. The Steckel mill has an annual capacity of 800,000 tons.

**Brazil**

### **Novelis do Brazil Ltda.**

The existing automation system for the aluminum hot-strip mill of Novelis in Pindamonhangaba will be upgraded by Primetals Technologies.

**Brazil**

### **Société Internationale Métallique (SIM)**

SIM has chosen Midrex Technologies, Inc. and its licensee Primetals Technologies to furnish the equipment and oversee the technological aspects for the construction of a 2.0 million t/a hot-briquetted iron (HBI) plant in the Bécancour Waterfront Industrial Park on the shores of the Saint-Lawrence River in Quebec, Canada. Construction is expected to begin in 2017, which will enable the plant to start operations in 2019.

**Canada**

### **Baotou Iron and Steel Group Company Ltd.**

The China Railway Construction Company (CRCC) issued to Baotou the official certification that rails U75V head-hardened by the idRHa+ system are in full compliance with Chinese standards. The idRHa+ system was developed by Primetals Technologies in cooperation with RINA-Centro Sviluppo Materiali, Italy.

**China**



Series 5 Red Ring rolling stand installed on the roughing train of the H.E.S. bar mill, Germany

**Rizhao Steel Group Co., Ltd. (Rizhao Steel) China**

Primetals Technologies received the final acceptance certificate from Rizhao Steel for three (out of a total of five) Arvedi ESP lines that are now in operation at the company's steelworks in Rizhao, Shandong province.

**Outokumpu Oyj Finland**

Upgrading of the Mold Expert system (strand break-out prevention) will take place in 2016 on a slab caster that Primetals Technologies originally installed at Outokumpu's Tornio steelworks in 2003. The project scope includes the installation of the latest algorithms for strand-sticker detection, strand depressions and critical friction conditions as well as deviations from normal stopper- or mold-level behavior. The newly developed Process Expert system, which indicates optimum values of important casting parameters, will be implemented. Furthermore, an Oscillation Expert system will be supplied, which immediately issues warnings in case of any deviations from the set-point oscillation, in addition to an automatic thermocouple tester.

**SSAB Europe Oy Finland**

The second of three exchanged LD (BOF) converters supplied by Primetals Technologies recently commenced operation at the SSAB Raahe Steel Works. The third replacement converter is scheduled to start up in September 2016.

**Ugitech SA France**

French stainless steel wire rod producer Ugitech has awarded the final acceptance certificate to Primetals Technologies for its customized engineering solution to upgrade and automate the compacting and coil-handling process in the company's rod mill, which recently met all performance targets.

**ArcelorMittal Eisenhüttenstadt GmbH Germany**

The process-optimization system of Blast Furnace 5A of ArcelorMittal Eisenhüttenstadt will be upgraded by Primetals Technologies. Advanced management

modules will be installed that include a 3-D hearth-wear model and - for the first time - a new blast furnace data-mining tool for defining the most suitable burden-distribution pattern on the basis of previous operational data. Commissioning is scheduled for late 2016.

**BGH Edelstahlwerke GmbH Germany**

An order was placed with Primetals Technologies by German steel producer BGH Edelstahlwerke to modernize the electric arc furnace at its Freital site in order to optimize furnace movements and convert its tapping system. The furnace will be modernized in two conversion stages, and the work is scheduled for completion during the summer shutdown in 2017.

**Georgsmarienhütte GmbH Germany**

The Level 2 ELO/Sekmet systems will be remotely upgraded and integrated in the existing human-machine interface (HMI) of Georgsmarienhütte.

**H.E.S. Hennigsdorfer Elektrostahlwerke GmbH Germany**

Primetals Technologies received the final acceptance certificate for the upgrading of a bar mill in Hennigsdorf. Two roughing mill stands were replaced with new Red Ring stands, which do not have housings. This solution requires less space and the new stands offer greater rigidity for rolling products with ever-tighter product tolerances.

**JSW Steel Ltd. India**

The final acceptance certificate was received by Primetals Technologies for four LD (BOF) converters that were upgraded in Steel Making Shop II. The project scope comprised the complete replacement of the converter shells and tilting drives (for two converters); installation of bottom-purging stations, condition-monitoring systems and forced-air shell-cooling systems; and the supply of an LACAM (refractory profile monitoring) system. Converter tap-to-tap times could be shortened and the lifetime of the refractories increased. Most notably, the productivity of the LD (BOF) converters could be improved by a remarkable 18.5%. »



Manufacturing workshop of Primetals Technologies Mexico

## PRIMETALS TECHNOLOGIES MEXICO EXPANDS ITS MANUFACTURING WORKSHOP

Primetals Technologies Mexico recently expanded its manufacturing workshop in order to better serve the North American electric steelmaking market with the manufacture, supply and maintenance of core EAF components, such as electrode arms, nose panels, Refined Combined Burners (RCB), EAF shaft fingers, water-cooled components and complete sets of spare parts for electric furnaces. Guillermo Gonzalez, CEO of Primetals Technologies Mexico, remarked, "Expanding the workshop's capabilities will not only satisfy the constantly growing demand for core EAF components, but it will also secure local jobs."

### JSW Steel Ltd.

India

Two new Red Ring stands were sold for installation in the roughing train of the existing bar mill at the company's Salem steelworks. Start-up is scheduled for early 2017.

### JSW Steel Ltd.

India

Hot commissioning of the Continuous Casting Machine No. 5 of Steel Melt Shop II was successfully performed at the company's Vijayanagar steelworks on April 7, 2016. The cast slabs are 1,550 mm wide and 220 mm thick. Furthermore, the final acceptance certificate was received for the new process-automation system for a total of 25 subsystems in the Steel Making Shops Nos. 1 and 2 at the Vijayanagar plant. The integrated automation solution included production-monitoring and ladle-tracking systems.

### National Mineral Development Corp. (NMDC)

India

The cold trial run was successfully undertaken on the sinter cooler on February 24, 2016, which marks an important milestone in the completion of the 3 million t/a sinter plant project that is being supplied by Primetals Technologies on a greenfield basis in the Bastar district of Chhattisgarh.

### Rashtriya Ispat Nigam Ltd.

India

The state-owned Indian company announced the commencement of the plant shutdown to thoroughly modernize Blast Furnace No. 2 at Visakhapatnam Steel Plant (Vizag Steel). This modernization, which will be undertaken by Primetals Technologies, will boost the interior volume of the furnace from 3,200 m<sup>3</sup> to 3,820 m<sup>3</sup> in order to increase the hot-metal production capacity to 7,150 tons per day. Moreover, a total of five hot-blast stoves will be upgraded on Blast Furnaces No. 1 and No. 2 with state-of-the-art technologies. The capital repair of Blast Furnace No. 2 is scheduled for completion in 2016, while modernization of the hot-blast stoves will be carried out in 2017.

### Steel Authority of India Limited (SAIL)

India

On April 19, 2016, Primetals Technologies received the final acceptance certificate for the 300-ton ladle furnace installed in the Steel Making Shop II of the Bokaro Steel Plant.

### Steel Authority of India Limited (SAIL)

India

A repeat order was received for the supply of Morgoil bearings and three sealing kits for the Cold-rolling Mill II at SAIL's Bokaro Steel Plant. Spare parts will also be provided for the Pickling Line and Tandem Cold Mill (PLTCM) of the Cold-rolling Mill III, including polyurethane (PU)-coated and metal-coated rolls.

### Steel Authority of India Limited (SAIL)

India

On January 1, 2016, the final acceptance certificate was issued to Primetals Technologies for the upgrade of the electrical and automation systems of the Sinter Plant No. 2 at Bhilai Steel Plant.

### Steel Authority of India Limited (SAIL)

India

Following the start-up of a medium-size structural mill at the Durgapur Steel Plant, the preliminary acceptance certificate was issued to Primetals Technologies on March 17, 2016. Six different saleable sections are now being produced.

### Steel Authority of India Limited (SAIL)

India

On February 22, 2016, Primetals Technologies was awarded the preliminary acceptance certificate for the supply and installation of an RH degassing plant to the Rourkela Steel Plant.

### Tata Steel Ltd.

India

On February 29, 2016, the blow-in of Blast Furnace No. 1 took place at Tata Steel's Kalinganagar steelworks. This is the largest blast furnace in India and it was supplied by Primetals Technologies. The project scope included the design the furnace, stoves, slag-granulation system and gas-cleaning plant; the supply of specialized imported machinery and equipment; and the installation of a full suite of blast-furnace equipment.



Continuous slab caster previously supplied by Primetals Technologies to MMKI, Ukraine

#### **Aktobe Rail and Section Works LLP (ARBZ) Kazakhstan**

The start-up certificate for a rail and section mill supplied by Primetals Technologies was signed on February 24, 2016. This certifies the correct industrial operation of the mill. The required laboratory tests were carried out at Kazakh and Russian railway research institutions, which confirmed that the rails produced and processed by the idRHa+ inline head-hardening system meet the required quality and safety standards. Rails produced in the supplied mill have already been installed in regional railway networks.

#### **Novelis Korea Ltd. Korea**

Primetals Technologies received an order from Novelis for the supply of a new roll-coolant spray system for the aluminum hot-strip mill in the company's Yeongju plant. The project will lead to further improvements in strip quality.

#### **YKGI Holdings Berhad Malaysia**

An order was placed with Primetals Technologies India to supply new line and auxiliary drives and to upgrade the existing automation system for a continuous galvanizing line.

#### **Amreli Steels Limited Pakistan**

Mill guides will be engineered and supplied for an 8 mm to 40 mm rebar mill.

#### **Saudi Iron & Steel (Hadeed) Saudi Arabia**

On May 23, 2016, Primetals Technologies received the final acceptance certificate for a project that included the supply of new roughing mill stands.

#### **ÇEMTAŞ Çelik Makina Sanayi ve Ticaret A.Ş. Turkey**

An agreement was signed with Primetals Technologies on May 26, 2016 that closes a bar mill project for the production of special quality steels.

#### **Tata Steel Ltd. U.K.**

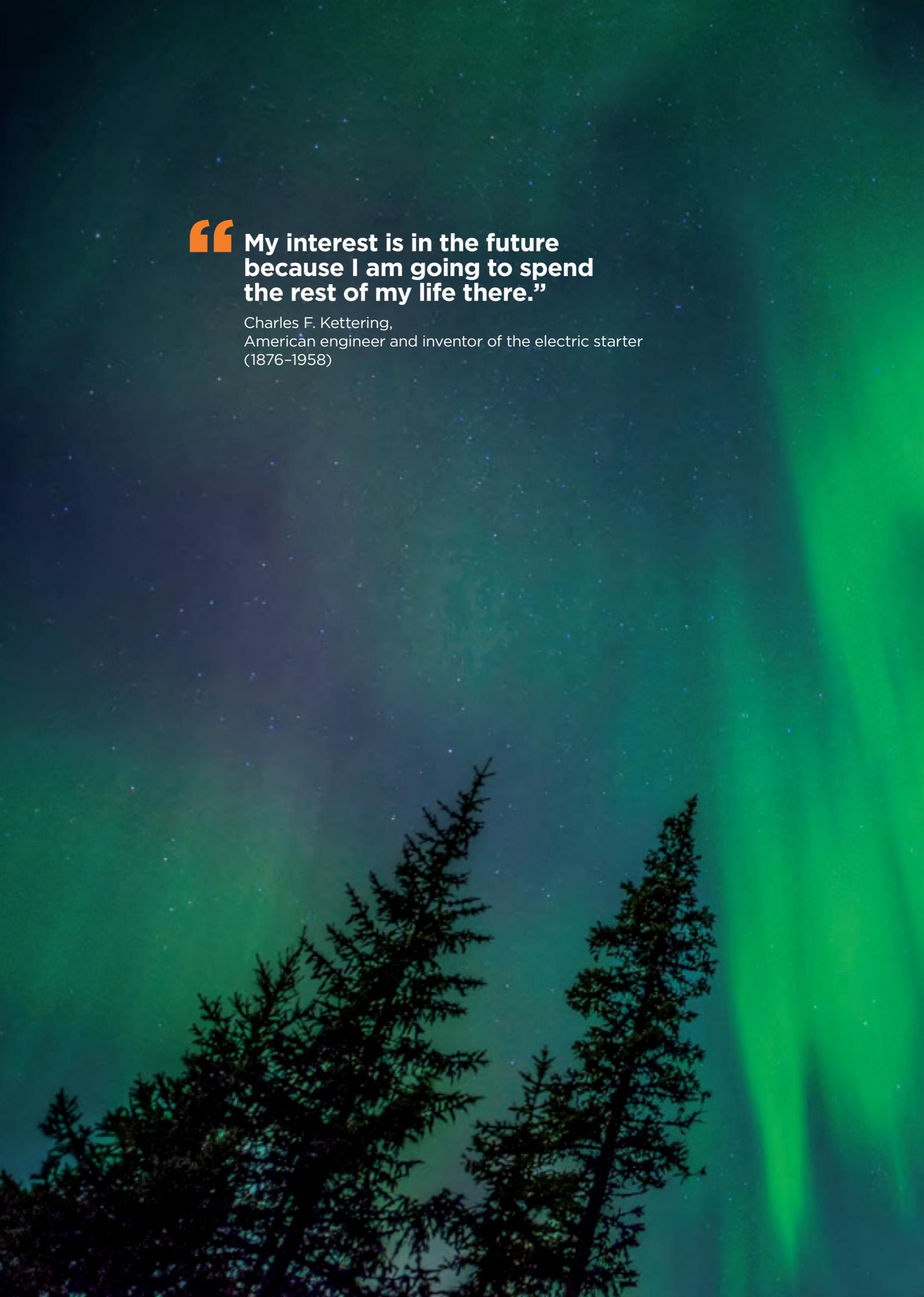
An optimized tuyere camera-monitoring system was recently developed by Primetals Technologies on the basis of operational feedback from a successful trial period that had already been conducted at Tata Steel in Port Talbot in the latter part of 2015 using a previous model of the camera-monitoring system. The new superior camera system enables analytical evaluations to be carried out thanks to the high-quality optical output. This includes warnings of potential tuyere failure and the ability to perform observations away from known high-risk areas near the furnace.

#### **Metallurgical Combinat in Mariupol (MMKI) Ukraine**

MMKI placed an order with Primetals Technologies for the engineering of a continuous slab caster, a twin ladle furnace with an alloying station, and the associated dedusting system. The engineering covers all installations from the ladle turret and ladle car through to the caster exit zone that includes torch cutting, weighing, marking and deburring machines.

#### **Formosa Ha Tinh Steel Corporation Vietnam**

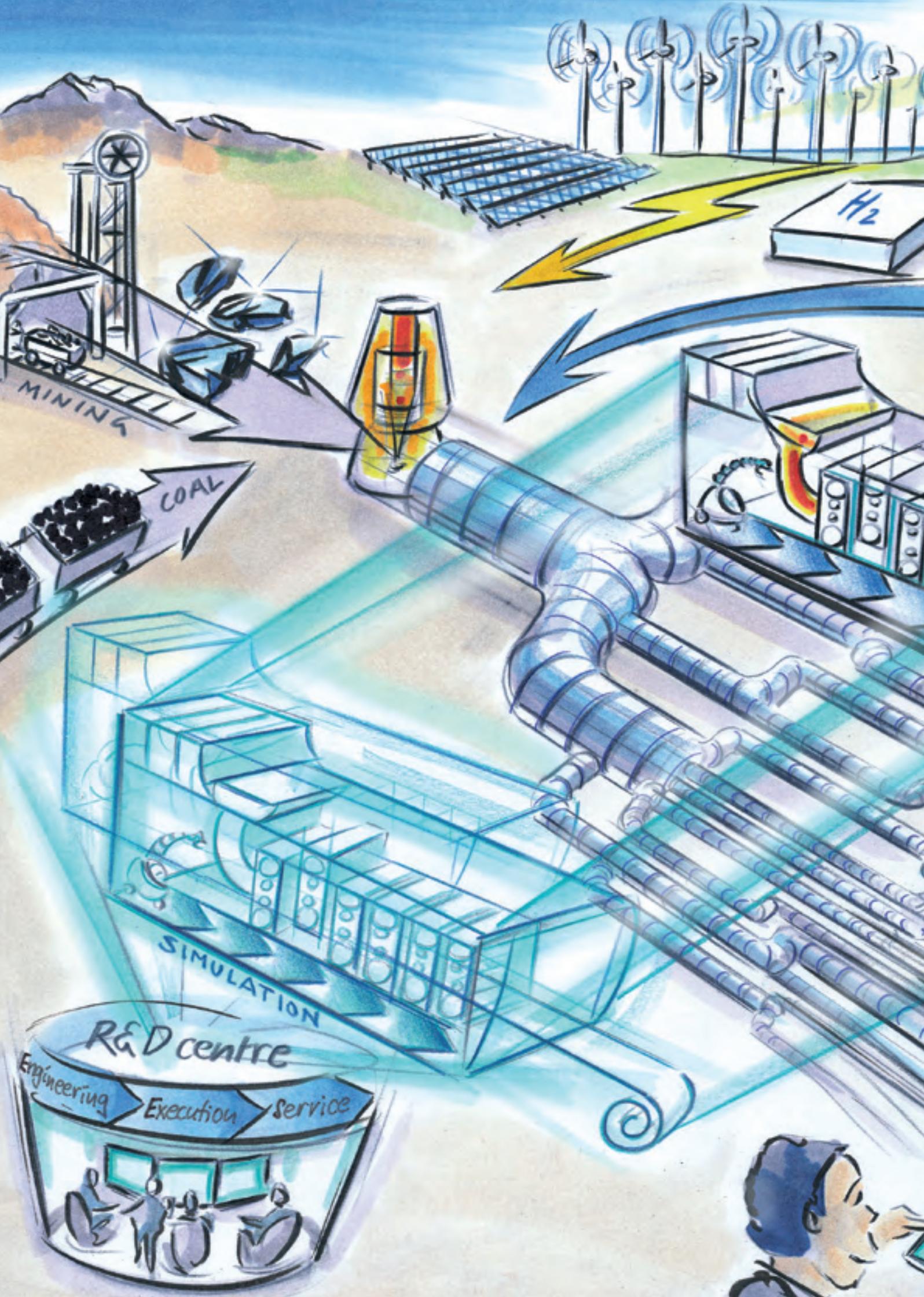
Two contracts were signed with Formosa Ha Tinh for the supply of major spare- and replacement-part packages in connection with the upcoming commissioning of four continuous casting machines and a wire rod mill.



**“ My interest is in the future  
because I am going to spend  
the rest of my life there.”**

Charles F. Kettering,  
American engineer and inventor of the electric starter  
(1876-1958)







# THE FUTURE OF METALS

**THE OUTLOOK FOR THE METALS INDUSTRY  
IN THE DECADES TO COME**

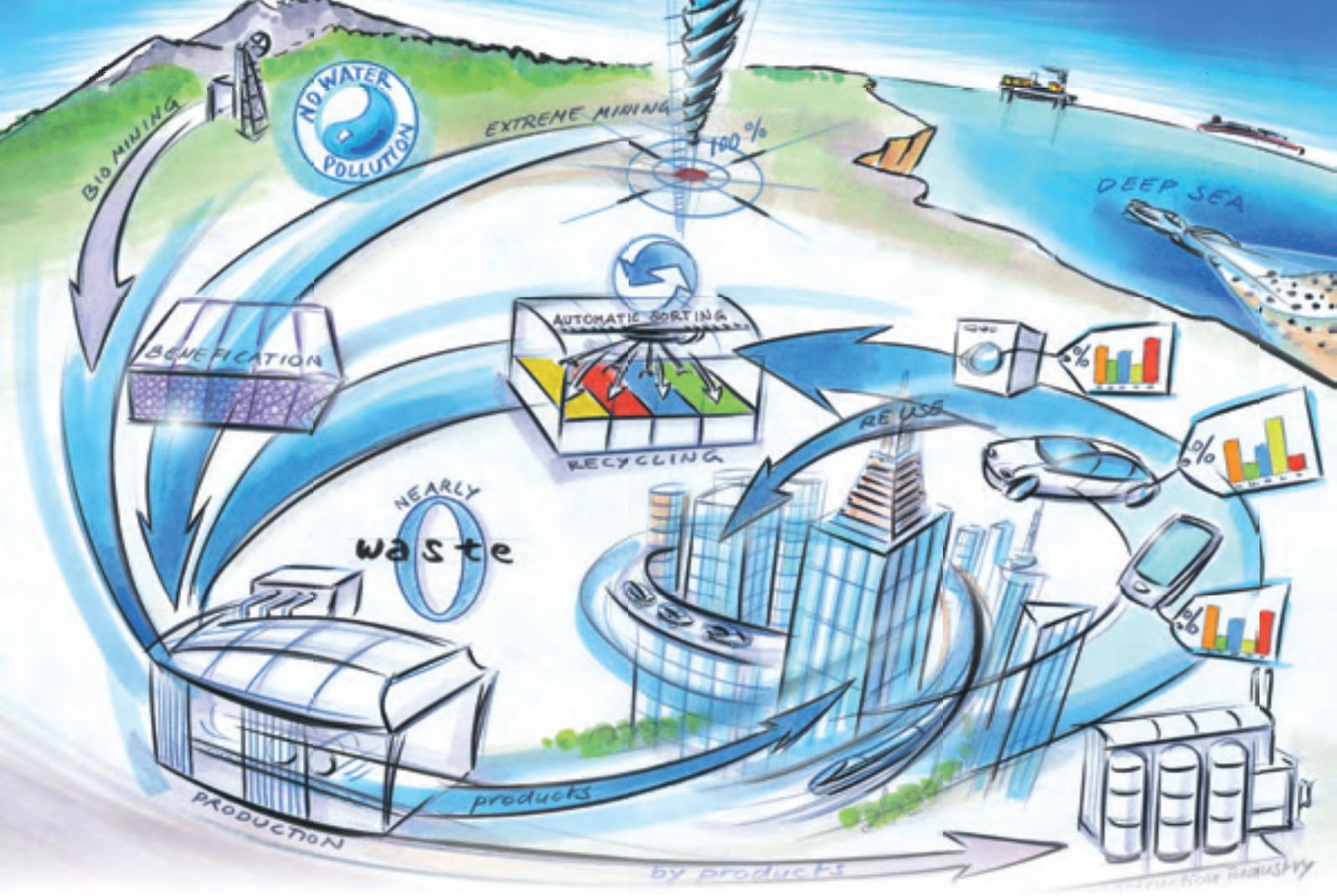
How will the metals industry look in the decades to come? Which developments, innovations and technologies will prevail? Primetals Technologies is asking questions like these today so that the company, together with its customers and partners, can play a key role in “creating the future of metals as one” – the company’s slogan.

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If you want to create the future, you have to have the right ideas and solutions today. For this reason, Primetals Technologies has examined multiple trends, considered hundreds of hypotheses and, over the course of several years, held discussions with some 80 metals producers, their customers, researchers, industry experts, governmental and non-governmental organizations, and industrial partners throughout the world. With this information, it has become clear where the metals industry is heading. A preeminent goal of Primetals Technologies is to develop long-term strategies that support customers to remain competitive and successful. The company’s comprehensive portfolio of technologies, modernization packages, products and services that cover the entire lifecycle of a metallurgical plant – combined with integrated automation and environmental solutions – helps producers optimize plant performance and costs, and meet increasingly rigorous standards in environmental protection and energy efficiency. This is the best starting point for a sustainable future. In the following pages, a preview of the future of the metals industry is presented on the basis of expert analyses and in-depth research that show how ongoing developments will have an impact on the future.

**A preeminent goal of Primetals Technologies is to develop long-term strategies that support customers to remain competitive and successful.**





# RAW MATERIALS, RECYCLING AND SOURCING GOVERN OUR LIVES

**2040:** The metals industry has found ways to overcome the increasing scarcity and lower quality of raw materials. All material sources are tapped, and advanced technologies and solutions are applied such as sensor systems, artificial intelligence and biological processes. New technologies for material extraction and beneficiation are utilized, and radical solution approaches have been adopted.

## New raw material sources

Society must still rely on the raw materials found in nature. Subsea mining is practiced, as it provides access to new raw materials and sources deep within the ocean. Required materials are also sourced from “extreme mining,” that is, mining in areas characterized by extreme conditions, such as in remote regions of Siberia, the Antarctic, or at extreme underground depths.

## Biomining processes

Biomining is applied to extract copper and other metals from mine tailings and industrial wastes with the help of bacteria. Various biological processes are also being optimized to extract metals from lower-grade ores.

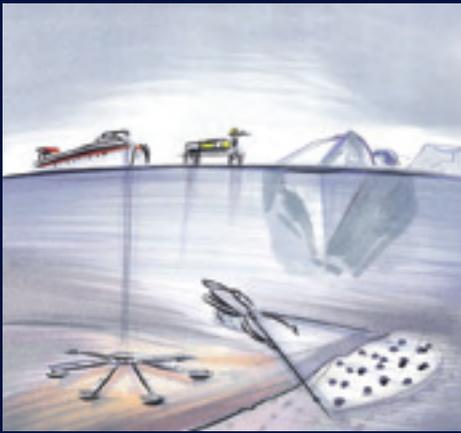
## 100% recycling

The metals industry takes full advantage of the potential of recycling. Consider an old car or any appliance. It consists of carbon fibers, plastics, glass and metallic components. After being completely disassembled, self-learning robots and automated sorting systems separate the parts down to the smallest pieces, which are recovered. This provides the basis for the optimum reuse of base materials that are returned to the production process.

Urban wastes are entirely recycled and serve as another important source of reused materials. Through urban mining, anything that has become trash or rubbish is automatically broken down and sorted. Tracing and tracking systems support this process and provide detailed information on where reused materials are located within their respective lifecycle.



## THE FUTURE VIEW ACCORDING TO PRIMETALS TECHNOLOGIES



### EXTREME MINING

- Subsea mining provides access to new sources of raw materials to meet growing demands.
- Extreme mining takes place under challenging conditions, such as at extreme depths.



### BIOMINING

- Biomining offers an environmentally compatible solution approach for exploiting resources.
- New raw material sources are explored as a result of advances in biomining.
- Copper ore beneficiation is well established in biomining.



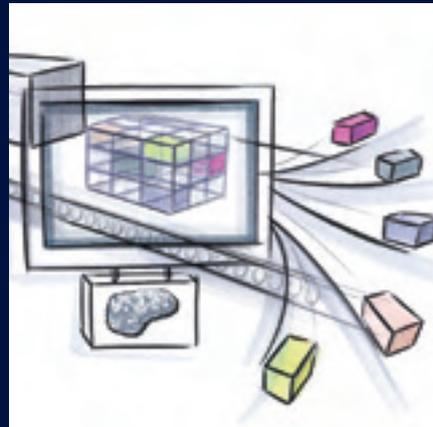
### LOW-GRADE MATERIAL BENEFICIATION

- Beneficiation of low-grade materials is standard practice due to decreasing availability of high-quality coal, ore and scrap.
- Customized beneficiation of raw materials is carried out in accordance with the final product requirements.



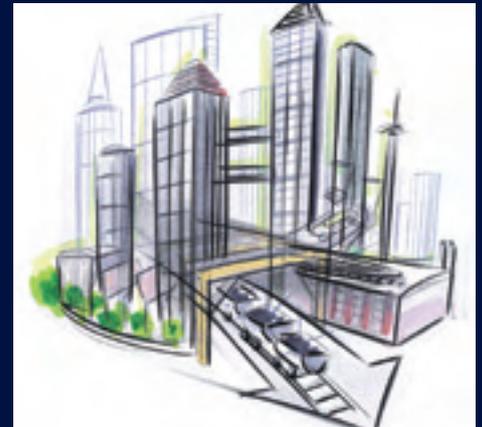
### ZERO-WASTE PRODUCTION

- Zero-waste production is now reality with the recovery of all by-products and their reuse in the metals industries and in other industrial segments.
- Production processes are carried out with almost zero by-products, landfill waste and water pollution.



### AUTOMATED DISASSEMBLY AND SORTING

- Chemical and mechanical separating processes are performed by complex automated disassembly and sorting systems.
- Raw material tracking supports an optimized control of material flows.

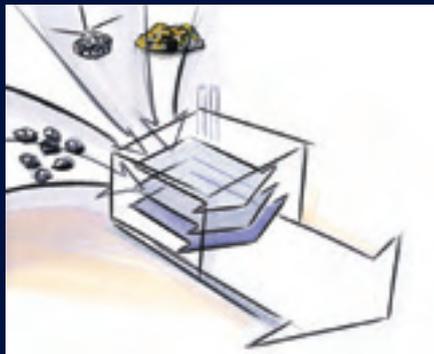


### URBAN MINING

- The contents of urban waste are almost fully recovered and provide additional raw materials and additives.
- Complete material recycling is essential since raw materials are becoming increasingly scarce and costly.



## THE FUTURE VIEW ACCORDING TO PRIMETALS TECHNOLOGIES



### FLEXIBLE PRODUCTION DEPENDENT ON MATERIAL INPUT

- Adaptive production routes are widespread as an answer to poorer raw material grades (coking coal, iron ore).
- Plant operators are supported by simulation techniques to cope with varying qualities of input materials.
- Optimized scrap selection and raw-material beneficiation processes play an important role in the production of metals.



### GLOBAL FOOTPRINT-ORIENTED PRODUCTION

- Lifecycle assessments acquire a high degree of importance in industry and society.
- Primary processing steps for aluminum and magnesium are exclusively located near inexpensive energy sources.
- The main leverage is energy savings and raw material efficiency along the entire value-added chain.



### CLOSED-LOOP WATER AND SCRAP CYCLES

- Water pollution and useless by-products are reduced to a minimum.
- Closed-loop water cycles are universally applied, particularly in arid regions.
- Re-collection of all metallic scrap is standard practice.

# GREEN PRODUCTION

## THE BASIS FOR GROWTH

**2040:** The accelerated growth of the world's population and the progressive changes in the global climate demand a radical rethinking and transformation of industrial production processes. The metals industry has therefore adopted ultra-efficient measures and solutions to ensure wide-scale green production that is aligned to local market requirements and regional developments. Concepts such as cradle-to-cradle and lifecycle product assessments are already employed to ensure economically sustainable and environmentally compatible production plants and processes.

### Material and energy efficiency drive the economy

Prices for raw materials, fuels and electricity have steadily risen – even faster than the general inflation rate. Sustainability, eco-friendliness and production costs have become paramount in importance. Energy consumption per material unit has dropped to unprecedented levels since the onset of the industrial revolution, yet it remains vital that further improvements be adopted on a global basis. Recovery of 95% of waste heat is state of the art. Taxation and governmental subsidies strongly support the public's awareness of energy-efficient solutions, the use of renewable energy sources, smart-grid systems and the intelligent linking of metal-production steps. The same applies to

waste consciousness and the avoidance of wastewater. All metallic scrap is now collected, and yield losses that occur during metallic production processes have been slashed by 50% within two decades by the best-in-class producers. Any remaining CO<sub>2</sub> generation is mostly used in artificial photosynthesis systems to produce and utilize bioenergy.

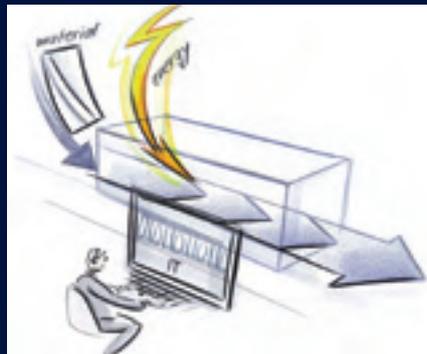
### Fully integrated and highly flexible production units

The depletion of most high-grade ore and mineral deposits has led to the need to mine low-grade material deposits. Metal producers have already adapted to cope with lower-quality input materials, and technology suppliers have developed the required plant technologies and systems. Operational complexity has increased due to the need for greater plant flexibility to process raw materials of varying quality and to utilize different energy sources. The latter includes renewable energy, hydrogen generation (with on-site storage), shale gas and oil as well as artificial CH<sub>4</sub> from surplus renewable energy. These energy sources are interconnected by means of a smart grid and energy-management system. Different material and energy sources are interchangeably used – depending on price, availability and targeted metallic yields. All of this is controlled by advanced information and communication systems that are remotely cloud-monitored using mobile interfaces. »»



### ENERGY-ORIENTED PRODUCTION

- In-house production and utilization of regenerative energy sources (water, sun and wind energy) is commonplace.
- Hydrogen and synthetic gases are widely used (substituting shale gas and natural gas).
- Energy consumption is minimized through the linking of processes.
- Nearly all waste heat is recycled in all industries.



### INTEGRATED GREEN PRODUCTION MANAGEMENT

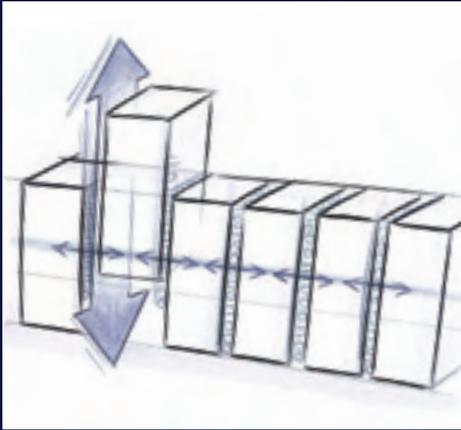
- IT solutions drive energy- and material-efficient linking of processes that were formerly separate steps.
- Downstream processes are oriented to the availability and economy of renewable energy sources.
- Plants are integrated into a smart grid/integrated resource management system.



### ADVANCED MATERIALS AND SURFACES

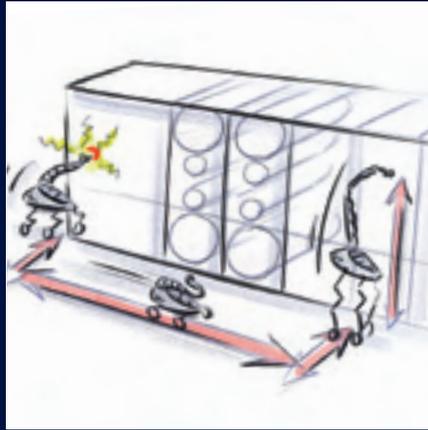
- Use of products with the most favorable economic and ecological footprint.
- With greater functional uses for materials, material mixes have become much more complex.
- Increased use of all metals, sandwiched materials, fibers and composites.
- Continually increasing steel versatility.

## THE FUTURE VIEW ACCORDING TO PRIMETALS TECHNOLOGIES



### MECHATRONIC MACHINERY

- Production plants consist of mechatronic plug-and-play modules that are easy to exchange or scale up.
- The modules are equipped with online sensors, actuators and control systems that support autonomous self-organization.



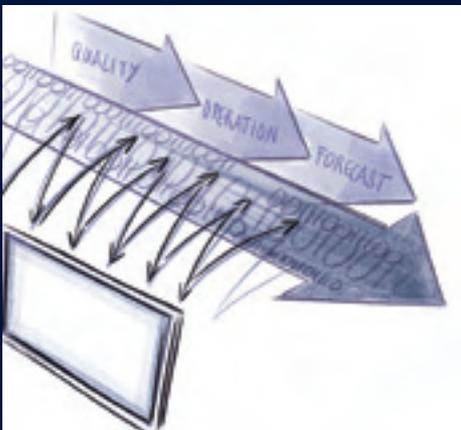
### SELF-LEARNING ROBOTS AND MANIPULATORS

- Specialized robots support work at the plant and self-adapt to changes in production modes, leading to a reduction of necessary onsite personnel.
- Robots are universally used in dangerous work areas and are operated from remote stations.



### SEAMLESS ONLINE PROCESS ANALYTICS

- Each component or module is condition-monitored online.
- All module data, current plant setup, maintenance schedule, operating times and statuses are shown on intuitive HMI (human-machine interface) screens.
- Ubiquitous analytic sensors seamlessly detect material properties and quality.



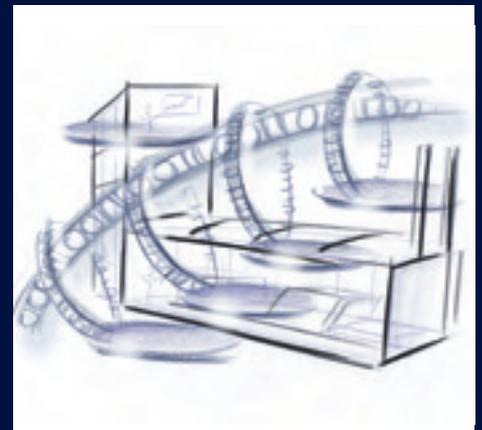
### VIRTUAL PRODUCTION

- Full production simulation that covers quality, operation and forecasts, and efficiently controls real plant processes on the basis of a permanent exchange of data and information.
- Simulations are seamlessly connected to suppliers and customers, facilitating advanced comprehensive forecasts and optimization of operation planning.



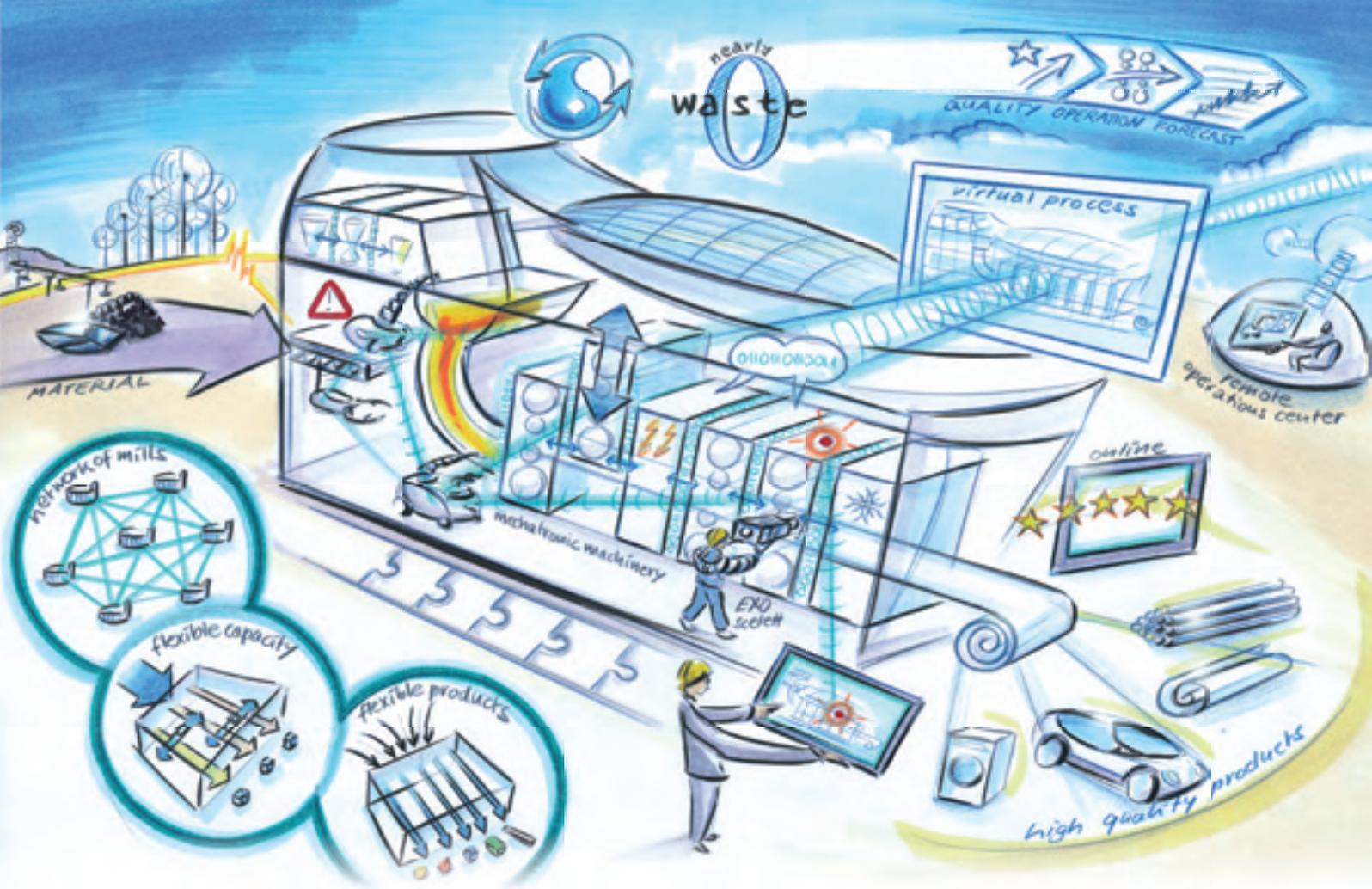
### CENTRALIZED REMOTE OPERATIONS

- Globally distributed plants are operated from centralized remote centers.
- Control and condition monitoring utilize data from all connected plants.
- This data is used for benchmarking and continuous improvement of all connected sites.
- Maintenance is based on predictive measures and self-learning models.



### NETWORKED AUTOMATION STRUCTURE

- An intelligent and autonomous automation grid substitutes the pyramid of plant automation.
- The plant automation grid is comprised of networked field devices with integrated control functions that run at the field level.
- Advanced automation applications, such as execution systems and resource planning, operate in the industry cloud.



## HOLISTIC PLANT OPERATION IN A VIRTUAL WORLD

**2040:** Plant operations are increasingly simulated in a virtual world using cloud-based solutions. Cyber-physical machinery is now standard in metallurgical production processes. Current plant operation is monitored and controlled thanks to a continuous interchange of data and information between the real and virtual worlds in real time. Operators can supervise processes in parallel with the virtual world, or check the reliability of forecasts and intervene in ongoing operations whenever necessary.

### Lean automation structure

Virtual plant operation has redefined applied control technologies. Parameters for quality, capacity and productivity are permanently measured and accurately simulated in real time. The continuous interchange of data and setpoints supports the application of a lean automation structure that is backed by a connected know-how database. The database itself is characterized by highly sophisticated content and feedback loops.

### Seamless analytics and robotic systems

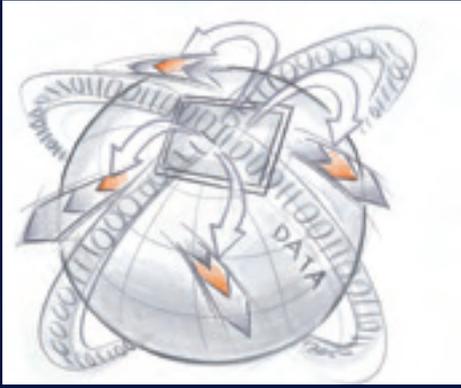
Online product quality and process analytics, including self-learning robots that support plant operations, are extensively applied. They work autonomously when small-cycle loops are performed, and provide the required general information to allow holistic plant operation and production

control. The robots are used in hazardous areas and for all routine maintenance work. They can self-adapt to production-mode changes and considerably facilitate the work of plant operators.

### Online monitoring assures reliable operations

Production plants consist of a series of standardized mechatronic modules with embedded intelligence that allows nonstop plant monitoring to be performed. Integrated, highly sophisticated sensors and the associated communication technologies transmit a steady flow of data and information about the status of the installed mechatronic equipment throughout the entire production process. This makes it possible, for example, to flexibly adjust operation modes and parameters when machine or component wear becomes apparent. Necessary maintenance work is automatically scheduled just in time. Plant installations throughout the world are remotely operated and controlled from a central station. This allows operators to determine if process technologies and equipment are functioning similarly at different sites. Furthermore, support is provided to identify those conditions that would enable systems to perform better or to produce higher-quality products. Since all plants are fully inter-linked, plant capacities and product dispositions are easily and quickly adapted to current requirements. »

## THE FUTURE VIEW ACCORDING TO PRIMETALS TECHNOLOGIES



### HOLISTIC SERVICE INTEGRATION

- Service innovations are driven by increased data availability.
- Emerging challenges for services are green production, recycling, smart-grid energy management, environmental footprints and seamless tracing and tracking.
- Comprehensive services are tightly integrated into production systems.



### INTERACTIVE ON-SITE OPERATION AND MAINTENANCE SERVICE

- Plant operation and maintenance has changed to a great extent from reactive to predictive procedures.
- Remote services are supplemented with only a few on-site staff members.
- On-site services are supported by interactive autonomous robots and augmented-reality techniques.



### DIGITAL DATA ANALYSIS AND KNOWLEDGE-BASED SERVICES

- Data analysis and knowledge-based services are available everywhere and at any time through cloud computing.
- App-based services are standard for customers, plant builders and external developers, and are linked to production systems for the development of new steel grades and equipment checks.

## SERVICE MODELS PROMOTE LIFECYCLE PARTNERSHIPS

**2040:** Central service sites capable of remotely managing operations and maintenance have become commonplace. Available around the clock, they regulate operations in real time from remote locations. Metal producers have at their disposal a wide variety of services that extend from metallurgical support to the supply of spare parts. The increased availability and efficient management of plant data provides the basis for a number of new service models.

### Maintenance from a distance

Proactive maintenance activities based on the data from condition-monitoring systems are state of the art. These systems not only predict certain events and perform predictive maintenance, they also optimize overall plant operation. Remote access and plant control increase machine availability and reduce on-site staff work. Robots and automated systems are remotely controlled and support production operations and maintenance activities.

### Spare parts just in time

Optimized spare-part logistics and just-in-time delivery mean reduced capital expenditures for producers. Additive manufacturing technology is one solution. Drawings are

provided on demand to enable customers to produce certain spare parts or temporary exchange parts when needed. The spare-parts management system is linked to the predictive maintenance system to optimize the overall process in a holistic approach.

### Managing the flood of data

Huge data volumes are managed intelligently. Data analytics and on-demand knowledge-based services are available anywhere and at any time with cloud computing. Numerous apps dealing with various aspects throughout the value-added metals-production chain related to metallurgy, logistics and cost management can be downloaded to immediately support operators. Managers are able to access and analyze operational data and know-how at any time.

### A virtual marketplace

The virtual marketplace for distribution and consulting serves as a platform for the automatic distribution of raw materials, energy, new and used parts, and even new plant technology and communication software. Agents automatically supply customers with raw materials or energy according to customized parameters. »



### CENTRALIZED REMOTE 24/7 SERVICE CENTERS

- Service centers are centralized and perform real-time operation and maintenance from remote locations.
- Service centers are networked globally, thus ensuring continuous 24/7 availability and service quality.
- Autonomous software tools for services support local operator decisions related to, for example, forecast models.



### JUST-IN-TIME SPARE PARTS PRODUCTION

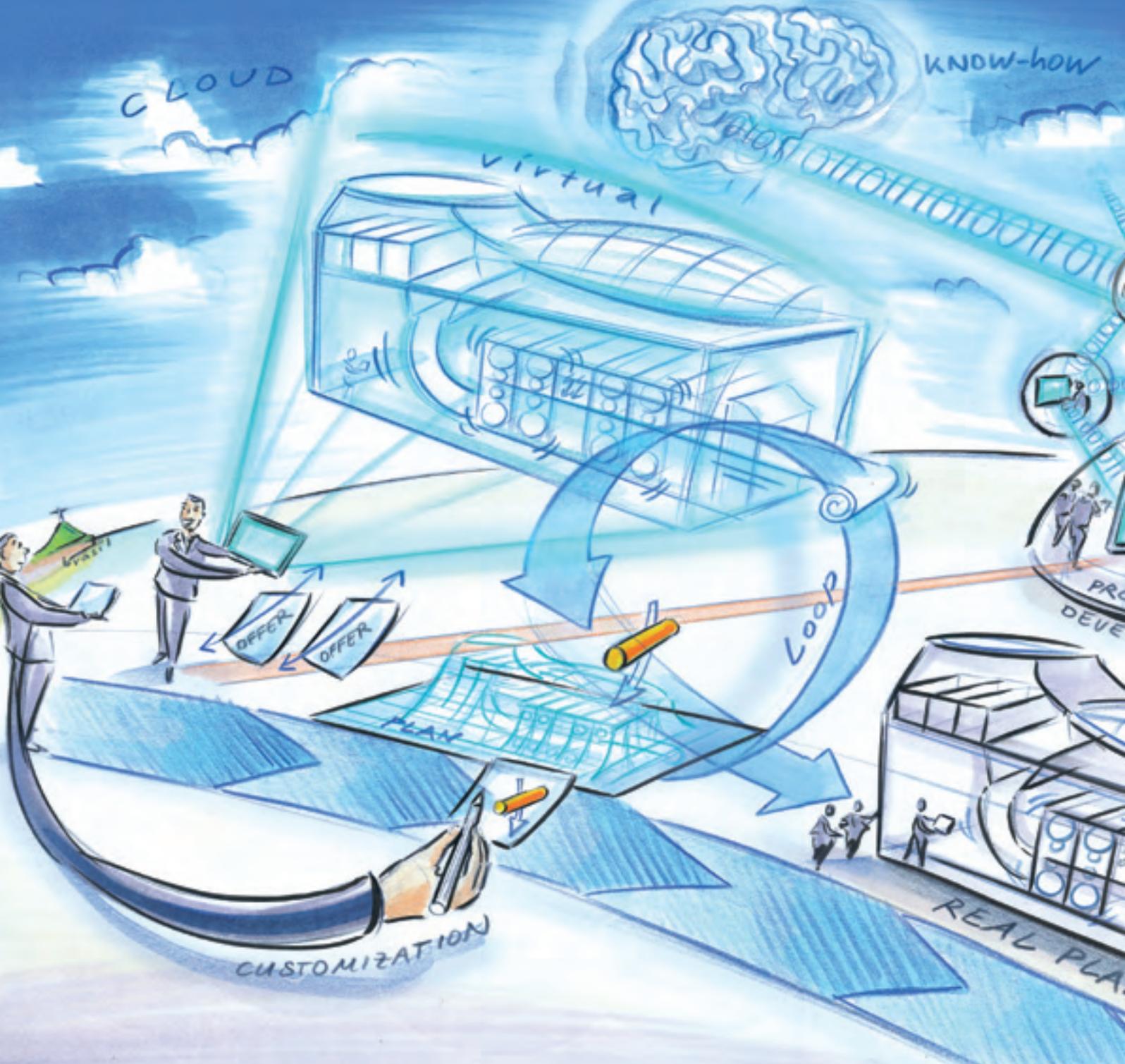
- Spare parts are provided by clustered service centers and/or on-site production.
- Innovative manufacturing methods such as 3-D printing ensure local just-in-time availability and lead to new business models.
- Spare-part management is linked online with predictive maintenance models.



### VIRTUAL MARKETPLACE FOR SALES AND CONSULTING

- Virtual marketplaces provide platforms for automatic brokering of raw materials, energy, new equipment or used parts.
- Brokering software agents automatically supply raw materials or energy according to individually customized parameters.





The megatrends of the next decades include the relentless growth of the global population, climate change, shortage of raw materials, increasing demand for energy, the shift of economic gravity, the ongoing urbanization trend and the accelerated creation of information networks. These factors will influence and even dominate the developments on planet Earth in the future.

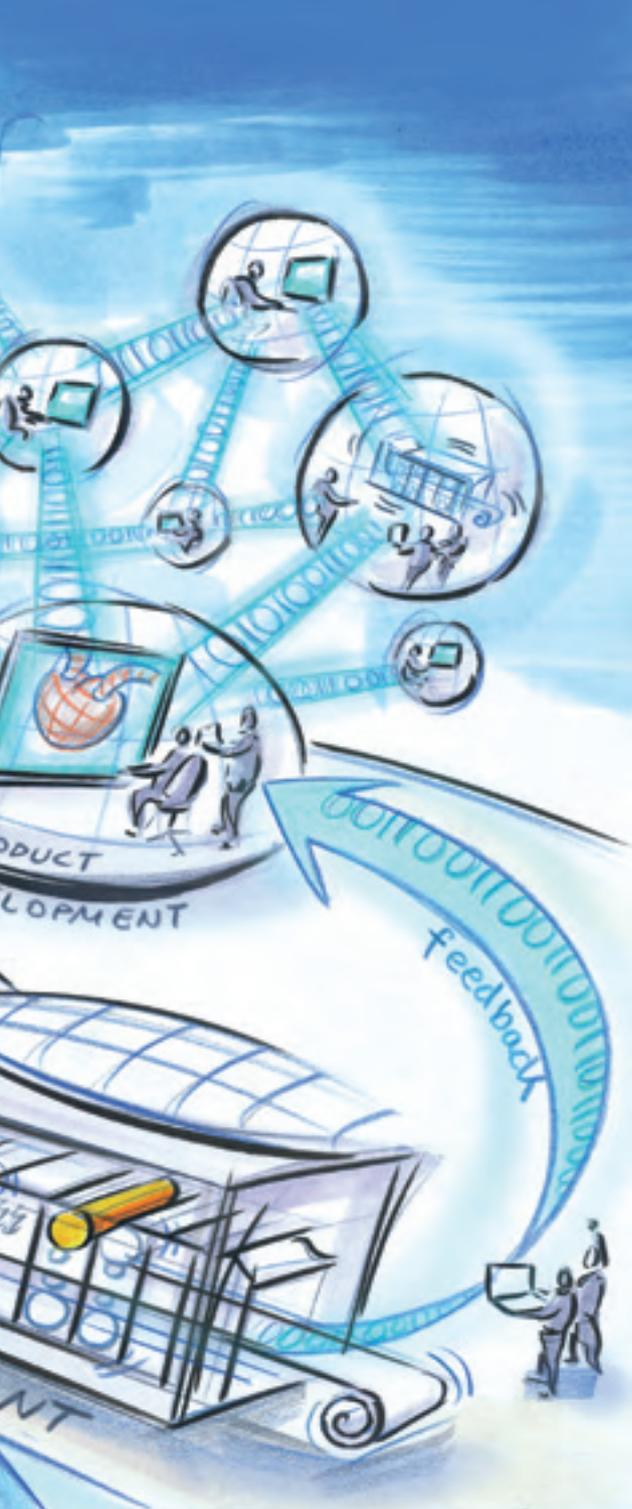
### **STRONG DEMAND FOR STEEL AND ALUMINUM**

Within the next two decades, it can be expected that global crude steel demand will increase by approximately 50% to more than two billion tons per year. Aluminum production will grow by 100%-130% to around 100 million t/a. The potential of aluminum and steel is not exhausted yet. Extremely sophisticated aluminum and steel alloys are required for special

applications in transportation and energy production, and for specialized manufacturing. More than ever, continually increasing construction and transportation activities are the main driving forces behind the growth in demand for metals.

### **A NEW GENERATION OF METALS**

Sandwiched materials, fiber materials and materials that can change their properties as a function of temperature are widely in use in 2040. They represent a whole new generation of materials with optimized properties for their intended purposes. Top values of material strength, toughness, deformability and other properties exceed by far the benchmark figures in 2016.



## WHAT DOES THE FUTURE HOLD?

SUMMARY VIEW BY  
PRIMETALS TECHNOLOGIES

Together with its customers and partners, Primetals Technologies is fully committed to “creating the future of metals as one.”

### TOTALLY INTEGRATED SMART PRODUCTION

Production processes of industrial metals will become increasingly integrated – from the mining of the raw materials up to the finished surface-coated product. Most metals are still manufactured on the basis of so-called traditional process steps comprising the reduction and smelting of ores, and the casting and rolling of solidified slabs or billets. However, new installations and modernizations will all be characterized by resource efficiency with respect to raw materials, yield, energy, space requirements, materials, production wastes and water consumption. The use of hydrogen for metallurgical work will grow considerably in importance. Information and communication technologies will dominate all areas of metals production and the associated plants and services.

### CREATING THE FUTURE OF METALS AS ONE

Experts worldwide agree: the metals industry will witness major changes in the next decades. Exciting new developments related to technological processes and applications are inevitable. Primetals Technologies has listened carefully to the views of top managers, entrepreneurs, specialists and opinion leaders, and doing so has allowed us to take a glimpse into the exciting metals world of tomorrow. Forecasts help to identify and quantify future markets, anticipate the needs of customers, and pinpoint those technologies that offer the greatest potential for sustained growth, new business opportunities and to create a better world for society. It is now up to the industry to prepare for what will come and to implement the necessary steps today. Together with its customers and partners, Primetals Technologies is fully committed to “creating the future of metals as one.” »

# IRON- AND STEELMAKING

## ONE HUNDRED YEARS FROM NOW

“It is difficult to make predictions, especially about the future,” said Niels Bohr, the Danish physicist and Nobel prize winner. Accordingly, predictions about the iron- and steelmaking industry in 2116 are a difficult task indeed. Assuming that civilization and society will continue to advance one hundred years from now, the total quantity of steel produced from iron ore since the beginning of ferrous metallurgy thousands of years ago will exceed 150 billion tons. With consideration to such a huge global steel availability, more than two-thirds of the steel manufactured each year is derived from recycling and the processing of scrap in electric melting furnaces.

The energy efficiency of best-available electric steelmaking technologies is close to 90%, compared to what is theoretically possible. Waste heat is almost negligible. Solid waste is no longer dumped in landfills, but is entirely recycled in production processes or used by other industries. All mass-produced materials are completely sorted, disassembled, tracked and reused. The composition of the charge materials for electric steelmaking is thoroughly known and specified in advance, thus minimizing alloying requirements following scrap melting.

Iron- and steelmaking from virgin iron ores is predominantly based on direct-reduction metallurgy. Smelting-reduction technologies such as Corex and Finex prevail, while blast furnaces still in use continue to be optimized. The majority of plants, however, are direct-reduction-based facilities that utilize various reduction gases and energy sources. The total generation of CO<sub>2</sub> per ton of steel is now less than one-fourth of the figure in 2016, if evaluated according to the ISO Lifecycle Assessment methodology. Steelworks are well-honored recycling enterprises and value-added production facilities with a minimum ecological footprint.

Steel is produced on a just-in-time basis. A continuous liquid-steel production process is employed that minimizes

the number of required process steps. Direct casting and rolling dominate hot-rolled coil production of flat and long steel products. Cold rolling, annealing, processing and finishing are fully linked within a continuous production line for the majority of steel products. This is made possible by the application of highly specialized technologies that are part of an intricate steel-service-center business.

Operators in hazardous areas of the steel mill are a thing of the past, as these jobs have been completely taken over by robots. In addition, robotic manipulators are executing all quick-change routine procedures as well as standard maintenance tasks involving the handling of heavy components. The operation and maintenance of iron- and steelmaking plants is entirely remotely controlled from central operation centers. Production is monitored by videos linked to computers, hand-held devices and eyeglasses with augmented reality. Predictive and proactive maintenance is totally optimized and universally applied, hence unforeseen plant stops no longer occur, especially due to the broad application of data-based services by means of machine learning, data-mining, cloud computing and perfected failure forecasting and prediction methodologies.

The former “voodoo magic” of liquid and solid metallurgy has been decrypted to a considerable extent. Metallurgy, technology and plant operations are completely simulated and modeled using advanced cyber-physical-mathematical tools integrated in sophisticated cascades of computer models. Holistic diagnostics, quality forecasts and steel recipe prescriptions are applied to assess the status of the production plant, energy-related parameters, through-process product quality and the required media supply to achieve the targeted product properties.

More than 10,000 main steel grades are now produced, compared to some 3,500 steel grades in 2016. Key steel properties have dramatically improved thanks to the



## Predictive and proactive maintenance is totally optimized and universally applied, hence unforeseen plant stops no longer occur.

widespread application of “nano-alloying” and “quantum technologies” – comparable to silicon and germanium micro-structure technologies used in microchips in 2016. The maximum yield strength, toughness and ductility have doubled during the past 100 years, and near-perfect steel quality is state of the art.

Technological components are not only mechatronic-symbiotic solutions equipped with embedded sensors, they operate autonomously, similar to bees in a swarm. The individual components monitor their own status, inform or alert the remote control center, and trigger the supply chain for self-substitution, maintenance planning, and wear- and spare-parts ordering.

Thanks to the close cooperation of industrial partners worldwide and the continuous development of value-added steel products, steel will continue to stay competitive and serve as a key index factor for progress and prosperity in the next 100 years. ●

**Dr. Gerald Hohenbichler**, Principal Expert, Primetals Technologies Austria  
**Karl Purkarthofer**, Head of Metallurgical Services, Primetals Technologies Austria

Interviews with both authors follow on the next pages. Primetals Technologies hereby expresses its sincere thanks to all interview and discussion partners for their time, patience and passion in sharing with us their visions of the future of the metals industry. The research team of Primetals Technologies comprised Bernd Bourdon, Dr. Gerald Hohenbichler, Dr. Jens Kluge and Karl Purkarthofer.



# THE FUTURE OF **METALLURGICAL SERVICES**

## **INTERVIEW WITH KARL PURKARTHOFFER, HEAD OF METALLURGICAL SERVICES AT PRIMETALS TECHNOLOGIES**

It is no longer enough just to have the right technology. Global overcapacity and merciless competition are forcing metals producers to continuously optimize operations and slash costs at every step of the value-added production chain. Karl Purkarthofer, who recently became head of the Metallurgical Services Business of Primetals Technologies, discusses not only how traditional plant services can be taken to the next level of quality, but also how breathtaking IT advances and the tremendous strides made in data analytics will radically transform service business models and open the door to new ways of partnering with customers. Above all, he sees service as the key to maximize value for metals producers.

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**Since becoming head of Metallurgical Services at Primetals Technologies, what is your primary objective and what do you see as the main challenge that needs to be addressed?**

**Purkarthofer:** As a lifecycle partner, we are a global company acting in local markets close to our customers. Being connected both physically and digitally makes us better at understanding the needs of our customers and more efficient in providing the right solutions. At the end of the day, the service business is predominantly a local business. How to provide as much value as possible for our customers from such a powerful global network of »

some 1,800 service specialists at more than 30 locations worldwide and ultimately to serve our customers even better is the main challenge. We need to provide value-added solutions and earn the trust of our customers day by day in order to be able to form partnerships. Personally, I strongly believe in the value of partnerships and global networks. Especially in today's challenging industry environment, those who can build such partnerships and networks and are able to create value from our hyperconnected world will have a better chance to succeed in the long run.

**What is your vision for improving the scope of services that Primetals Technologies can offer its customers in connection with digitalization and "Industry 4.0" technology?**

**Purkarthofer:** In the service business digitalization will act as an enabler in the short to medium term, yet in the long run, it will transform our whole business. It will affect all parts of our organization and activities in a positive way. There is enormous potential in connecting the digital and physical service worlds. All of the traditional services we offer today, like maintenance and repair, spare-part supply and management, training and consulting will be affected and can be taken to a next level of service quality through digitalization. Furthermore, the availability and analysis of data will open up new service business models and new ways of partnering with our customers. We are very active in this field and already offer a number of applications, such as for predictive maintenance, all based on advanced analytics and modeling. Here we can optimize maintenance planning and reduce the cost of unscheduled shutdowns. Every dollar we can save per ton of produced metal by better managing the customer's assets will have a huge impact on their bottom line. Generally, the field of future IT-driven applications is infinite. It is important not to target the all-in-one solution, but to focus more on creating small applications that can be easily implemented and provide immediate benefits for our customers.

With our deep technology, process, automation and maintenance know-how, we have the perfect ingredients necessary to excel in those developments. Therefore, we are speeding up our transformation efforts to match the pace of IT and sensor technology. For this again, partnerships are very important, specifically because IT in the past has not been the focus of traditional plant or machine builders or technology providers. Therefore, we are thinking out of the box and embracing open innovation practices. For example, with our Business Factory program, we are linking our company with IT start-ups to benefit from the developments and the momentum in this field.

**What portion of metallurgical services do you think might be conducted remotely, say in ten years' time?**

**Purkarthofer:** We think that in time there will be a step-by-step shift from on-site-driven to remote-driven services. The speed of this shift will depend on the availability of technology and the related switching cost. In the future,

robotic solutions and automated component-exchange systems will be remotely controlled to fulfill maintenance-related tasks. Artificial intelligence and machine learning will play a major role here. There are already self-learning robots that can sort waste materials and scrap. Can you imagine the impact that this will have on production flexibility? Also, remotely provided maintenance assistance systems that use augmented reality and mobile devices will further optimize routine activities and provide different types of recommendations. Additive-manufacturing technology will allow specific spare parts to be supplied on demand and just in time to the required site. All such activities will eventually be controlled from a centralized remote operation and maintenance center.

**In which regions do you expect the service business to grow and in what ways?**

**Purkarthofer:** In talking with customers, we see that there is potential for the service business across all regions. Just as the maturity stage of the service markets is different in different parts of the world, the service approach must also be different. For example: North America has been a service-driven market for decades. In comparison, the emerging nations – especially in Asia – are just on the verge of entering into a service-driven



## PUSHING SERVICE TO THE NEXT LEVEL OF QUALITY

Karl Purkarthofer is Senior Vice President and Head of Metallurgical Services at Primetals Technologies. He holds a master's degree [Dipl.-Ing.] in mechanical engineering and economics from the University of Technology in Graz and an executive MBA from IE [Instituto de Empresa] in Madrid. After completing his university education, Purkarthofer joined Voest-Alpine Industrieanlagenbau (VAI, a predecessor company of Primetals Technologies) – in 1993. He served in managerial positions in different countries and company areas, including steelmaking, environmental technologies, rolling and processing, before heading the company's strategy department and joint-venture integration.



**“ We are creating win-win situations with our customers and – most importantly – long-lasting personal relationships.”**

Karl Purkarthofer

society, which opens the door to a huge future potential for industrial services. A lot of high-end technology has been installed during the last decade, which now – together with a strong demand for productivity and the necessity to differentiate with high-quality products – also makes quality maintenance and know-how services essential. With our technology, process and maintenance know-how, we are supporting our customers to produce better quality and become more cost efficient at the same time.

**In these days of hackers and malicious software, don't you think that customers might be extremely cautious about allowing an external service provider to remotely access sophisticated plant and process software systems?**

**Purkarthofer:** Data security is a big topic in the world of digitalization. A lot of progress has been made in the meantime to guarantee data protection. Here, the consumer industry is paving the way for the industrial world. In the Facebook society, data protection is imperative and it drives technological progress and regulatory necessities. The industry sector is learning from these developments. However, it should also be mentioned that in the service field we are not always talking about highly sensitive production, quality or process data. And, at the end of the day, it's always the customer who decides what data and in which way to make it accessible. Partnership and trust also play a major role here.

**What has been the experience of Primetals Technologies in the past in connection with performance-based service models with no upfront cost? Do you think that this type of service business model will expand in the future?**

**Purkarthofer:** Our experience with such models has been excellent. We have been providing performance-based service models quite successfully to certain customers for over 20 years. More than ever, the steel industry is driven by cost competitiveness, so everything that can be shifted to opex-driven models is a favorable way for customers to do business. So we expect these and other new types of service models – especially those driven by digitalization – to increase in the future.

**Most producers have been in the market for decades and they know their plant and its idiosyncrasies better than anyone else. Why do you think a service provider can offer better solutions than the producers themselves?**

**Purkarthofer:** Because as an integrated technology and service provider with deep process know-how, we will always be at the forefront of innovation – and so will our customers when they have a service partnership with us. Besides this, over the years we have developed service-related technologies, practices and know-how to help our customers to improve the lifetime and performance of their plants. Furthermore, we are tapping into the expertise of our 1,800 service specialists and sharing best practices across our service centers, which all members in our global network can ultimately benefit from. So we are talking here again about globally networked and optimized services. Based on all of this, we are creating win-win situations with our customers and – most importantly – long-lasting personal relationships, which, despite all future achievements through digitalization, will remain as the ultimate gauge of a successful service organization. ●

# BRILLIANT MIND

# BRILLIANT SOLUTIONS

## INTERVIEW WITH DR. GERALD HOHENBICHLER, PRINCIPAL SENIOR EXPERT IN CASTING & ROLLING, AND GLOBAL HEAD OF INNOVATION FOR METALLURGICAL SERVICES

Dr. Gerald Hohenbichler, with an academic education in physics and engineering, is arguably the most prolific inventor at Primetals Technologies. He has spearheaded a myriad of groundbreaking technological novelties, and was honored as “Inventor of the Year” at Siemens in 2008. In this insightful interview with Dr. Thomas Widter, Deputy Managing Editor of Metals Magazine, Hohenbichler partially reveals the source of his creativity and hints at why he has a positive outlook for the future of the steel industry.

**I was told that you have fathered or co-fathered some 300 patents and have submitted over 50 first patent applications at Primetals Technologies and its predecessor companies. What, in your opinion, was the most economically successful innovation for the company and which one are you most proud of?**

**Dr. Gerald Hohenbichler:** My most successful innovations are the ones contributing to the various endless casting and rolling technologies, from twin-roll strip casting, to Arvedi ESP, up to WinLink. Here, the great achievement was finding the right core processes and components that would allow an endless production process to become a reality. The key problems were related to quality stability de-bottlenecking and ensuring uninterrupted availability of the plant. In fully endless production, if any given element in the production chain fails, it stops the entire line. So we had to ensure 100% process robustness and reliable operation. Five Arvedi ESP lines were ordered by Rizhao Steel in China, and recently we were awarded a WinLink plant project by GPH [GPH Ispat Ltd.] in Bangladesh.

As for the innovation that I am the most proud of, the most interesting game changer was the Dynacs cooling system. It vastly improved continuous casting, because it – for first time – enabled us to dynamically control and stabilize the secondary cooling process. This significantly enhanced the consistency of the final product and made

us the frontrunners in the field of continuous casting. To date, we have sold Dynacs more than 300 times as an integral part of a new continuous casting machine or as a key technological package in an upgrading project.

**In your experience, are most of your ideas and innovations the product of a persistent systematic approach, or are they more of a serendipitous or accidental result?**

**Hohenbichler:** In fact, it's quite a systematic approach. That does not mean that inventions come about automatically if you simply follow certain rules. There is no “recipe.” But generally, it is essential to ask the right questions and to stay curious, particularly if the answers you are given are contradictory. In the beginning, the

**“ I think that creativity is strongly connected to curiosity and can only partly be trained.”**

Dr. Gerald Hohenbichler



most important thing is to “hear the challenge,” to listen out for what’s really at the core of the problem.

**Do your ideas arise when you have to deal with finding a solution to a specific problem, or do they mostly come “out of the blue?”**

**Hohenbichler:** Normally, good ideas just never come out of the blue [smiles]. However, it has happened to me a number of times, for example, with a ChatterBlock patent as well as in connection with the development of an automatic fault-detection system. In this case, I was suddenly struck by an idea that did not fit into the environment I was in at the time, but it was a potential solution to a problem I was working on elsewhere.

**In your view, is creativity something that a person is born with, is it something that can be fostered with proper training and education, or is it mostly a product of synergy when working together with other people?**

**Hohenbichler:** I think that creativity is strongly connected to curiosity and can only partly be trained. It is a talent you are born with, but for it to blossom, it also requires sufficient support from your family when growing up as well as from the society you live in. One is not always rewarded for creative ideas. New ideas are sometimes viewed as crazy and are suppressed, even though they could be very useful. It is only when you find yourself in

a creativity-prone environment and are inspired by others that new ideas can be brought to fruition – for example, in the form of a team patent and innovation.

**Do you see a correlation between intelligence and creativity?**

**Hohenbichler:** I do not believe in such a correlation. There is creativity with no intelligence and vice versa. Intelligence and creativity are two important pillars for generating patents and innovation, but it’s by far not all that’s required – at least in metals technologies.

**Is there any place where you personally have found that new ideas come to you particularly easily? Some people have named, for example, the shower as such a place – so-called “bathroom inspiration.” Others say their car. What’s yours?**

**Hohenbichler:** I found that I’m the guy who usually gets interesting ideas or solutions in the morning, in dreams, or when getting up. I am not sure if it’s when I’m half-dreaming or half-awake. But I have found it useful over the years to have a notepad next to my bed.

**Do you think someone can be an outstanding creative person and a successful manager at the same time?**

**Hohenbichler:** Yes, I am convinced this is possible, because the required set of skills broadly overlaps. For instance, two core qualities that define creativity »

## PASSION FOR INNOVATION

Dr. Gerald Hohenbichler has been with Primetals Technologies and its predecessor companies since 1992. He holds a PhD in physics and a master's degree in mechanical engineering, both from the Technical University of Vienna. At Primetals Technologies, he has served as a continuous casting technologist, as Head of R&D for Rolling and Processing, and as Head of Technology Development for Arvedi ESP. Today he is the Principal Senior Expert in Casting & Rolling. Hohenbichler has some 50 first patent applications to his name, which led to 300 patents worldwide. When he's not on one of his extensive business trips, Dr. Hohenbichler lives and works in Linz, Austria.

are divergent thinking, which is thinking beyond normal boundaries, and cognitive flexibility, which is the capacity to restructure ideas and see connections that others miss. Hence, you may go beyond what is safe and familiar, even if it may damage your reputation. It's important that you draw the line between these roles when you're involved with both, and you always have to find the right place and the right time to do each of these functions well.

**Is there a particular inventor or scientist from the past that you particularly admire or who has been an inspiration for you?**

**Hohenbichler:** Thomas Alva Edison! Because he was not only a great inventor, but was also capable of implementing his ideas on a very large scale. He was able to attract sufficient attention from politicians and other investors to, for example, fund his laboratories. One could say that Edison got his innovations "to the market" resourcefully and successfully.

**When you look at the iron and steel business today, is there any area where you feel that more creativity should be applied in the future?**

**Hohenbichler:** This is what we are trying to do right now in our Metallurgical Services area. We are seeing a great opportunity to make use of our accumulated know-how by connecting it to new enabling technologies, which have come onstream over the last decade. This will widen our field of competence, create new business models, and enlarge the portfolio of eServices [electronic services] that Primetals Technologies will be able to offer.

**In which process steps of the iron and steel production chain are groundbreaking developments and solutions especially crucial?**

**Hohenbichler:** Due to mature markets and technologies, groundbreaking developments are crucial everywhere. However, the chance for inventions to be successful is

usually higher at the moment when you have something in the pipeline that could be a game changer in the downstream area, particularly where Primetals Technologies is very strong thanks to the backing of Siemens and Mitsubishi with certain core technologies. This is a consequence of the current market-pull situation and the existing overcapacity in the steel industry.

**What innovations or technical solutions are you working on now that stand out from the rest?**

**Hohenbichler:** Actually, we are working on a concept that had already been launched several years back, but was not successful enough due to a lack of enabling technologies at that time. We are now relaunching it under different circumstances. I can't give away too much information here, but I would say the key term for this endeavor is big data.

**The steel industry has been through a number of rough years. What does your crystal ball tell you? Do you think the situation might change for the better anytime soon?**

**Hohenbichler:** My crystal ball tells me that a big surprise for the steel industry will be coming up during the next two to three years. It will be a positive change for the steel economy. But it will not be intrinsic to the steel industry; it will come from the outside.

**In what ways has the innovation potential at Primetals Technologies increased as a result of the merger between Mitsubishi-Hitachi Metals Machinery and Siemens VAI in January 2015?**

**Hohenbichler:** The overall innovation potential definitely got a tremendous boost because of the merger. The diversity within the company increased, and very different perspectives and working styles were brought together. This vast agglomeration of diversity is really fueling creativity. ●



**“ My crystal ball tells me that a big surprise for the steel industry will be coming up during the next two to three years. It will be a positive change, and it will be coming from outside the industry.”**

Dr. Gerald Hohenbichler, Primetals Technologies

# THE FABRIC OF LIFE

## INTERVIEW WITH CARL DE MARÉ, VICE PRESIDENT AND HEAD OF TECHNOLOGY STRATEGY AT ARCELORMITTAL

Despite his busy schedule as Head of Technology Strategy at ArcelorMittal, the world's largest steel producer,\* Carl De Maré took the time to conduct a Skype interview on March 16 with Primetals Technologies' Bernard Cléré (Key Account Manager for ArcelorMittal), Hélène Bulteau (Marketing Manager) and Emile Fatticci (Sales Director for Cold Band Division). De Maré addressed some of the key challenges and requirements of the steel industry today, and presented a clear view of his vision for the future of steel.

### What do you see as the main challenges facing the steel industry at the present time?

In the last 15 years the steel industry has developed in an incredibly fast way. With production output expanding so fast, actions have to be taken to correct overcapacity. As an industry, we must ensure that solutions are found to address this issue for the long term. A key part of the answer lies with Chinese reform, given that the country accounts for the majority of global overcapacity. China recently stated its intention to cut its production by 100-150 million tons. This will clearly take time, so while we remain cautious as further details emerge, politically the intent seems very serious and is driven from the top. For ArcelorMittal, the biggest challenge lies in the fact that those corrective actions are not being taken on a level playing field for everybody. Until the issue of overcapacity is addressed, effective trade defense instruments are needed to ensure a level playing field to correct unfair practices. This is the precondition to develop and invest further.

### Recent commentaries have highlighted a paradox: steel is the most useful man-made material, but it is poor business for most of those making it. What can the steel industry do to collectively ensure its future prosperity?

That is a very good question. Steel is so present in our lives that we take it for granted. But without steel, modern life is not possible. One challenge of the global steel sector is to remind everyone of the importance of steel. This is the essence of ArcelorMittal's slogan "The fabric of life." A second challenge concerns the value of steel. The difference between the value of the steel in end products and the value reflected in steel prices creates an enormous opportunity. The modest percentage of steelmaking to the GDP [gross domestic product] of the countries is not reflecting the real economic contribution toward the local manufacturing industry. We need to keep explaining this to policymakers. »



Harmony of the Seas – dubbed “Europe’s biggest hotel” – was launched on its inaugural voyage to Rotterdam on May 22, 2016. ArcelorMittal sites in Spain and France provided 100% of the steel used in this 362 m long, 65 m wide floating city – the largest cruise ship ever built. (Courtesy of ArcelorMittal)

“Steel is very competitive. You can use it practically everywhere. I don’t see a threat in substitution as such.”

Carl De Maré



## CARL DE MARÉ, VICE PRESIDENT OF ARCELORMITTAL

Carl De Maré graduated from Ghent University in 1985 with a master’s degree in civil engineering in the specialized area of electro-mechanical engineering. He joined ArcelorMittal in September 1988 and first worked at the company’s Ghent site in Belgium where he was active in IT development, a research center for steel applications, and in quality control in the finishing area. From 2002 to 2006, he served as General Manager of the steel plant of ArcelorMittal Ghent. In late 2006 he rose to the segment level of ArcelorMittal and was first responsible for continuous improvement at Flat Europe (now ArcelorMittal Europe’s Flat Products division). In May 2008, De Maré was promoted to the position of Vice President of ArcelorMittal and CTO of the company’s Flat Carbon Europe division. Here he was in charge of technology, strategy, innovation and continuous improvement. Since 2014, De Maré has served as Vice President of ArcelorMittal and as Head of Technology Strategy. In this function he also leads the company’s global program of Low Impact Steel technologies.

### How will the processes and equipment of a typical steel plant of 2050 differ from today?

In 2050, the world will be more developed, with more materials and more waste products. We will have to recycle more. How can we adapt our current production processes to use more recycled steel? We need to go even further: how can we recycle plastics and other wastes to make new steel products? Today, large integrated steel plants already produce a lot of energy from carbon recovered from blast furnaces. With more electricity being generated from renewable sources of energy, we as steel-makers also need to look for solutions that use renewable power and do something different with our waste carbon. This is why we have developed a partnership with LanzaTech and Primetals Technologies to build a first-of-its-kind LanzaTech industrial demonstration plant that will create bioethanol from waste gases produced during the steel-making process [see article box]. It will be a challenge to integrate all aspects in our ecosystem, and to contribute more to developing an energy- and resource-efficient solution for the economy.

### Do you see any dramatic breakthrough technologies coming up in the next few decades from the environmental side or from other fields?

One area concerns adding value to our waste products. The answers may not exist yet, but many new solutions in R&D labs might be interesting for the steel industry. A second area is digitalization. Many sectors have a more decentralized production model with a dramatically



shortened supply chain. Manufacturers can practically produce small batches just in time for end users. This model is increasingly being applied in material manufacturing together with technologies such as 3-D printing.

**From which sectors does steel face a substitution threat and what needs to be done for steel to remain competitive and the material of choice for downstream manufacturers?**

Steel is very competitive. You can use it practically everywhere. I don't see a threat in substitution as such. With the world population expected to approach nine billion people by 2050, we will need so much material that we should teach people to make the right material selection and not to use materials for the wrong purpose. A typical example is the automotive sector driven by the policy to reduce CO<sub>2</sub> tailpipe emissions.

This policy does not take into account CO<sub>2</sub> emissions during the production phase: materials such as aluminum and carbon fiber require more energy during production, making their overall CO<sub>2</sub> emissions per ton higher than steel. Thus, we promote the use of lifecycle analyses when choosing a particular material. What are the emissions for making the product? What will be the emissions when using it? How can it be recycled afterwards? If it seems that other materials are better than steel, that's fine. We are, however, convinced that steel's infinite recyclability means that people will use it even more. The important thing is to make the right choice when selecting a material.

**What do you see as the main areas where further research and development is necessary?**

We will always try to further optimize operational costs. We need to move to higher-strength steels, which also means thinner steels. How can we increase the productivity of processing lines to reduce costs and also be less capital intensive? With higher-strength steels, we can reduce the thickness of steels by 25%. With no new solutions, this means a 25% productivity loss. We also need to improve line-speed limitations for flat and long products.

A second area where research is needed is product customization and simplification of the supply chain – especially for a mass-production sector such as steel. The intention is always to make more steel, faster and in larger batches. Yet at the same time, customers are asking for more customized products. My question to the technology providers is: How can you merge these two contradictory objectives?

**How should the global steel industry be addressing the problem of emissions, especially with consideration to the Kyoto 2050 deadline?**

It's a complex question. First, we should definitely not address it by displacing production from one region to another. The sustainability of steel should not only consider today's emissions but also the long-term possibility that steel can become a fully circular commodity – with all new steel products made from steel scrap. »



## THE LANZATECH BIOFERMENTATION PROJECT AT ARCELORMITTAL'S GHENT STEEL WORKS

ArcelorMittal, LanzaTech and Primetals Technologies have entered into a partnership to construct Europe's first-ever commercial-scale production facility to create bioethanol from waste gases produced during steelmaking. Construction of the flagship plant, which is located at ArcelorMittal's steel plant in Ghent, Belgium, has already commenced. The process will make use of a technology developed by LanzaTech, whereby gasses released during metallurgical reactions are fermented by microbes that secrete ethanol. The generated bioethanol will predominantly be used in gasoline blending, but it can also be further processed for blending with jet fuel. In this way, greenhouse gas emissions can be cut by over 80% compared with the combustion of conventional fossil fuels.

"This partnership is an example of how we are looking at all potential opportunities to reduce CO<sub>2</sub> emissions and support a transition to a lower-carbon economy," says Carl De Maré. "Steel is produced through a chemical process that results in high levels of waste gases being emitted. This new technology will enable us to convert some of these waste gases into fuels that deliver significant environmental benefits when compared to conventional fossil fuels. It is a further example of why our carbon footprint should be viewed on a lifecycle analysis basis, given that steel is 100% recyclable."

For more information, please see <http://www.steelanol.eu>.

Secondly, we are convinced that the use of carbon is the most efficient way to make steel from iron, and that blast furnace technology is the most efficient solution in terms of CO<sub>2</sub> emissions. Will technologies such as LanzaTech that we are currently exploring be a solution to recycle carbon? Finally, the steel sector needs to merge its efforts with other sectors, since we will not be able to address this problem alone.

### How do you see future changes in the geography of global steel manufacture and applied technological processes?

We have learned from the past that steel should be produced in collaboration with customers and end users. It does not make sense for one region to produce steel for the rest of the world. Each region should have its own manufacturing industry and work in close cooperation with local steel producers. We also believe that considering the development still needed in some regions, it is better to go step by step and start with small-scale operations. For example, for countries that still need to create their own steel industry, steel production based on recycled steel and electric arc furnaces offers an attractive option. These countries can apply energy-efficient and small-scale technologies such as minimill technology that would allow them to start their own business using scrap from developed regions. Once they are more developed, they can build larger integrated sites with production based on iron ore. That is how we believe the transition can be made.

### What new sets of skills will be required from employees in the metals industry in the future?

Today, operators need to be trained and should have broad skills in many areas to make the right decisions during production, to quickly address problems and to guide maintenance strategies. A logical evolution is to continuously train our employees so that they have a more multidisciplinary background and can oversee the complexity of all technologies integrated within a single production step. This requires continuous effort.

### All in all, are you optimistic or pessimistic about the future of the metals business?

I would not try to push new emerging technologies if I were not an optimist! If you look back at the last two hundred years, the success of steel and metals is huge. There is no reason why it should not continue. It's a bit of survival of the fittest. Why is one material used so extensively while others are not? – because metals best suit our needs. But we should really come back to the first question for an optimistic future. Companies need to continuously invest in research, new technologies and new installations – and this can only be done in a framework where we have a stable legal policy and a level playing field so that competition can take place fairly. ●

\*In 2015, ArcelorMittal's crude steel production was 92.5 million tons.

# A BRIGHT FUTURE AHEAD

## INTERVIEW WITH FRANZ ROTTER, VOESTALPINE EDELSTAHL GMBH, ON THE FUTURE OF SPECIAL STEELS

Special steels manufactured at voestalpine Edelstahl GmbH meet the unique requirements of a wide range of demanding industrial applications. The high-performance metals are sold globally and find use in the aviation, oil & gas, tool-construction and consumer-goods industries, in addition to the energy, chemical and medical sectors. But what does the future hold for special steels? Franz Rotter, Chairman of the Management Board of voestalpine Edelstahl GmbH and Member of the Management Board of voestalpine AG, answers this question and addresses other topics in the following interview.

### What do you see as the main challenges currently facing the special steel industry?

**Franz Rotter:** The increasing volatility of the markets calls for a significant improvement in the flexibility of processes along the entire value-added chain right up to the customer. Ever-tougher competition across all sectors of the industry means that the cost position has to be continually optimized. Secondly, every aspect of operational excellence – in terms of both product and process quality – needs to be significantly improved.

In the case of the Special Steel Division of voestalpine, we are striving to further consolidate our global market leadership in tool steel. We are also building on our superiority in the field of special materials for high-tech niche areas such as aviation, oil & gas exploration, and other technology-driven sectors. We are able to do that because of the total commitment of our employees to improve our processes and increase efficiency. We also rely on special programs such as Lean Management, CIP [continuous improvement process] and other initiatives to achieve this.

### What type of solutions or developments would additionally support you to meet these challenges?

**Rotter:** As far as we're concerned, innovations in the process stability of production technologies and the implementation of conceptual solutions from the Industry 4.0 arena are essential. Digitalization at all process stages is already reality and will continue to be absolutely critical. The human factor is obviously also important, such as the

highly qualified, skilled specialist that represents the interface between IT and machines.

### Do you see any dramatic breakthrough technologies coming up in the next few decades?

**Rotter:** On the one hand, I see various technologies that enable continuous processes and process integration. On the other hand, I would like to mention additive manufacturing – or 3-D printing – with metal powder as an example of a disruptive development in manufacturing technology. This allows prefabricated components with the most complex geometric shapes to be produced. It's still too early to say exactly what the implications of this development will be in terms of market logic. This is why it is so important for the Special Steel Division to play a leading role in shaping this area. At our sites in Austria, Sweden and Germany, we are working on both the development of metal powder for this process and on component manufacturing. This innovation is currently at the market-entry stage. The fact is that the strengths of these technologies can only be demonstrated when component design changes result in a genuine benefit for the customer, which requires a full understanding of the customer's application know-how.

### From which sectors does special steel face a substitution threat, and what needs to be done for steel to remain competitive and the material of choice for downstream manufacturers?

**Rotter:** I strongly believe that also in the future, steel-based technological innovations will continue to be the cornerstone of virtually every technological challenge. »

“Because the substitution of special steels is not possible, the long-term demand for steel and special steel can be seen as assured. Steel is the ideal product for many technologies and has considerable potential for development.”

That applies to both mobility systems and energy generation, and particularly to environmental technology. The greatest difficulty in implementing these innovation steps might be the disparity in timing between politically motivated regulations and technological developments.

## FRANZ ROTTER

Franz Rotter studied mechanical engineering at the University of Leoben in Austria. Between 1981 and 2006 he held senior positions at voestalpine Group, Iso-Holding AG, Austria Antriebstechnik AG and AMAG Group. In 2007 he was appointed as a Member of the Management Board at Bohler-Uddeholm AG, which became voestalpine Edelstahl GmbH in January 2011. Since then, Rotter has served as the Chairman of voestalpine Edelstahl GmbH and also as a Member of the Management Board of voestalpine AG.

## What new product applications for metals can be expected to emerge by 2050?

**Rotter:** That's a difficult question, because the answer lies in knowing the technological prospects of the "back markets" of individual industrial sectors. In the special steel sector, the potential at the product level for new composite materials, for example in powder metallurgy, is huge. But developments in manufacturing processes are also starting to exhibit both evolutionary as well as disruptive aspects. Examples here include again additive manufacturing processes or the further development of classic process technologies in conjunction with digitalization.

## What do you see as the main areas where further research and development is necessary for improving production operations, costs and market opportunities of the metals business?

**Rotter:** The careful use of resources, process automation, digitalization along the entire value-added chain and overall operational excellence are the main areas of innovation in terms of creating added value.



**What impact does the Kyoto 2050 deadline, which specifies a reduction of specific greenhouse gas emissions by 50% compared to 2005 levels, have on special steel production?**

**Rotter:** The production of special steel in the electric arc furnace is actually a very CO<sub>2</sub>-lean process. But apart from that, we obviously strive, wherever we can, to be as environmentally and resource-conscious as possible. One example of our efforts to further reduce the use of natural gas and to lower CO<sub>2</sub> emissions at our own production facilities is the replacement of old burner systems in the heat-treatment and reheating furnaces with more modern burner technologies. But our commitment is reflected not just in our environmental efforts and the subsequent reduction in process-related emissions; it also covers innovations in recycling, new technologies for replacing fossil fuels and reducing agents, the area of energy as mentioned earlier and, last but not least, transparent and efficient environmental management.

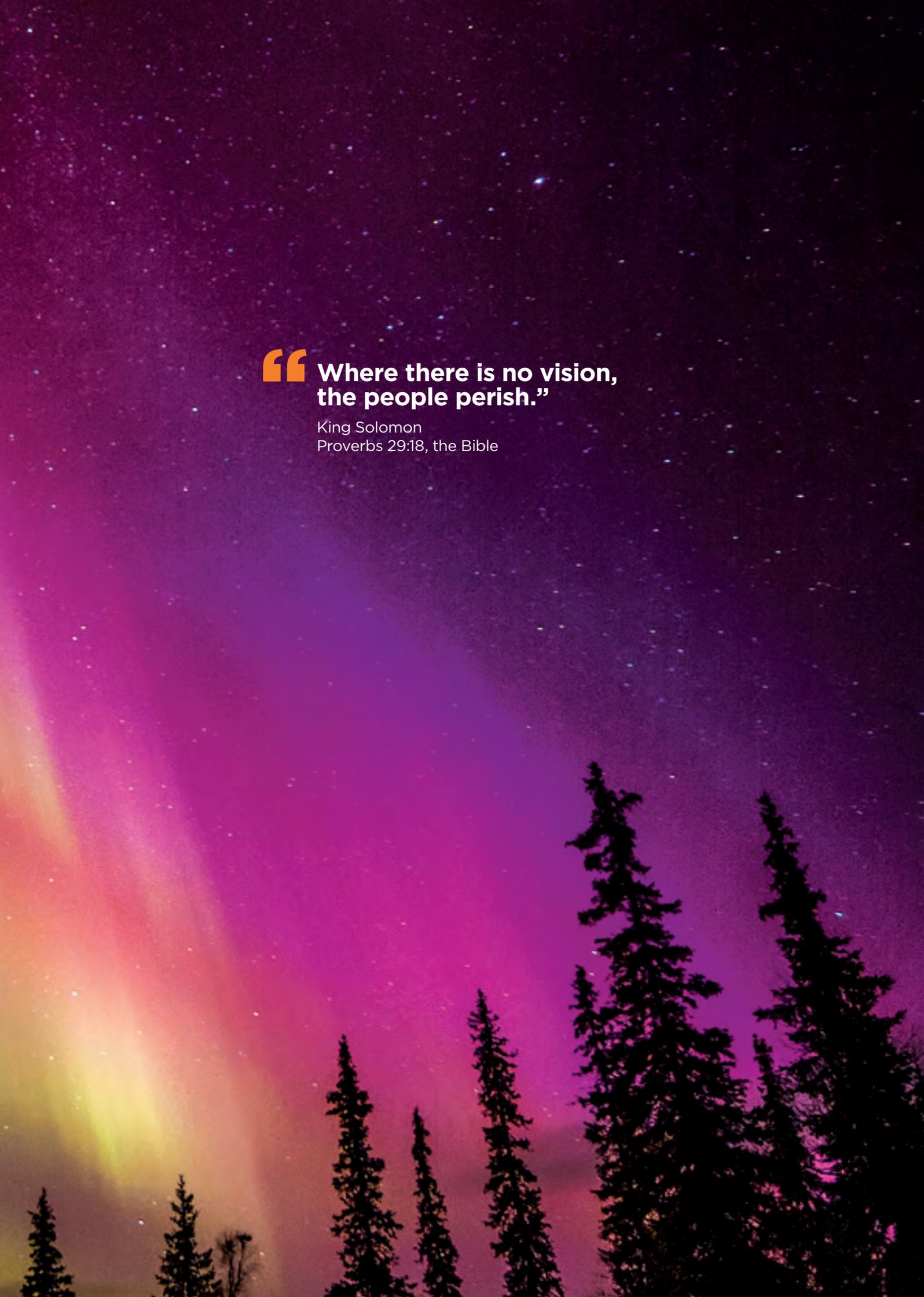
**You already mentioned the importance of the human factor. What new sets of skills will be required from employees in the metals industry in the future?**

**Rotter:** The classic heavy labor that you often see in movies is a thing of the past. We're seeing a shift from the more traditional manual labor toward the greater use of technologies. Employees are becoming "high-tech process supervisors." They sit in control rooms that resemble an aircraft cockpit. The jobs involved require highly qualified, skilled people.

**All in all, are you optimistic or pessimistic about the future of the metals business?**

**Rotter:** Because the substitution of special steels is not possible, the long-term demand for steel and special steel can be seen as assured. Steel is the ideal product for many technologies and has considerable potential for development. Its broad range of applications ensures its marketability. We, as the Special Steel Division of voestalpine, focus on technological niches in global markets where the customer's exacting requirements are aligned with our own strengths. This is a strategy that relies on years, if not decades, of groundwork as well as on extensive and permanent innovation. ●





**“ Where there is no vision,  
the people perish.”**

King Solomon  
Proverbs 29:18, the Bible

# THE FUTURE VIEW

## FROM NORTH AMERICA

### STEEL'S LONG-TERM FUTURE IS BURNISHED AND BRIGHT

With current markets presenting so many challenges, it can be difficult to imagine any future for the steel industry. But a steel industry consultant, the leader of a global steel organization and a trade policy expert for a North American industry group all agree that once the steel markets cycle through the current crisis of overcapacity and sinking prices, the industry's future remains bright.

"For the near term, the number-one concern is global overcapacity," says Adam Parr, Vice President for Policy and Communications for the Steel Manufacturers Association. In a late March 2016 conversation, he points to an estimated gap of more than 700 million metric tons between global capacity and demand for steel. "We will not be able to grow our way out of this problem," he says. Despite facing some of the most challenging economic conditions in the industry's history, he notes: "Several U.S. producers remain profitable largely through productivity, efficiency, consolidation and control of variable costs. Utilization rates in the 70% range threaten investments and are not sustainable in the long-term."

Ron Ashburn, Executive Director for the Association for Iron & Steel Technology, explains, "While some regional capacity utilization rates have fallen into the lower 60% range, steel producers generally need to operate at 85% of capacity to see a return on their cost of capital. Companies can't sustain a deficit operation, only governments have this entitlement."

"And the government of China, the world's largest steel producer and exporter, has to find the trigger they find acceptable to allow the natural reshaping for the industry to take place," says James Moss, steel industry strategy

consultant and partner in First River Consulting. "The inevitable restructuring will require dramatic capacity reductions and closures. Once the government's path is clear, then the rest of the world can plan appropriately."

Adds Ashburn, "Making steel keeps people employed, but you can't export an unemployment dilemma by dumping excess production. Governments everywhere have to decide whether or not manufacturing is important for GDP [gross domestic product] growth and regional economic stability. If the answer is yes, then the regulatory bodies need to rigorously enforce and defend fair trade laws."

#### RESPONDING WITH TECHNOLOGY

"A big part of the solution for U.S. steel producers is technology," says Ashburn, "because of the market advantages it yields. Companies that use technology to address energy efficiency, environmental stewardship, employee safety and financial profitability will be in a much better position than those who do not."

Moss sees new cokeless technologies as a way to meet current challenges. Parr finds encouragement in the growth of the electric arc furnace (EAF) industry's share of U.S. steel production - now about 63% - and the »



Ron Ashburn, Executive  
Director for the Association for  
Iron & Steel Technology

**“ Making steel keeps people employed, but you can’t export an unemployment dilemma by dumping excess production.”**

Ron Ashburn

industry's commitment to research and development, "with major initiatives underway at both integrated producers and greenfield EAF facilities." Other anticipated positives for Parr are advances in the development and use of advanced high-strength steels (AHSS) and the use of ore-based metallics as scrap supplements. "Steel producers are recognizing the necessity to reinvest in their processes to develop new products," says Ashburn. "In North America, we've had a robust automotive sector for the past several years, and producers are aggressively evolving unique steel attributes to remain a strong partner for this market."

### MILLS OF THE FUTURE

Experts agree that the evolution of steel production will continue apace. "A typical steel plant in the year 2050 will not be completely remade, but will be cleaner, faster, better controlled and more continuous," says Moss. "We will have new melting technologies, new forms of raw materials and new energy sources."

"At some point," says Ashburn, "steel plants will be fully energy self-sufficient. To achieve this, the industry needs to figure out how to make cogeneration and even regeneration the norm for steel plant operations, tapping waste heat to produce steam-generated electricity, and converting captured heat directly into electrical energy. Looking further ahead, new process technologies could include microwaves, electron beams and laser-induced plasma,"

he says. "These are highly efficient sources of heat with minimal residual energy loss, but they are not yet economical for melting steel on a production scale. Technologies that capture and recycle heat energy are just the beginning." Ashburn expects breakthrough technologies in smart automation, advanced sensors and robotics to play major industry roles in the next few decades. "Advancements in networks and artificial intelligence will continue to evolve, enabling steel producers to eventually have 100% condition monitoring for all their processes."

Parr predicts that steelmakers will embrace technology and the Internet to bring themselves closer to their customers, optimize production, and encourage the exchange of information in real time. "Technology," adds Ashburn, "can be deployed for dramatic improvements in product yield. Part of the evolution of alloy development, technology will enable the industry to design and manipulate the microstructure of steel in unique ways for a variety of customer requirements – already possible to a degree through thermomechanical rolling processes."

### MARKETS OF THE FUTURE

Steel producers will continue to seek new ways to customize steel properties for customer demand, and Ashburn predicts that applications of 3-D printing present a new frontier in the evolution of the steelmaking process for new applications that can only now be imagined.



**“For the near term, the number-one concern is global overcapacity. We will not be able to grow our way out of this problem.”**

Adam Parr

Adam Parr, Vice President for Policy and Communications for the Steel Manufacturers Association

“A typical steel plant in the year 2050 will not be completely remade, but will be cleaner, faster, better controlled and more continuous.”

James Moss

James Moss, steel industry strategy consultant and partner in First River Consulting



Disaster-resistant building materials also offer new market opportunities. “I expect to see an increase in the use of steel products for resilient building applications,” says Parr, “particularly in disaster-prone areas. Modest upfront investments have the potential to yield significant benefits in terms of safety and damage mitigation.”

#### ENVIRONMENTAL REQUIREMENTS OF THE FUTURE

Responding to increasing environmental regulations will also generate new approaches to meeting market demands, including the adoption of more locally produced steel to reduce the impact of transportation. “Smaller facilities – minimills and micromills – can produce less than 500,000 tons annually and still be profitable,” says Ashburn.

With environmental restrictions and possible carbon trading on the horizon, Moss says, “Hitherto hidden costs to the integrated steel economic calculations will become more obvious and force a broader transition away from integrated steel production to EAF-based melting. This will be the most difficult transition to be made by a single company anywhere in the steel industry.”

#### PREPARING FUTURE GENERATIONS

What will be the skills required to support this brave new world? Computer skills and communications savvy

developed through greater global investment – not just in production equipment but in engineering, science, math and technology education from the earliest grades. “As steelmaking is a high-tech job,” notes Parr, “future steelmakers need to have mechanical aptitudes, be comfortable with computers, and have customer-focused mindsets.” Adds Moss: “IT will be part of every aspect of the business, in addition to the traditional knowledge sets.” This will be a natural fit for future generations, says Ashburn. “Children today are rooted in technology, and are well on their way to obtaining the technology background needed to be successful in the steel industry of the future.”

Future prospects for the metals business are positive, agree Moss, Parr and Ashburn. “The U.S. EAF steel industry,” says Parr, “is characterized by entrepreneurship, flexibility and efficiency, and has demonstrated its ability to survive and even grow.” For Moss, steel is essential to modern life and vital to the world we’re about to build. “Because of steel’s inherent qualities,” says Ashburn, “I have unbridled enthusiasm for the future of the industry because steel represents the foundation for innovating and building products that serve humanity.” ●

Allison Chisolm, Freelance editor

Tom Suski, Communications, Primetals Technologies USA

# THE VIEW FROM CHINA

## ON THE FUTURE OF METALS

**INTERVIEW WITH LI XINCHUANG, PRESIDENT  
OF CHINA METALLURGICAL INDUSTRY PLANNING  
AND RESEARCH INSTITUTE**

Worldwide, the steel industry is facing overcapacity and increasing environmental restraints. At the same time, steel is losing its leadership role to alternative materials for many applications. In the following interview, Li Xinchuang, President of China Metallurgical Industry Planning and Research Institute, discusses these issues and outlines solutions on how to meet the challenges plaguing the industry. A central theme is the importance of innovation.

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**What do you see as the main challenges facing the steel industry at the present time?**

**Li Xinchuang:** The major challenges that the global steel industry is facing are severe overcapacity and the need to develop new applications for steel. However, it must be stated that overcapacity in steel production is a common issue worldwide, and it requires joint efforts by the main steel-producing countries. This is not an issue only in China, and it is also not caused by Chinese steel exports. The main reason for overcapacity is that, ever since the financial crisis, economic growth has slowed in many countries and steel demand has greatly dropped world-

wide due to fewer infrastructure projects, industrial construction and reduced consumer consumption. To illustrate this, in 2015, for example, the global average capacity-utilization rate was 69.7% and 71.5% in China. This utilization rate has been continually dropping during the past years. This is the key reason why the international steel market is faced with a tough situation.

**What type of solutions or developments would be necessary in order to meet these challenges?**

**Li Xinchuang:** Sustained efforts have to be made on both the supply and demand sides in order to reduce



“ By 2050, more than 30% of steel manufactured in China will be via the EAF route.”

overcapacity and develop new steel applications. The efforts on the supply side have to focus on improvements in both quality and profitability. Qualitative improvements provide the basis for increased demand. On the demand side, the focus needs to be placed on exploring new market opportunities and developing new applications to attract customers. This expands the market and supports the efforts on the supply side. The supply and demand sides are complementary, and neither should be considered by itself. A sustainable and healthy development in the iron and steel industry can only be secured by reducing stock levels on the

supply side and promoting and meeting the basic needs on the demand side.

**Recent commentaries on steel production have highlighted a paradox: Steel is the most useful man-made material, but nevertheless is poor business for most of those making it. What can the global steel industry do to collectively to ensure its future prosperity?**

**Li Xinchuang:** First of all, it should be clarified that this is not a paradox. Steel is one of the important basic raw materials, and it contributes significantly to the economic development of every country, regardless of the »

profitability of its production. To ensure the future prosperity of the iron and steel industry, it is very important to maintain market fairness. A fair market environment has to be assured by fair law enforcement – such as by the careful introduction of trade protectionist policies. Fair competition is helpful to eliminate outdated production capacity and promote industrial upgrades. Under fair circumstances, steel producers can concentrate on environmental protection, on energy-saving measures to increase profits, on quality to hold their leading market position, on assured production to secure steady growth, and on technology improvements to consolidate their development base.

#### **How will the processes and equipment of a typical steel plant of 2050 differ from today?**

**Li Xinchuang:** Intelligent manufacturing and green development will be the key words in the steel industry for a long time. Technology advancement and equipment revamping will be the basis for intelligent manufacturing and green development, which will raise the level of technology and equipment significantly. Therefore, in the foreseeable future, large-sized equipment and intelligent production will be quite different from what they are now. For example, robots will perform operations in harsh and dangerous environments or where high consistency is required, such as for temperature measurements and sampling, product handling, marking and labeling. As a result, work efficiency will improve dramatically. Furthermore, the traditional image of steel plants will be changed completely with coordinated, green and shared development with cities.

### **LI XINCHUANG**

Li Xinchuang is the President of China Metallurgical Industry Planning and Research Institute (MPI) and an expert on special government allowances at China's State Council. He is also a professor-level senior engineer and a licensed consulting engineer for investment. Li was responsible for the design of China's national policy for the development of the steel industry from the Eighth Five-Year Plan to the Thirteenth Five-Year Plan. He has also been engaged in rejuvenation programs and industry-restructuring policies to reduce over-capacity. In addition to the publication of more than 70 articles related to the development of the steel industry, Li has also authored two monographs entitled "Sustainable Development of the Steel Industry" and "How to Transform and Upgrade China's Steel Industry."

#### **Do you see any dramatic breakthrough technologies coming up in the next few decades?**

**Li Xinchuang:** The iron and steel industry is technology-intensive, and innovation is the number one driving force for its development. With steel producers spending more and more money on technical innovation, we can expect to see many more technological breakthroughs. In fact, continuous technical advancements will be normal in the steel industry. For instance, in the last four years, the Chinese steel producer Shougang Jingtang has been intensively pursuing innovation and has applied more than 220 new technologies, several of which are world class. However, it should be noted that iron- and steelmaking processes are already very mature. So in the foreseeable future, we probably won't be seeing groundbreaking developments on par with revolutionary ones in the past such as converter steelmaking and continuous casting. Instead, technological progress will focus on specific areas, such as non-blast furnace ironmaking and near-net-shape rolling, coal-gasification innovations as well as on energy-saving measures and environmental protection.

#### **From which sectors does steel face a substitution threat and what needs to be done for steel to remain competitive and the material of choice for downstream manufacturers?**

**Li Xinchuang:** As the most popular material used in manufacturing and construction industries, steel is at increasing risk of being replaced. A variety of alternative materials have been developed in recent years by research institutes and producers in the automotive, aerospace, electronics and construction sectors, and some of these materials have been used quite successfully. Aluminum is the first steel substitute in car making. By replacing steel with aluminum, car weight can be reduced by 40%. Aluminum is now one of the major materials used in automotive manufacturing, next to steel and cast iron. Carbon nanopaper has been used in high-end military and aerospace applications. The material weighs only one-tenth of steel, but the strength is 250 times higher. High-strength foamed plastics are being used more and more for making drainpipes and water tanks in the construction industry. The steel industry has to take these threats seriously and actively take countermeasures. First of all, R&D has to concentrate on coming up with new lightweight and high-strength grades. Secondly, consumption and emissions have to be reduced in steel production through energy-saving measures to meet the requirements for low energy consumption, low emissions and low costs. Thirdly, R&D has to be closely linked to downstream users to ensure synchronization between the development of new grades and new products.

#### **What new product applications for metals can be expected to emerge by 2050?**

**Li Xinchuang:** The development of new metal products will be based on enhancing the properties of existing grades. New lightweight and high-strength alloyed materials such as aluminum, magnesium, titanium and precious-metal alloys will emerge rapidly. Furthermore,

**“Overcapacity is not an issue only in China, and it is also not caused by Chinese steel exports. The main reason for overcapacity is that economic growth has slowed in many countries and steel demand has greatly dropped worldwide.”**

liquid metal alloys [that remain liquid at room temperature] have become a hot topic in recent years. As one of the super materials that will dominate high-tech competition in the future, liquid metals will have considerable application potential in the fields of electronics, aerospace, biomedicine and precision mechanics.

**What do you see as the main areas where further research and development is necessary for improving production operations, costs and market opportunities in the metals business?**

**Li Xinchuang:** The steel industry has to be actively involved in the material R&D of downstream users. A high awareness of the demand for new steel grades is a must. The steel industry will have to support downstream manufacturers in their R&D for new metallic products with both technical and financial support. This will ensure their leadership in this area and the use of steel materials in new products, which will effectively reduce the risk of steel being substituted by non-metallic materials. With excellent properties and lower prices, they may even acquire some market share of non-metallic materials to gain even more market opportunities. Production costs will be minimized by reducing energy consumption, increasing production efficiency, and by promoting product yield based on process optimization and technology innovation.

**How should the global steel industry be addressing the problem of emissions, especially with consideration to the Kyoto 2050 deadline that specifies a reduction of specific greenhouse gas emissions by 50% compared to 2005 levels?**

**Li Xinchuang:** About 90% of CO<sub>2</sub> emissions from iron and steel production are generated from the combustion of fossil fuels such as coal and coke. So the primary focus has to be on reducing greenhouse gas emission in the steel industry by lowering the consumption of such fuels. This is possible by implementing energy-saving technologies, or through the use of renewable energy sources such as solar and wind. At the same time, steel production routes that emit less CO<sub>2</sub> should be favored. For example, the blast furnace-LD route produces approximately 2 tons of CO<sub>2</sub> per ton of steel, yet an

EAF-based minimill emits only around 0.6 tons of CO<sub>2</sub> per ton of steel. Therefore, increasing the ratio of EAF steelmaking is an important way for the steel industry to reduce greenhouse gas emissions.

**How do you see future changes in the geography of global steel manufacturing and applied technological processes?**

**Li Xinchuang:** Especially in China, there will be a shift from a strategy based on inland resources to a strategy of being closer to the market and using more imported ores. The tendency will be to promote further development in coastal and riverside areas. From a technical point of view, the EAF route will grow rapidly due to environmental pressure and the ever-increasing amounts of scrap. By 2050, more than 30% of steel manufactured in China will be via the EAF route. I believe that China will still be the center of world steel production in the future, and in the meantime other developing countries will gradually increase their steel output.

**What new sets of skills will be required from employees in the metals industry in the future?**

**Li Xinchuang:** The qualifications of steelmaking personnel will have to improve to match industrial advancements. In my view, several aspects will be particularly important, namely the ability to cultivate the combined capability of technology and management; pursue excellence; deal with environmental constraints; work with multinational management; apply intelligent manufacturing; and manage innovation.

**All in all, are you optimistic or pessimistic about the future of the metals business?**

**Li Xinchuang:** All industries develop cyclically, and the steel industry is no exception. It is really difficult for the steel industry to change from decades of rapid growth to shrinking development. A long and complicated course lies ahead, and we need ten years or more to reach the targets of cutting overcapacity and making structural adjustments. Along the way, world-class steel companies will emerge to guide the direction of the Chinese or even the global steel industry. Therefore, I am optimistic about the future of the steel industry. ●

A photograph of the Aurora Borealis (Northern Lights) in a snowy forest. The sky is a deep blue, filled with stars and the vibrant green and blue light of the aurora. The forest below is dark and silhouetted against the bright sky.

**“ If you think in terms of a year, plant a seed;  
if in terms of ten years, plant trees; if in terms  
of 100 years, teach the people.”**

Confucius (551–479 B.C.)





# BETTER CONTROL BETTER COKE

## PLC MODERNIZATION FOR THE COKE OVEN PLANT OF SSAB'S RAAHE STEEL WORKS

Primetals Technologies implemented an order at SSAB's Raahe Steel Works in Finland to modernize the PLC (programmable logic controller) systems of the coke oven plant. Almost all project activities were conducted without interrupting ongoing cokemaking operations and without accident or injury.

**FIG. 1:** View of the cokemaking facilities at the Raahe Steel Works of SSAB

SSAB Europe Oy operates three coke oven plants – two at Oxelösund and Luleå in Sweden, and one in Raahe, Finland (Figure 1). At the plant in Finland, approximately 870,000 tons of metallurgical coke are produced each year for smelting iron ore in the company's two blast furnaces. Back in 2013, the decision was made to modernize the PLC systems of the cokemaking facilities in Raahe. The targets of this modernization were to extend the lifespan of the existing automation system, increase the degree of automation applied for cokemaking, safeguard the future availability of spare parts, and also to improve machine safety, failure diagnostics, IT network security and documentation. Two vital project prerequisites were that all modernization activities had to be carried out during routine production operations and in the safest manner possible.

### PROJECT SCOPE

SSAB's modernization covered machine-control PLC systems (21 units) with 8,500 input/output signals for raw coal material handling, Coke Oven Batteries Nos. 1 and 2, coke oven machines, a dry-quenching plant and NH<sub>3</sub>/H<sub>2</sub>S treatment. The existing S5 PLC system was upgraded to S7 classic. All new PLCs and HMI (human-machine interface) stations were integrated into new redundant Profinet rings and routed via firewall to other plant networks and systems. A separate DMZ (demilitarized zone) area was provided for automation system servers and engineering workstations. Over 30,000 variables were entered into a new IBA (incident-based automation) diagnostic tool for process-data acquisition and analysis. Furthermore, several frequency converters were renewed and machine safety was significantly improved (Figure 2). »

## Over 30,000 variables were entered into a new IBA diagnostic tool for process data acquisition and analysis.



**FIG. 2:** Coke oven control pulpit - located in the control room of the coke dry-cooling plant

SSAB Raahe Investment Services took care of general project management, procurement, coordination, safety management and site supervision. The Primetals Technologies scope of supply included the machine control PLCs (9 units) for the Coke Oven Batteries Nos. 1 and 2, five coke oven machines and burner-safety PLCs (2 units) for  $\text{NH}_3/\text{H}_2\text{S}$  treatment. Primetals Technologies was the main contractor that coordinated and was responsible for project management, PLC modernization, hardware design and supply, software development, performance of the factory acceptance tests, erection supervision and all safety-related systems for those areas of its supply scope. Furthermore, supervision of commissioning, training and documentation preparation were carried out.

Tapio Hyvölä, Project Manager at SSAB Raahe Steel Works, was pleased with the good collaboration among the different subsuppliers: "The cooperation with all project members worked smoothly. All contractors are known to be reliable local partners, which also ensures dependable local support in the future."

### **NO INTERRUPTIONS TO ONGOING COKEMAKING**

The coking process allows few possibilities for process or production shutdowns, which could have a major effect

on downstream production steps. All on-site upgrading activities had to therefore be implemented without interrupting production. This requirement was taken into account throughout the project, from the basic design phase all the way to commissioning. In fact, engineering, erection and commissioning were done in separate phases for each process section to avoid production interruptions.

Project Manager Jorma Jalkanen from Primetals Technologies admits that it was challenging to schedule the different commissioning phases without interrupting operations. He attributes flexibility and good communication between all parties as key factors to being able to finalize all commissioning phases within the scheduled time. SSAB's Tapio Hyvölä adds that detailed time schedules, careful preparation and double checks were all factors that contributed to the successful project results. "A critical challenge was to change the coordination of the machine tasks for the coke oven batteries to the new PLC using a new WLAN communication link, and to create new communication links to Level 2 systems. So we had the old and new PLCs working at the same time for a short period." Hyvölä further: "To ensure a smooth start-up of the upgraded systems, simulation environments were created



**FIG. 3:** Reliable production of high-quality coke at the Raahe Steel Works

### PROJECT MILESTONES

- Contract signing: February 26, 2013
- Completion of last engineering phase: May 30, 2015
- Last factory acceptance test: June 30, 2015
- Erection: November 2013 to September 2015
- Preliminary acceptance certificate (PAC): October 13, 2015

The 24-month warranty period commenced with the PAC. Operation and maintenance training took place throughout the project with the latest phase of training completed on February 5, 2016.

**The main project goals with regard to machine functions, technical solutions, time schedule and budget were all reached – without a single safety incident occurring during the entire project.**

for the coke oven battery machines and PLC coordination. Virtual production and control of the cokemaking process could be carried out in the training room with the HMIs.”

### SUCCESSFUL PROJECT OUTCOME

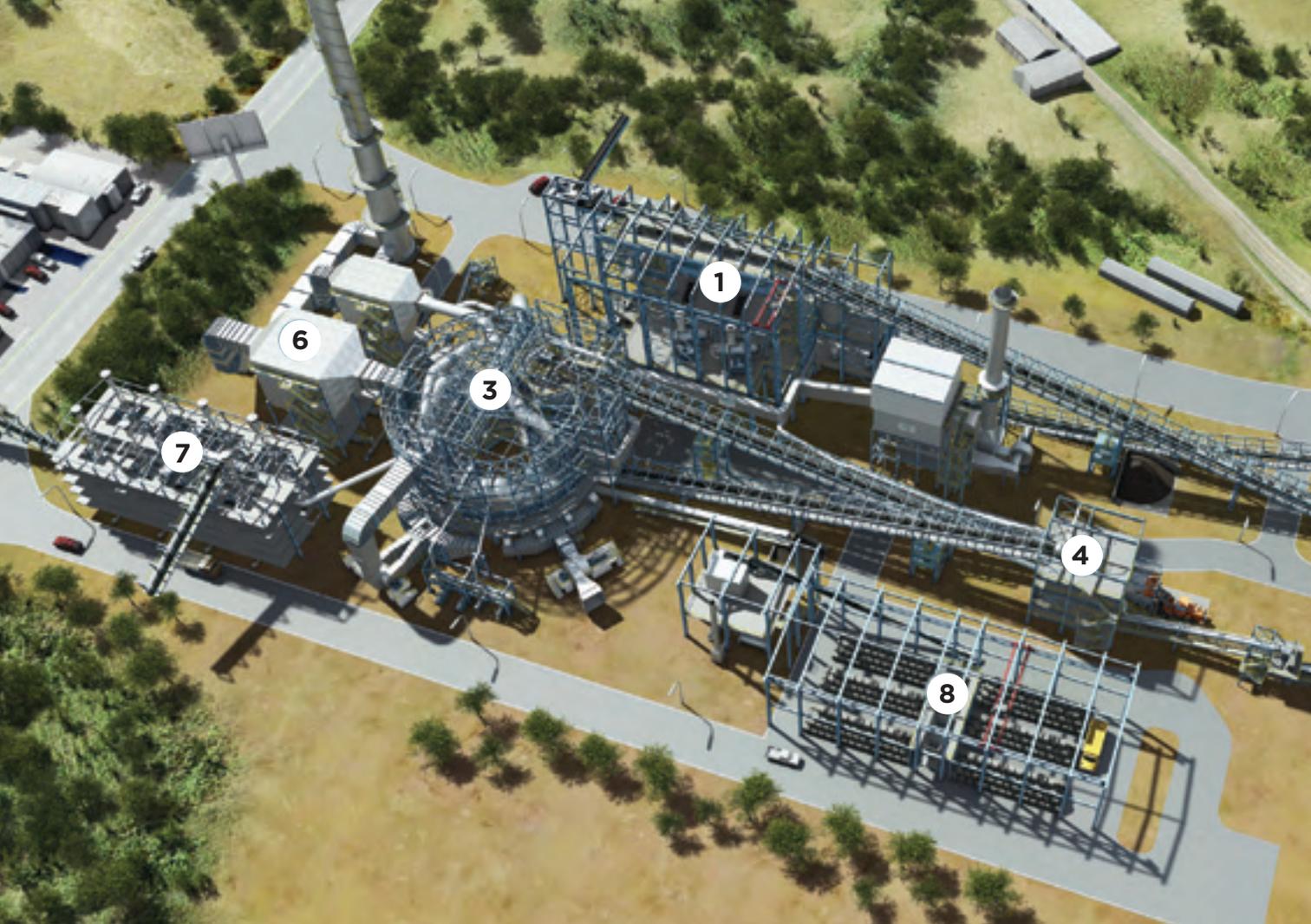
With the commissioning of the final by-product plant PLC, the project could be declared a success for both SSAB and Primetals Technologies. The main project goals with regard to machine functions, technical solutions, time schedule and budget were all reached – without a single safety incident occurring during the entire project. “Thanks to the comprehensive design and professional support, everything went as planned,” Hyvölä concludes.

With the upgraded PLCs, SSAB has been able to extend the lifespan of their automation system and is now benefiting from improved cokemaking reliability and assured coke quality (Figure 3). ●

**Tapio Hyvölä**, Project Manager, SSAB Raahe Steel Works

**Jorma Jalkanen**, Project Manager, Primetals Technologies Finland

**Aarno Kellin**, Sales Manager, Primetals Technologies Finland



#### **SCHEMATIC VIEW OF THE CPT FACILITY IN INDIA**

The total space requirement of the entire CPT plant layout is less than two hectares

#### **LEGEND**

1. Dosing and green balling
2. Mixing station
3. Induration furnace
4. Product classification
5. Product stockpile
6. Process air cleaning
7. Coal-gasification plant
8. Additive storage and grinding

Affordable, high-quality raw materials for ironmaking are steadily decreasing on a global scale. This means that fine and ultrafine iron ores will command an ever-larger share of iron ore sales in the future. For this reason, a growing number of iron and steel producers are looking into the possibility of increasing the portion of pellets in their production operations. The use of pellets, however, leads to a number of issues. Fluctuating prices on the world market can seriously affect cost-efficient ironmaking. The installation of a pelletizing plant within an existing steelworks is often problematic due to space constraints. Furthermore, capital expenditures for a conventional pelletizing facility are typically prohibitive. To address these challenges, Primetals Technologies has developed Circular Pelletizing Technology (CPT) and built the world's first CPT plant in India.

#### **A UNIQUE CIRCULAR DESIGN**

The core innovation of the CPT plant is the unique circular design of the induration furnace. This means not only that space requirements for the induration furnace building are reduced by 50% compared to conventional pelletizing plants, but also that production efficiency is vastly improved. While plants with a straight induration furnace alignment typically employ only 40% of the pallet car number at any given time, the circular furnace layout in CPT allows 75% of the pallet cars to be in permanent active use

inside the furnace. Thus, a far more efficient utilization of installed equipment is achieved.

#### **WORLD'S FIRST CPT PLANT**

The first CPT plant with a nominal production capacity of 1.2 million tons of pellets per annum was built for the Indian steel producer Pro Minerals Pvt. Ltd. in Keonjhar, in the state of Odisha. The total space requirement of the complete ironmaking facility, from raw material dosing and balling up to process gas cleaning, including a coal-gasification plant for energy generation, is less than two hectares. The induration furnace can be fired using a combination of coal gas and heavy fuel oil.

# CIRCULAR PELLETIZING TECHNOLOGY

## A HIGHLY INNOVATIVE AND FLEXIBLE SOLUTION FOR IRON AND STEEL PRODUCERS

When Italian painter Giotto di Bondone was asked by the Pope to demonstrate his skills as an artist, he drew a perfect circle, free-hand. Perfection was a powerful message in 1300, and the notion still holds true in 2016. With the highly innovative and flexible Circular Pelletizing Technology solution, Primetals Technologies has perfected iron ore pelletizing.



### THE CPT PLANT IN INDIA - READY FOR START-UP

The first-ever CPT pelletizing plant was erected in the Indian state of Odisha. It has a capacity of 1.2 million tons of pellets per year.



### FLEXIBLE PRODUCTION OF HIGH-QUALITY, LOW-COST PELLETS

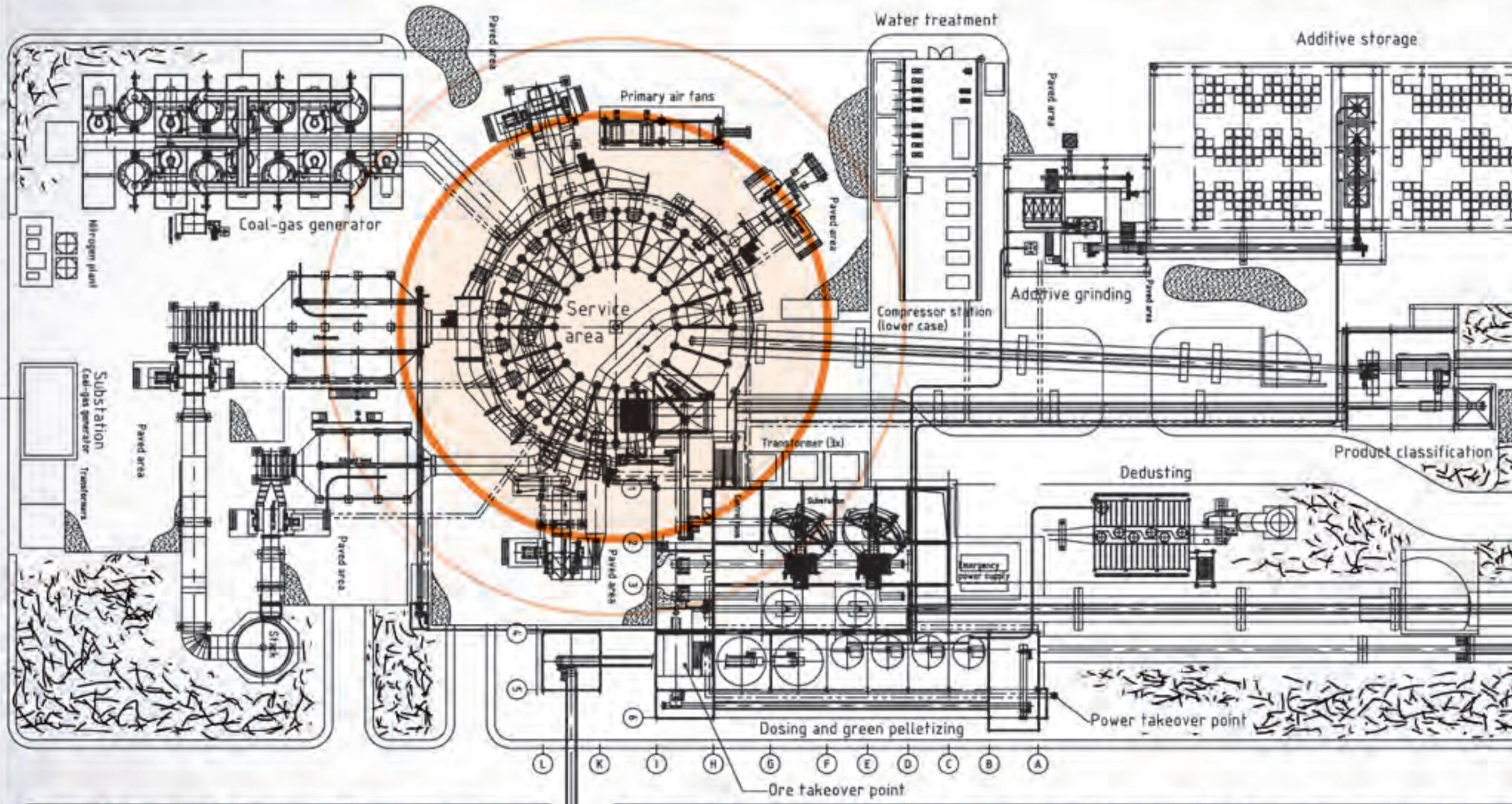
The chemistry of CPT pellets can be adjusted to meet the desired specifications for optimized iron- and steelmaking.

### ADDITIONAL PRODUCER BENEFITS

The highly compact design and lightweight construction of a CPT plant greatly facilitate its efficient and low-cost installation within an existing iron and steel complex. Capital expenditures for civil works, equipment and the steel structure are reduced accordingly, and plant installation can be completed far more quickly. Producers gain control over their own pellet production, which allows them to flexibly adjust the pellet chemistry and quality to optimize iron- and steelmaking. Annual output of a CPT plant is also scalable between 0.6 and 3.0 million tons of pellets to ideally meet production expansion targets. Another benefit of CPT is the high degree of flexibility to use different energy sources for the combustion system depending on price and availability. Through the utilization of recovered hot process gases, the energy consumption required for pelletizing is lowered. Total recycling loops for waste materials and steel mill reverts minimize the overall environmental impact of the process.

CPT represents the world's most compact plant for pelletizing and sets new benchmarks for cost-efficient pellet-based ironmaking. ●

**Reinhard Redl**, Agglomeration Sales, Primetals Technologies Austria



Paved area

Primary air fans

Water treatment

Additive storage

Coal-gas generator

Service area

Compressor station (lower case)

Additive grinding

Substation Coal-gas generator

Transformers

Transformer (3x)

Product classification

Dusting

Emergency power supply

Power takeover point

Dosing and green pelletizing

Ore takeover point

Nitrogen plant

Paved area

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K

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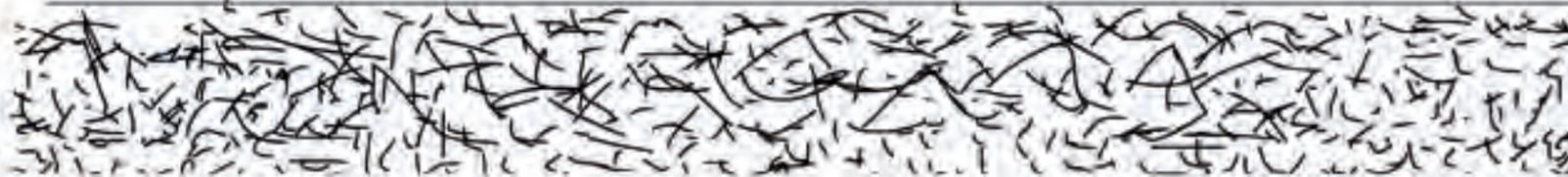
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# AUGMENTED REALITY, AUGMENTED BENEFITS **CPT IS HERE**

## **DARE TO BE AMAZED – CIRCULAR PELLETIZING TECHNOLOGY IN THREE DIMENSIONS**

In order to appreciate the detailed design of a Circular Pelletizing Technology (CPT) plant, Primetals Technologies has prepared a unique interactive application that is compatible with most smartphones and tablets. The app features an augmented-reality function that allows users to see and explore the Indian CPT plant in 3-D. But there's even more: by clicking on the so-called hot spots marked by an "x," you are suddenly transferred into the heart of the induration furnace or the additive/green-pelletizing building, where you will certainly be awed by the incredible 360° panoramic view.

### **WATCH OUT FOR THE ELEPHANTS**

Rumor has it that there are a few elephants grazing about the pellet stockpile – which sometimes happens in India. To find out whether or not this is true, maybe you need to scratch the pellet stockpile to coax them out of hiding. But be careful not to touch or poke the elephants with your finger! As you know, elephants can sometimes be quite irritable ...

### **HERE'S HOW TO DOWNLOAD AND USE THE CPT APP**

You can download the augmented-reality CPT app by scanning the QR codes for your Android or Apple device, or by visiting the app page at Primetals Technologies (<http://primetals.com/apps>). After the app is downloaded and launched, the camera on your mobile device is ready. Just point the camera at the CPT layout, wait a few seconds, and suddenly the entire CPT complex comes to life in 3-D and in color. ●

**Dr. Lawrence Gould**, Managing Editor, Metals Magazine<sup>1)</sup>

**Dr. Thomas Widter**, Deputy Managing Editor, Metals Magazine<sup>1)</sup>

**Michael Wöss**, Marketing Manager<sup>1)</sup>

**Alexander Panag<sup>2)</sup>**

<sup>1)</sup>Primetals Technologies Austria <sup>2)</sup>Enova GmbH



Just move your mobile device across the layout and see the world's first Circular Pelletizing Technology plant in an animated 3-D environment (Suitable for iPad 4 or higher, iPhone 5 or higher and for Android devices)



Link to CPT app



For Android

For iOS

## **CIRCULAR PELLETIZING TECHNOLOGY**

THE CIRCLE OF FLEXIBILITY

# REBUILT FOR **RELIABILITY**

## **BLAST FURNACE RELINE AND EQUIPMENT REPLACEMENT AT SSAB LULEÅ**

During the summer of 2015, a major plant site rebuild was carried out at the SSAB steelworks in Luleå, Sweden. The project included improvements to Blast Furnace No. 3 (Figures 1 and 2) comprising a new refractory reline, installation of a specially designed stove-cooling system, and replacement of the hot-blast main and mixing pot. Thanks to meticulous planning and local prefabrication, the entire operation was completed on schedule within the 75-day planned shutdown period. Blast furnace output could be significantly increased due to a reduction of unscheduled maintenance stops.



**FIGS. 1 AND 2:** Blast Furnace No. 3 at SSAB steelworks in Luleå, Sweden

**Thanks to meticulous planning and local prefabrication, the entire operation was completed on schedule within the 75-day planned shutdown period.**



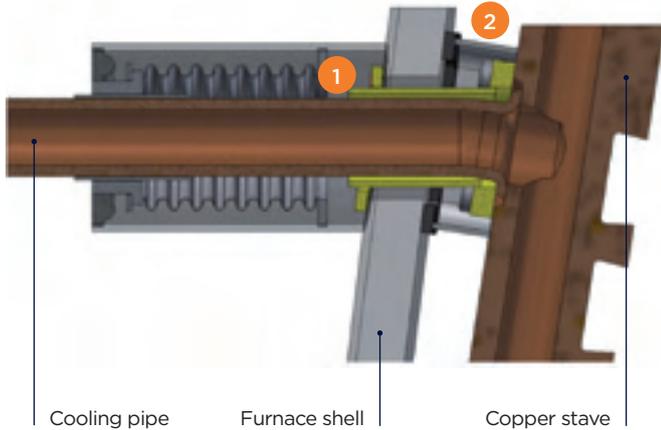
Blast Furnace No. 3 at the Luleå steelworks was blown in after a major upgrade in 2000. At that time, the working volume was increased from 1,440 m<sup>3</sup> to 2,376 m<sup>3</sup>, and large-scale infrastructure improvements were also carried out. The furnace performed well but suffered from operational problems after the use of poor-quality coke led to high heat loads on the cooling elements early in the campaign. This condition, coupled with shortcomings in the original design, is considered the cause of damage around the third row of copper staves of the furnace-cooling system and the resulting cracks in the water-cooling pipes. These issues led to repeated unplanned blast furnace stoppages in order to repair the affected stove pipe connections. Furnace production was therefore limited to about 2.1 million tons of hot metal per year.

As other areas of the plant were also nearing the end of their operational life, SSAB Luleå embarked upon a major plant shutdown in 2015. It was decided to completely reline the blast furnace and to replace the existing cooling-stave system as well as the hot-blast main, for which Primetals Technologies was awarded a contract.

#### **NEW COPPER STAVE FIXING SYSTEM**

The originally installed copper staves were not supplied by Primetals Technologies. The fixing bolts were positioned much lower than what Primetals Technologies would have advised, and it is believed that this had contributed to the previous failures of the cooling pipes. The SSAB contract stipulated that the existing bolt holes be reused, which presented a problem for the »

1. The sealing washer, welded only to the pipe, is designed so that it can move on the blast furnace shell but does not bend in.
2. Bolted to stave



**FIG. 3:** New stave-fixing arrangement



**FIG. 4:** Prebricked hot-blast main

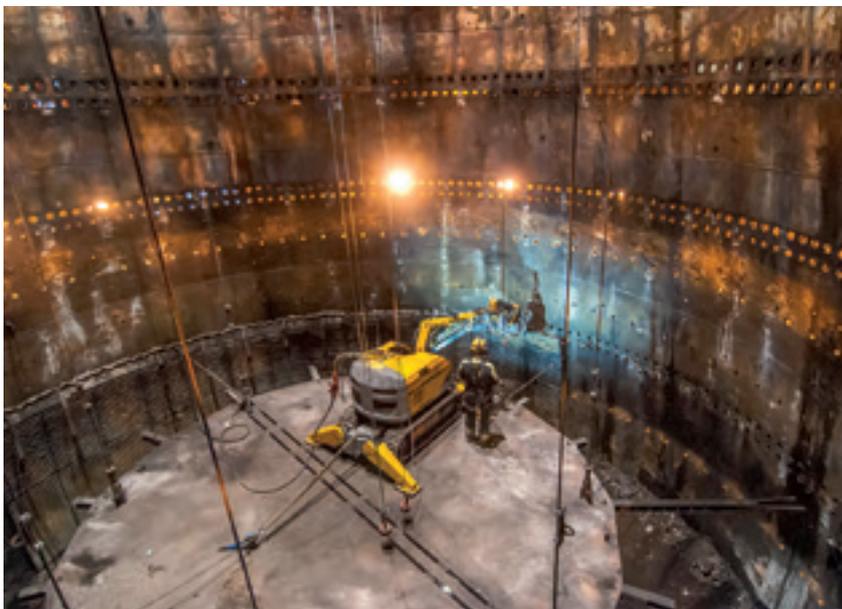
conventional stave-fixing system. Furthermore, a solution had to be found to prevent the staves from bending in at the corners. The solution was the use of a new patented fixing element system that had been previously developed by Primetals Technologies and implemented at Blast Furnace A of voestalpine Stahl in Linz, Austria. The system features a considerably improved design (Figure 3).

### REPLACEMENT OF HOT-BLAST MAIN AND MIXING POT

The existing blower also had to be upgraded, which meant that the hot-blast main and mixing pot needed to be replaced. As a result of extremely low winter temperatures in Luleå, the hot-blast main is fully enclosed within a building to reduce heat loss. A large amount of pre-shutdown work was therefore necessary, including a temporary modification of the building to provide access

for the removal of the old main and installation of the new main within 75 days. Another challenge was that the stoves had to be kept near operating temperatures during the shutdown in order to allow a fast return to normal conditions after restart. It was decided that the best way to meet this schedule was to prefabricate and preinstall refractory material into large sections of the new hot-blast main (Figure 4).

The old hot-blast main was cut into three sections and lowered to the ground with special lifting equipment. The removal of the old refractory material from these sections was carried out remotely. Sections of the new hot-blast main were pre-bricked near the steelworks by a refractory subcontractor and brought to site. These sections were then lifted into place and welded before final refractory installation.



Since returning to operation, the plant has demonstrated excellent operating conditions as confirmed by SSAB's issuing of the performance acceptance certificate for the furnace.

The entire project was fast-tracked from the enquiry phase up to blast furnace blow-in.

**FIG. 5:** A hidden world of know-how: installation of the new stave-cooling system. From left to right: removal of old blast furnace staves; completion of stave removal; new staves installed; close-up of new stave installment



### PROJECT IMPLEMENTATION

Access to the blast furnace site was possible starting from the beginning of June 2015. All relining and equipment-replacement work was completed by mid-August during the 75-day plant shutdown. Figure 5 shows a series of pictures taken during the removal of the old staves and replacement with the new staves.

Following the completion of the blast furnace reline and replacement of the hot-blast system, the refractory material was gradually dried out. The stove combustion air fans were used to generate low pressure within the main, mixer pot and blast furnace. This allowed a leak test to be performed in these areas, the results of which were checked by the third-party inspector.

### SUCCESSFUL PROJECT COMPLETION

During the blast furnace shutdown period, all demolition and construction work proceeded according to plan and within the tight time schedule. The entire project was fast-tracked from the inquiry phase up to blast furnace blow-in, after which SSAB Luleå issued the Taking Over Certificate. Another notable achievement in connection with the on-time project completion was that no lost-time accidents occurred.

The blast furnace rebuild by SSAB Luleå and Primetals Technologies in 2015 resulted in increased plant availability and an annual steel output of up to 2.5 million tons at the Luleå steelworks. Since returning to operation, the plant has demonstrated excellent operating conditions as confirmed by SSAB's issuing of the performance acceptance certificate for the furnace. ●

**Andy Sinclair**, Senior Project Manager, Primetals Technologies UK

**Edward Long**, Senior Process Engineer, Primetals Technologies UK

# NEXT-GENERATION IRONMAKING

## OPERATIONAL AND PRODUCTION BENEFITS OF THE FINEX F-2.0M PLANT

The need to reduce ironmaking costs, increase raw material and operational flexibility, and fulfill ever-stricter environmental regulations count among the decisive reasons behind the co-development of the FINEX® (hereinafter written as Finex) process by the Korean steel producer Posco and Primetals Technologies. Starting with a 600,000 t/a demonstration plant, Finex technology has evolved to a production facility with an annual output of approximately 2 million tons. This article outlines the operational and production benefits of the Finex F-2.0M facility that was put into operation at the Pohang steelworks of Posco more than two years ago (Figure 1).

**FIG. 1:** View of Posco's Finex F-2.0M ironmaking plant in Pohang, Korea

### EVOLUTION OF THE FINEX PROCESS

The first commercial Finex plant (F-1.5M model) was designed with an annual hot-metal production capacity of 1.5 million tons. Started up in April 2007, its economic feasibility as an alternative ironmaking process to the blast furnace could be quickly confirmed (Figure 2). The blow-in of the F-2.0M (2 million t/a) Finex plant in January 2014 and successful production of hot metal since that time has proven that the Finex process is a viable and competitive alternative to the conventional blast furnace ironmaking route with coking and sintering plants.

### DESIGN MODIFICATIONS OF THE FINEX F-2.0M PLANT

The design of the third-generation Finex plant features simplified plant construction and a lower overall weight compared to the F-1.5M plant concept. The following main design and process improvements were implemented:

- Pneumatic ore charging to a 3-stage (as opposed to the previous 4-stage) fluidized-bed reactor system resulting in a 30% lower building height

- Simplified design of the hot-compacted iron (HCI) plant for the compacting of direct-reduced ore and additives
- Installation of a dry-dedusting system in the HCI plant
- Elimination of the HCI bin and associated top-gas system in the melter-gasifier tower
- Installation of a center-positioned dynamic Gimbal Top distribution system at the top of the melter gasifier for the uniform charging of HCI, coal and additives into the melter gasifier

With these design and process improvements, the overall construction weight of the Finex F-2.0M facility was reduced by approximately 9% compared to the Finex F-1.5M plant – with no increase in the overall plant footprint. During the construction period of 31 months from groundbreaking to blow-in, roughly 77,000 tons of steel structure, equipment, piping and refractories were installed. Around 1,600 km of cables were laid and some 16,000 I/O (input/output) signal checks were carried out. »



## BENEFITS OF THE FINEX PROCESS

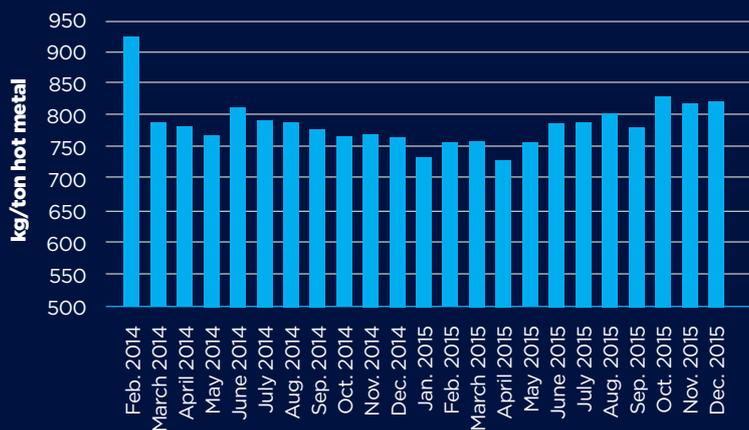
- Direct utilization of low-grade and low-cost iron ore fines as the oxide feed
- Direct use of non-coking coals as the reductant
- Favorable economics with respect to capex and opex (approximately 12% lower opex compared to a new blast furnace of similar capacity)
- Environmental benefits, including reduced emissions of NO<sub>x</sub> and SO<sub>x</sub> by 90% and 95%, respectively, compared to the conventional blast furnace route
- Flexibility in the selection of raw materials (e.g., use of ores with higher Al<sub>2</sub>O<sub>3</sub> contents)
- Production of hot metal in a quality that is identical to blast-furnace hot metal
- Release of a valuable export gas for other industrial uses such as for power generation, DRI production or the manufacture of chemical products
- Brownfield installation within an integrated steelworks offers synergies with existing blast furnaces that include the charging of undersized coke and sinter fines directly to the Finex process



**FIG. 2:** Finex 1.5M plant, Pohang, Korea (left: melter-gasifier tower, right: fluidized-bed reactor tower)



**FIG. 3:** Cumulative hot-metal production of the Finex F-2.0M plant from February 2014 to the end of December 2015



**FIG. 4:** Specific fuel rate of the Finex F-2.0M plant from February 2014 to the end of December 2015

**TABLE 1:****TYPICAL CONSUMPTION FIGURES OF THE FINEX F-2.0M PLANT WITH A PRODUCTION OUTPUT OF 2 MILLION TONS OF HOT METAL PER YEAR**

<b>Iron ore consumption</b>	1,550-1,650 kg/t hot metal
<b>Fuel rate</b>	750-800 kg/t hot metal (including 50-100 kg coke)
<b>Additive consumption</b>	250 kg/t hot metal
<b>Oxygen consumption</b>	500-550 Nm <sup>3</sup> /t hot metal*
<b>Export gas quantity</b>	335,000 Nm <sup>3</sup> /h
<b>Net calorific value of export gas</b>	5,500-6,250 kJ/Nm <sup>3</sup>
<b>Electrical power consumption</b>	220 kWh/t hot metal
<b>Nitrogen</b>	400-450 Nm <sup>3</sup> /t hot metal
<b>Make-up water</b>	1-1.5 m <sup>3</sup> /t hot metal

\*Nm<sup>3</sup> stands for normal cubic meter

### FIRST TWO YEARS OF HOT-METAL PRODUCTION WITH THE FINEX F-2.0M PLANT

Following the plant start-up in January 2014, process and production parameters were optimized and production was gradually ramped up to design capacity. Productivity of the F-2.0M Finex plant reached its target value of 5,760 t/d in April 2014. Since then, all other key operational targets were met and a plant availability of >95% was achieved during the first two years of production operations. Figure 3 shows the cumulative hot-metal production of the F-2.0M Finex plant during a 23-month period that extended from February 2014 to the end of December 2015. Figure 4 depicts the specific fuel consumption during the same period, and Table 1 shows typical consumption figures of the Finex F-2.0M plant with an annual hot-metal production of 2 million t/a.

### PLANNED ENERGY SAVINGS AND ENVIRONMENTAL SYSTEM INSTALLATIONS

Posco's Finex F-2.0M plant will be additionally equipped with a waste-heat recovery system, a dry-dedusting unit and a top-gas pressure-recovery turbine (TRT) with the objective to further enhance overall energy efficiency and environmental compatibility of this ironmaking facility. Start-up and commissioning is scheduled to commence in May 2017.

### A BRIGHT OUTLOOK FOR FINEX TECHNOLOGY

Finex is the world's only hot-metal production process that is based on the direct use of iron ore fines and

non-coking coal. As proven at the Pohang steelworks of the Korean steel producer Posco, Finex represents a highly competitive alternative to the conventional blast furnace route and offers producers decisive environmental advantages. Since the introduction of this technology in 2003, a total of more than 22 million tons of hot metal have been tapped from all Finex plant variants as of the end of April 2016. Currently, new Finex plant installations are under consideration for iron- and steelworks in China, India and Iran. ●

**Jaeho Lee**, Manager, Pohang Iron and Steel Company (Posco)

**Norbert Rein**, Product Lifecycle Manager, Primetals Technologies Austria

For more information about the Finex process, please go to [primetals.com](http://primetals.com). To view a video that explains the process and presents the advantages of Finex technology, please scan the QR code.

FINEX® is a registered trademark of Pohang Iron and Steel Company Ltd. and Primetals Technologies, Limited.



Link to Finex video



**“** Working with Primetals Technologies is always a nice experience as they are focused, hardworking and professional in achieving the goals.”

# A LONG SUCCESS STORY IN THE GULF AREA

## INTERVIEW WITH ALI BIN HASSAN AL-MURAIKHI, MANAGING DIRECTOR AND GENERAL MANAGER OF QATAR STEEL COMPANY

Qatar Steel Company, which commenced commercial steel production in 1978, is the first minimill built in the Arabian Gulf that is based on the production of iron via the gas-based direct-reduction (DR) process. The company's main production facility is located in Mesaieed Industrial City, about 45 km south of Qatar's capital of Doha. In 2005, Primetals Technologies Italy (VAI Pomini at that time) was contracted to supply a full turnkey rebar mill with a production capacity of 700,000 t/a. The mill started up in 2007. In 2015, a record annual output of 1 million tons was achieved, exceeding the nominal contract figure by more than 44%. Ali Bin Hassan Al-Muraikhi spoke about the rebar mill project and his company's relationship with Primetals Technologies.

### What were the main reasons for your company's decision to install a new rebar mill in 2005?

**Ali Bin Hassan Al-Muraikhi:** Motivated by the regional growth and demand for steel in 2005, and considering various infrastructure projects planned and ongoing in Qatar and around the Gulf area, Qatar Steel initiated a feasibility study and conducted market research. Based on the results of the feasibility study, the Qatar Steel Phase-1 Expansion plan was launched. This expansion plan included a new DR plant [DR-2], a new steel melt shop [EF-4] and a new rebar mill [RM-2]. All three projects were initiated, and execution took place during the same time period.

### What were the key challenges that had to be overcome during the execution of this project?

**Ali-Muraikhi:** Although all of the contracts related to design, manufacture, supply, installation and commissioning of Phase-1 expansion projects were awarded to international companies as EPC [engineering, procurement and construction] packages, we still faced huge challenges during execution. I would like to highlight a few of the many key issues, such as a lack of skilled labor and high-quality professionals, and unrealistic projections anticipated by all stakeholders, including the client, consultants and contractors.



“ During the last three years, this mill consistently achieved more than 900,000 tons per year and exceeded 1,000,000 tons in 2015.”



Production record award ceremony on March 22, 2016, Doha, Qatar  
From left to right: His Excellency Guido De Sanctis, Ambassador of the Italian Republic to the State of Qatar; Ali Bin Hassan Al-Muraikhi, Managing Director and General Manager, Qatar Steel Company; Giuseppe Ferrario, CEO of Primetals Technologies Italy

Opposite: Installed rebar mill at Qatar Steel Company, Mesaieed Industrial City, Qatar

**Has this investment enabled your company to enlarge its market presence or access new market segments?**

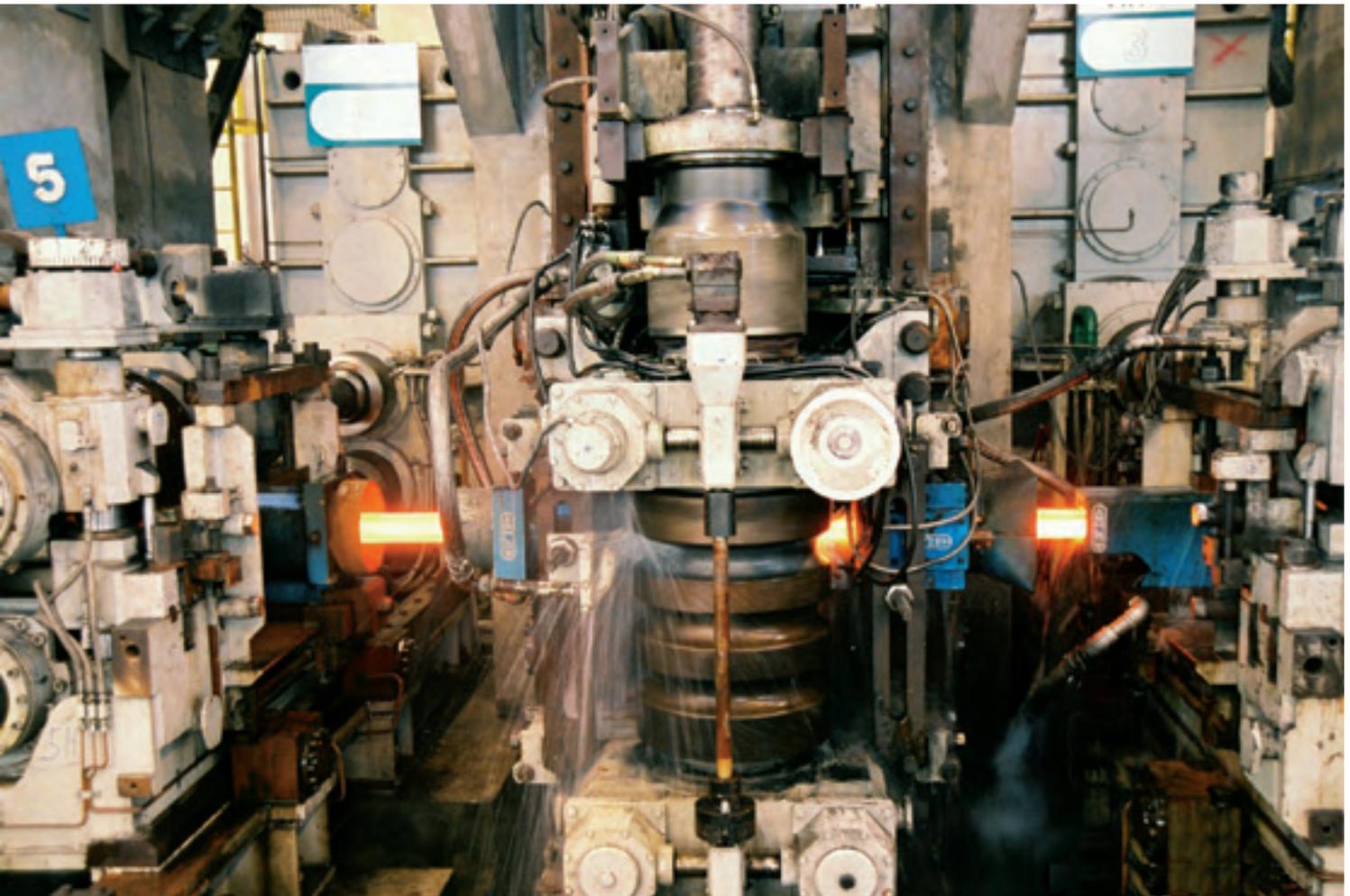
**Ali-Muraikhi:** Ensuring the market share locally for construction rebar was never a problem for Qatar Steel since its inception. However, after the completion of these expansion projects, Qatar Steel optimized its production, enhanced its competitive position, and also maintained its presence in the local and regional markets.

**Why was Primetals Technologies selected as the main partner for this project, and how would you characterize the working relationship with them?**

**Ali-Muraikhi:** As a supporter of innovative technologies

and a fair player in business projects, Qatar steel always believed in an unbiased evaluation of tenders. For most of the techno-commercial evaluations, the technical offer was weighted more heavily than the commercial offer. As the offer of Primetals Technologies matched most of Qatar Steel's requirements, naturally they were chosen for the project. Working with Primetals Technologies is always a nice experience as they are focused, hardworking and professional in achieving the goals.

**Did the rolling mill supplied by Primetals Technologies meet your expectations in terms of operational reliability and flexibility?**



**AI-Muraikhi:** Yes, the supplied mill met the expectations of Qatar Steel in terms of its operational flexibility and reliability.

**Although the nominal contract production capacity was 700,000 metric tons per year, in 2015 more than 1 million tons were rolled at the Rolling Mill No. 2 in Mesaieed. What, in your view, were the main reasons for this success?**

**AI-Muraikhi:** The contract specified a production capacity of 700,000 tons per year for the RM-2. During the last three years, this mill consistently achieved more than 900,000 tons per year and exceeded 1 million tons in 2015 due to the optimized product mix of rolling sizes D16 to D40. Other factors are the improved operational and maintenance efficiency by minimizing repetitive delays and thus achieving an RRR [roll rotating ratio] of 94%, improved throughput from the designed level of 130 to 134 tons per hour, and by optimizing the process parameters.

**Are there major investments currently planned by Qatar Steel in the near- or mid-term future?**

**AI-Muraikhi:** Although we are aware that setting up a new facility or plant at the end of an economic downturn is usually a key factor for the company's success in the subsequent economic upturn, presently we are focusing on cost-saving projects rather than expansion projects.

**While Qatar's economy is growing and diversifying into industry, finance, tourism and other sectors, oil & gas still claim the lion's share. How will the ongoing low prices of oil affect Qatar Steel and its plans for further expansion?**

**AI-Muraikhi:** As the oil sector still dictates most of the investment and infrastructure projects in this region, the low oil prices definitely have an adverse effect on our expansion plans. But as we are aware that this is a cyclic process, we are developing our own plans to counter this situation.

**What are the main challenges that your company is facing at this time?**

**AI-Muraikhi:** The main challenge is the heavy competition in the market from regional producers and overseas suppliers from China, Turkey, Russia, etc. Other challenges that we have are reducing costs and avoiding an increase in company overhead.

**How do you see future developments of the steel industry in your market region?**

**AI-Muraikhi:** As the steel demand is high locally, we will keep our market share, maintain good relations with our customers, and continue to do our utmost to achieve sustainable development in the steel industry. ●

# UNIQUE ON THE PLANET

## START-UP AND OPERATION OF THE WORLD'S MOST POWERFUL HOT-ROLLING MILL AT ATI

On March 18, 2014, a new, fully integrated hot-rolling and processing facility (HRPF) supplied by Primetals Technologies on a process-turnkey basis was started up at the Brackenridge facility of Allegheny Technologies Incorporated (ATI) in Pennsylvania, U.S.A. (Figure 1). The mill is capable of rolling up to 3.5 million t/a of a broad range of highly diversified stainless and carbon steels, specialty metals and electrical steel grades that find use in the aerospace, automotive, defense, petroleum, chemical, construction, mining and power industries, in addition to various medical, food-equipment, machine and cutting-tool applications. The rolling forces are the highest ever to be applied in a hot-strip rolling mill. This article outlines the features and highlights of this worldwide-unique rolling complex.



**FIG. 1:** View of ATI's hot-rolling processing facility, Brackenridge, Pennsylvania, U.S.A.

**The rolling forces are the highest ever to be applied in a hot-strip rolling mill.**



The HRPF project scope for Primetals Technologies included engineering, manufacture of special components, and the supply, installation and commissioning of mechanical equipment as well as electrical and automation systems. The scope of supply covered transfer and handling equipment for slabs and ingots; heating/reheating furnaces; primary and secondary descalers; slab and rotary crop shears; a 4-high reversing roughing stand with an integrated heavy edger; heat-retention Encopanels; a 7-stand, 4-high finishing train; a laminar-cooling section;

two Power Coilers with integrated pinch-roll polishers and quick-exchange pinch-roll units; a coil-handling system; integrated sampling, inspection, marking and strapping machines; fume-exhaust systems; and a water-treatment plant. The electrical and automation systems comprised the main and auxiliary motors, drives, instrumentation, basic automation, process automation, the Siloc yard-management system and a manufacturing execution system (MES). The general layout of the HRPF is depicted in Figure 2. »

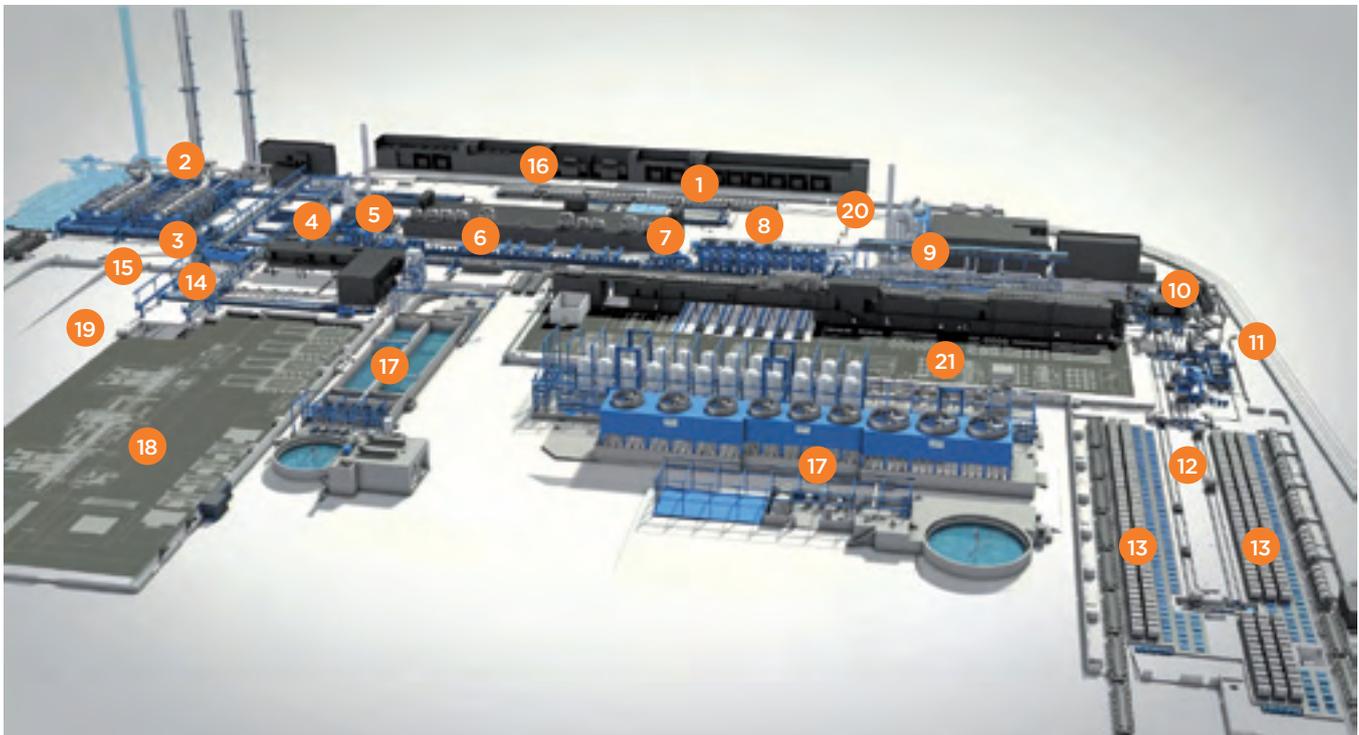
Leading-edge technologies are built into the HRPF to ensure top-class performance and to control key parameters such as thickness, cooling and coiling temperatures through the use of built-in process models and the associated automation-controlled actuators.

### HRPF EQUIPMENT AND SYSTEMS

#### Roughing mill

Following reheating and descaling, the slabs or ingots are initially rolled in the roughing mill (Figure 3), which is equipped with an edger and state-of-the-art twin drives with a motor power of 9.5 MW each. The roughing mill stand is capable of exerting a maximum load of 60 MN. This immense power gives the HRPF the capability and versatility to process and roll the broadest ranges of specialty metals in the industry. Slabs can be processed

**In order to ensure that the highest technological demands are met for rolling ATI's extremely sophisticated product mix, the mill is furnished with numerous state-of-the-art technological packages.**



- |  |  |
|--|--|
| 1. Slab handling and loading                 | 12. Coil handling  |
| 2. Walking-beam furnace                      | 13. Coil yard  |
| 3. Slab shear                                | 14. Manipulator and underground slab ferry   |
| 4. Primary descaler                          | 15. Ingot buggy  |
| 5. Roughing mill with edger                  | 16. Transformer  |
| 6. Encopanel, plate pusher and plasma cutter | 17. Water-treatment plant  |
| 7. Rotary crop shear and secondary descaler  | 18. Ingot yard with slab grinder, car-bottom heating systems and induction furnace |
| 8. Finishing mill                            | 19. Soaking pits   |
| 9. Laminar-cooling section                   | 20. Hot boxes for heat retention   |
| 10. Downcoiler section                       | 21. Roll shop  |
| 11. Coil inspection and heavy-gauge cutter   |  |

**FIG. 2:** Layout of ATI's new hot-rolling processing facility

up to thicknesses of 250 mm (10 inches), at widths up to 2,083 mm (82 inches) and at lengths up to 12,497 mm (492 inches) – allowing a maximum coil weight of up to 40 metric tons to be produced. Ingots can be processed with thicknesses up to 660 mm (26 inches), at widths up to 1,778 mm (70 inches) and at lengths up to 5,080 mm (200 inches). Following roughing, the transfer bar passes on to the finishing mill through an Encopanel-covered section to minimize temperature loss and provide a more uniform finish-rolling temperature.

### Finishing mill

The finishing mill is designed with seven 4-high stands, each of which is powered by 10 MW drives (Figure 4) and is capable of exerting a mill-stand load of up to 55 MN. Patented technological controls allow the application of long-stroke HAGC (hydraulic automatic gauge control)

cylinders for improved operation and maintenance. All stands feature dynamic work-roll cooling that permits defined cooling patterns across the work-roll barrel length to be carried out. Additional systems include interstand cooling, work-roll lubrication, a fume-suppression system, strip cross sprays, entry-guide cooling as well as looper cooling as the basis for optimum process parameters and equipment conditions.

In order to ensure that the highest technological demands are met for rolling ATI's extremely sophisticated product mix, the mill is furnished with numerous state-of-the-art technological packages. These include SmartCrown rolls installed in the finishing stands, which operate in conjunction with L-type bending blocks and the work-roll shifting system. This technology is a decisive factor for assuring excellent strip profile and flatness control. »



**FIG. 3:** Roughing mill with attached edger

**FIG. 4:** 7-stand, 4-high finishing mill

**FIG. 5:** Coiling section equipped with two Power Coilers

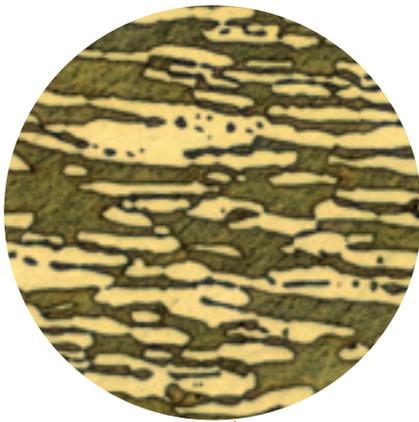
**FIG. 6:** API X80 pipe-grade coil product with a thickness of 25.4 mm (1 inch) and a width of 1,900 mm (75 inches)

**FIG. 7:** Roughing mill control pulpit

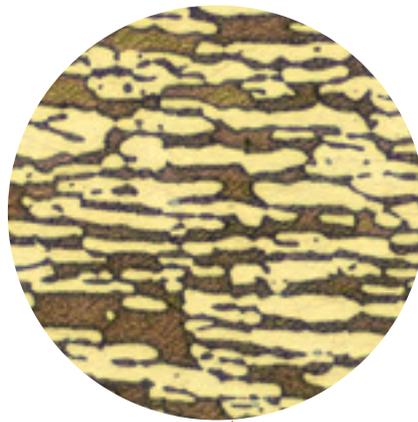
TABLE 1:

## PRODUCT MIX CAPABILITY OF THE HRPF

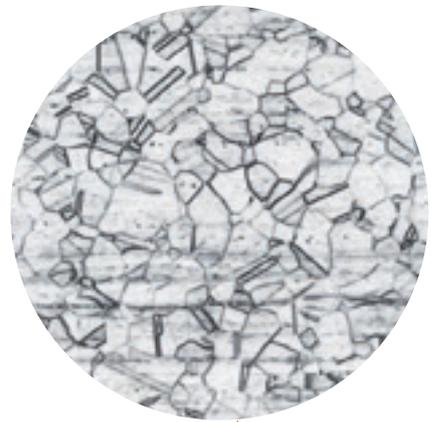
Strip produced from slabs	Strip produced from ingots	Carbon steels
<ul style="list-style-type: none"> <li>Stainless steel, including austenitic (200 and 300 series), super-ferritic (400 series), martensitic (400 series) and duplex grades</li> <li>High-strength/high-temperature alloys, including nickel-based and cobalt-based grades; armor plates and other specialty metals</li> <li>Titanium and titanium alloys</li> <li>Zirconium</li> </ul>	<ul style="list-style-type: none"> <li>Stainless steel (austenitic, ferritic and martensitic grades)</li> <li>High-temperature alloys</li> <li>Titanium</li> <li>Grain-oriented silicon steel grades</li> </ul>	<ul style="list-style-type: none"> <li>Dual-phase steel (as hot rolled)</li> <li>API pipe-grade products</li> <li>Multiphase steel (for cold rolling up to DP 1000)</li> <li>Steel for exposed automotive and other applications after cold rolling and coating</li> <li>Electrical steel grades</li> </ul>



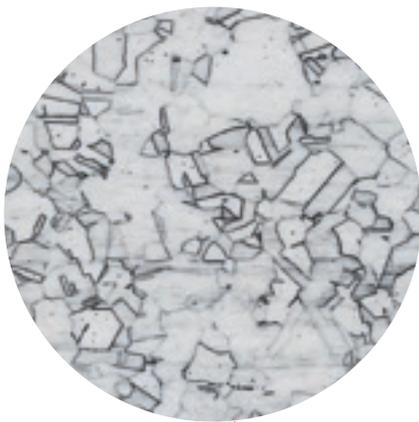
FeCrMo alloy



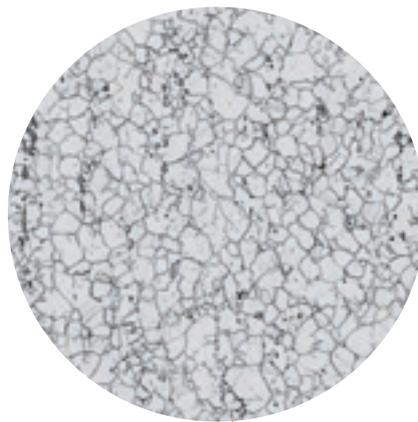
FeCrMo alloy



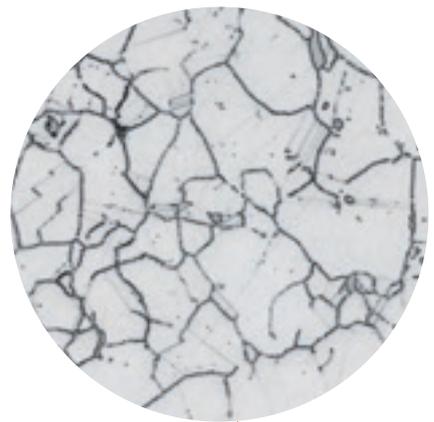
FeCrNiMo alloy



FeCrNi alloy



NiCrMo alloy



NiCrMo alloy

**FIG. 8:** Examples of metallographic images of metal alloys rolled on the HRPF

## ATI now has at its disposal the capability to offer its sheet and plate customers a significantly expanded range of specialty metals and product dimensions that are unique in the industry.

### Laminar-cooling section

The laminar cooling section comprises 54 top headers and 162 bottom headers that provide a maximum water-flow rate of 20,000 m<sup>3</sup>/h. The cooling headers are flow-controlled on the basis of calculations from a micro-structure target-cooling model. Laminar cooling is split into a fast cooling zone (first 20 top headers) and a normal cooling zone (remaining 34 top headers). Each top header and each group of bottom headers is separately regulated by a flow-control valve. This setup increases the overall flexibility of the cooling system and allows a variety of cooling rates to be applied for exact control of phase transformation, depending on the desired steel grade to be produced.

### Downcoiler section

Two so-called Power Coilers are installed in the coiling section, which are dimensioned so that they are capable of coiling API X100 pipe-grade material at a thickness of 21.2 mm (0.83 inches) and a width of 1,956 mm (77 inches) or API X80 pipe-grade material with a thickness of 25.4 mm (1 inch) and a width of 2,083 mm (82 inches) – Figures 5 and 6. The Power Coilers are equipped with servohydraulically controlled side guides, pinch-roll units and four wrapper arms. They are also outfitted with pinch-roll polishers, quick-exchange pinch-roll units and coil-springing-prevention devices. The coils are subsequently strapped, weighed, marked and, if required, inspected before they are transferred to the coil yard for subsequent processing or dispatch.

### Automation and logistics

The entire facility is controlled from control pulpits positioned at the roughing mill, finishing mill and downcoiler. A complete suite of Level 1 automation systems and sophisticated Level 2 process-optimization systems with integrated tailored process models ensures that nothing is left to chance (Figure 7). Level 2 rolling systems include models for the precise control of rolling parameters; models for monitoring and governing strip temperature, heat transfer and phase transformations; and other models for profile and flatness control, roll bending, roll thermal crown and roll wear, material flow, roll flattening and roll shifting. The cooling section includes models for temperature monitoring and control, heat-transfer and phase transformations. The application of a manufacturing execution system (MES) and a logistics system (Siloc)

serve as the basis for record-breaking melting-to-shipment throughput times. These systems enable ATI to operate this exceptional facility at maximum output without the need for a slab yard. Space requirements for the coil yard only had to be designed to store the coil output from a single production shift. Furthermore, the installed automation systems reduced personnel expenditures for the operation of the HRPF. All of these factors support ATI to reduce its managed working capital significantly.

### Expanded product mix and rolling capabilities

Following the successful completion of all required performance tests, the final acceptance certificate (FAC) was issued on February 3, 2016. ATI now has at its disposal the capability to offer its sheet and plate customers a significantly expanded range of specialty metals and product dimensions that are unique in the industry. Larger, longer, thicker and wider coils are produced with thinner gauges, superior tolerances, improved surface quality and more consistent mechanical properties. Overall hot-rolling performance has been significantly augmented with the new HRPF as follows:

- Unprecedented short melt-to-shipment lead times
- Reduced manufacturing throughput time
- Production of an incomparably and highly diverse product mix (Table 1 and Figure 8)
- Enhanced capacity to meet customers' product design needs and increased range of product applications
- Unique capability to offer best-in-class coil geometry
- Rolling of outstanding 1,500 mm to 2,000 mm wide coil and plate products at the lowest and highest gauges in the industry

### OUTSTANDING COOPERATION

The HRPF project represents an outstanding example of a successful cooperation between a market-leading supplier of specialty metals and a metallurgical plant builder. The installed power, size and advanced technology of the mill, combined with decades of operational expertise, allow ATI to fully meet the most demanding customer requirements in a highly efficient and productive manner. ●

**Thomas P. DeLuca**, Vice President and General Manager Primary Operations, ATI Flat Rolled Products Group

**Franz Xaver Schmoller**, Project Lead Engineer and HRPF Commissioning Manager, Primetals Technologies Austria



# THE POWER TO SUCCEED

**INTERVIEW WITH THOMAS DELUCA,  
VICE PRESIDENT AND GENERAL MANAGER OF PRIMARY OPERATIONS,  
ALLEGHENY TECHNOLOGIES INCORPORATED (ATI)**

Thomas (Tom) DeLuca joined Allegheny Ludlum (now ATI) in 1984 as a metallurgist after completing his university education in the field of metallurgical engineering at the University of Pittsburgh. He held a number of key management positions in the primary and finishing plants at various locations of Allegheny Ludlum. On September 1, 2012, DeLuca was appointed as Vice President and General Manager of Primary Operations for ATI's Flat Rolled Products Group.

The new hot-rolling and processing facility (HRPF) in operation.  
From left to right:  
Thomas P. DeLuca, ATI; Louis W. Koprivnikar, Jr., ATI; Franz Xaver Schmoller, Primetals Technologies

“Primetals’ leadership in E&A, combined with tailor-made mechanical engineering, allowed ATI to develop what we believe is the most efficient and advanced rolling mill of its kind in the world.”

#### What were the main reasons for your company’s decision to invest in the HRPF?

**Tom DeLuca:** We saw the investment in the HRPF as an opportunity to replace two other 1950s vintage hot mills in our system. We also had the vision to lower our hot-rolling costs by using state-of-the-art automation. The facility has no slab yard, and has a totally automated coil yard. We also saw the opportunity to improve our finishing plant productivities and yields by maximizing the power and size card [capacity and efficiency] of the facility.

#### Why was Primetals Technologies selected as the main partner for this project?

**DeLuca:** Primetals’ leadership in E&A [electric and automation], combined with tailor-made mechanical engineering, allowed ATI to develop what we believe is the most efficient and advanced rolling mill of its kind in the world. This, coupled with the single-source hardware supply, was an important consideration in our decision.

#### What were the key challenges that had to be overcome during the execution of the project?

**DeLuca:** As with any large-scale project, there were a number of challenges in design, engineering, installation, commissioning and ramp up. Particularly during the latter stages of the project, we gained synergies from essentially integrating the Primetals commissioning engineers into our manufacturing team to jointly solve problems as they arose. In addition, unlike many other hot-mill installations in the world, ATI’s

diverse product portfolio also represented a challenge that we were able to overcome in all phases of the project.

#### Did the supplied rolling mill meet your expectations in terms of operational reliability and flexibility?

**DeLuca:** It did in several ways: Firstly, the flexibility of the combustion\* and mill delivery system designed into this facility was unique to accommodate the broad range of products we manufacture. Secondly, qualification of the automation systems was performed relatively quickly. Furthermore, our collective teams shared a common goal to quickly ramp up mill production as well.

#### How is your company responding to ever-increasing environmental demands, especially with consideration to the Kyoto 2050 deadline that specifies a reduction of specific greenhouse gas emissions by 50% compared to 2005 levels?

**DeLuca:** The HRPF is designed with state-of-the-art air and water quality systems that will easily be able to meet the strictest of environmental standards.

#### Has this investment enabled your company to enlarge its market presence or access new market segments?

**DeLuca:** The mill’s designed power, size card capability and technology are unparalleled. ATI will be able to leverage this capability internally and externally for years to come. ●

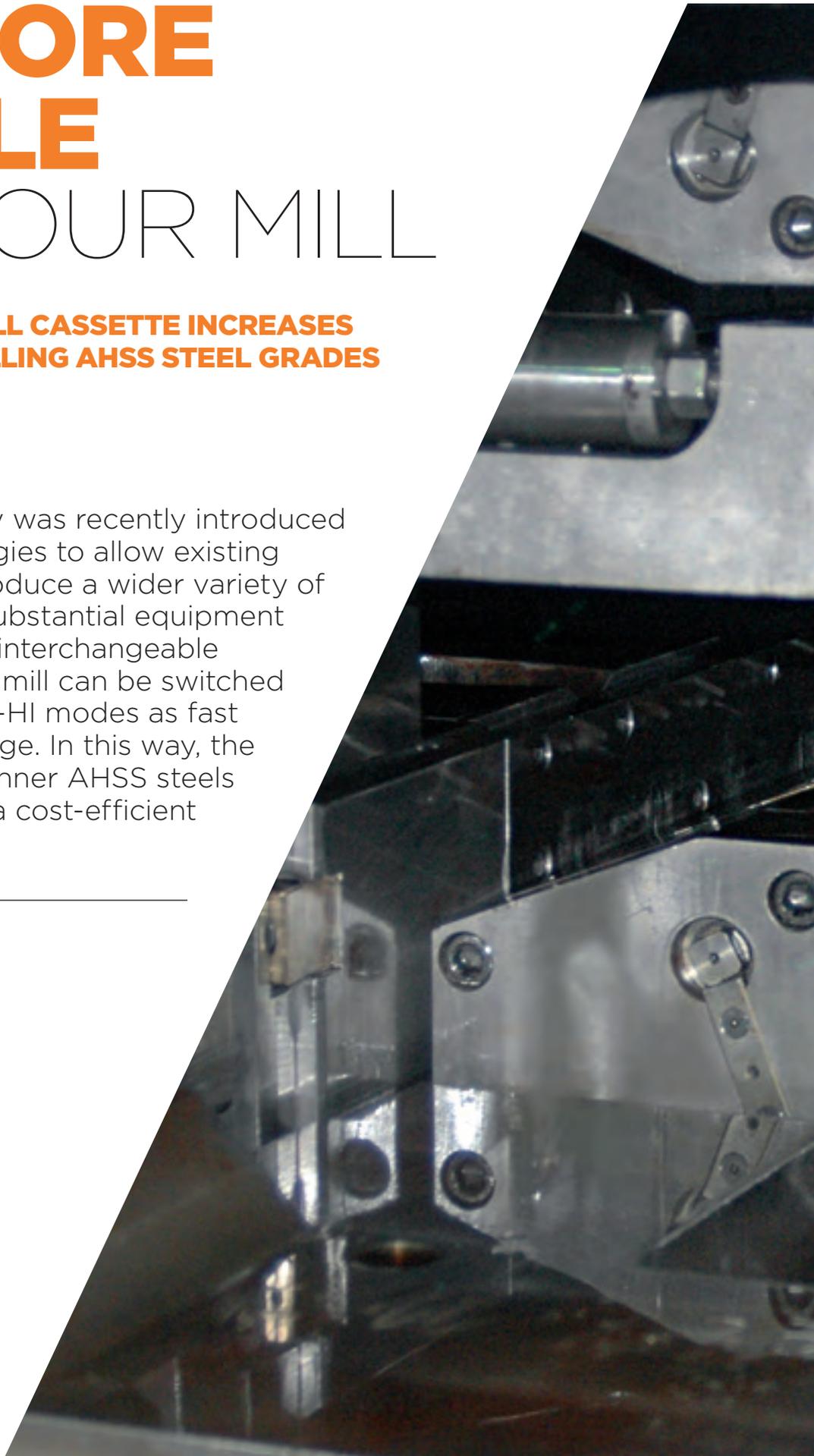
\*The combustion system includes the induction furnace, soaking pits, heat boxes for heat retention, and car-bottom heating systems.

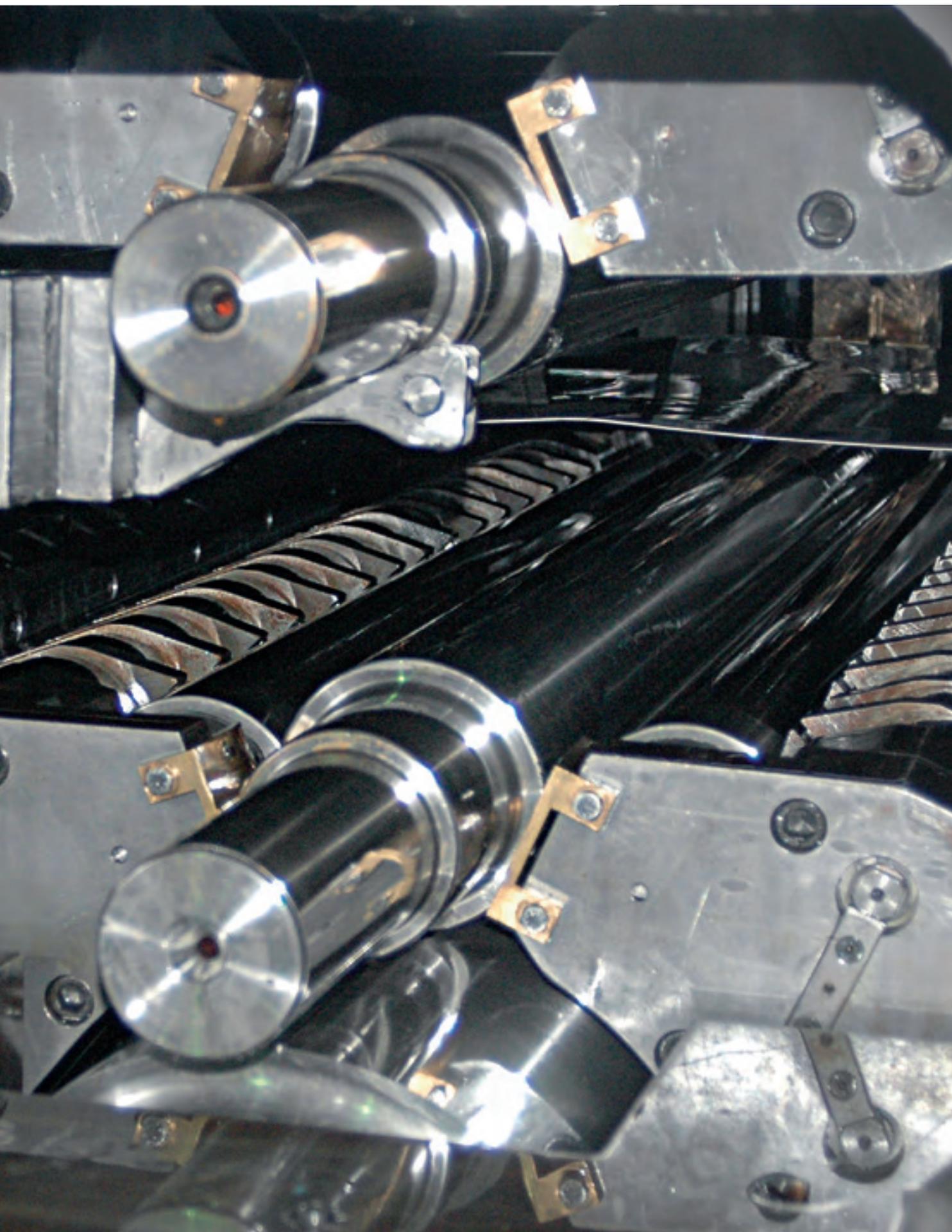
# PUT MORE MUSCLE INTO YOUR MILL

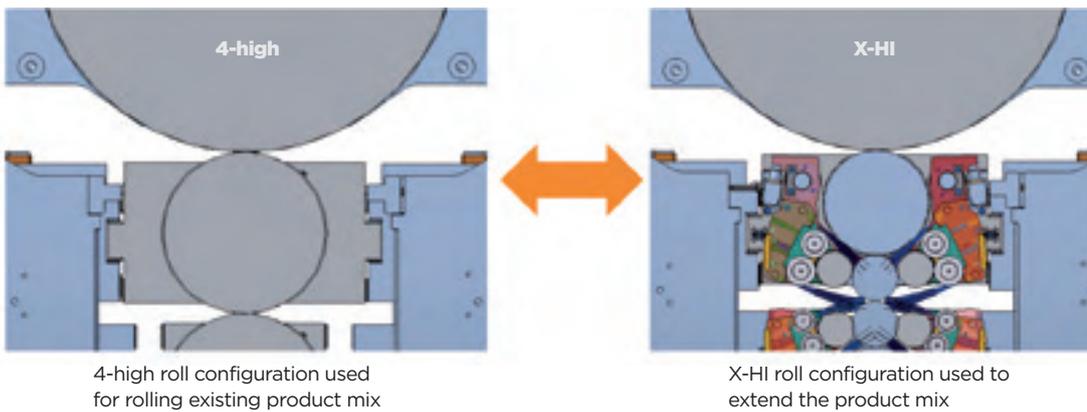
## THE NEW FLEX-HI ROLL CASSETTE INCREASES MILL POWER FOR ROLLING AHSS STEEL GRADES

Flex-HI mill technology was recently introduced by Primetals Technologies to allow existing cold-rolling mills to produce a wider variety of steel grades without substantial equipment investments. Using an interchangeable roll-cassette system, a mill can be switched between 4-high and X-HI modes as fast as a standard roll change. In this way, the demand for harder, thinner AHSS steels can be quickly met in a cost-efficient manner.

**FIG. 1:** X-HI rolling mode with small work-roll diameters and driven intermediate rolls







**FIG. 2:** Comparison of 4-high and X-HI roll configurations. A rolling mode change is carried out by exchanging the 4-high and X-HI roll cassettes within a typical roll-change time

## Primetals Technologies has developed a unique solution that significantly extends the cold-rolling capabilities of existing 4-high mills with only minor modifications.

Beyond traditional steel grades, demand has been growing steadily for AHSS (advanced high-strength steels), in particular for use in the automotive industry. Harder and thinner flat-steel products contribute significantly to weight reduction of vehicles and consequently to improved fuel economy. Steel producers are therefore faced with the challenge of producing dual-phase or TRIP (transformation induced plasticity) steels for the automotive industry and silicon steels for electrical appliances, which frequently exceeds the capability of installed rolling facilities.

Established 4-high and 6-high cold-rolling mills (typically with driven work rolls) have known limits in their reduction capability. This is mainly due to excessive work-roll flattening that takes place with high rolling forces. This widely acknowledged fact has led in the past to the introduction of cluster mill types (for example, 20-high or Z-high) with much smaller work-roll diameters to be able to produce stainless steel and special steel grades.

### INTRODUCTION OF THE FLEX-HI MILL SOLUTION

As new mill installations require substantial investments, steel producers prefer to continuously upgrade existing equipment to maintain and strengthen their competitive position. In order to meet current and future requirements of mill operators, Primetals Technologies has developed a unique solution that significantly extends the cold-rolling capabilities of existing 4-high mills with only minor modifications. This new mill technology, called Flex-HI, enables the operation of individual stands either in 4-high mode with large work rolls or in 6-high mode with small work rolls (X-HI mode). This is achieved with the use of quickly interchangeable cassettes. Flex-HI thus makes it possible to maintain high productivity for soft to medium-strength

materials in the 4-high mode, and to extend the product mix with new generations of AHSS or silicon steels in the X-HI configuration (see Figures 1 and 2). This solution thus represents the innovative combination of two proven technologies of Primetals Technologies.

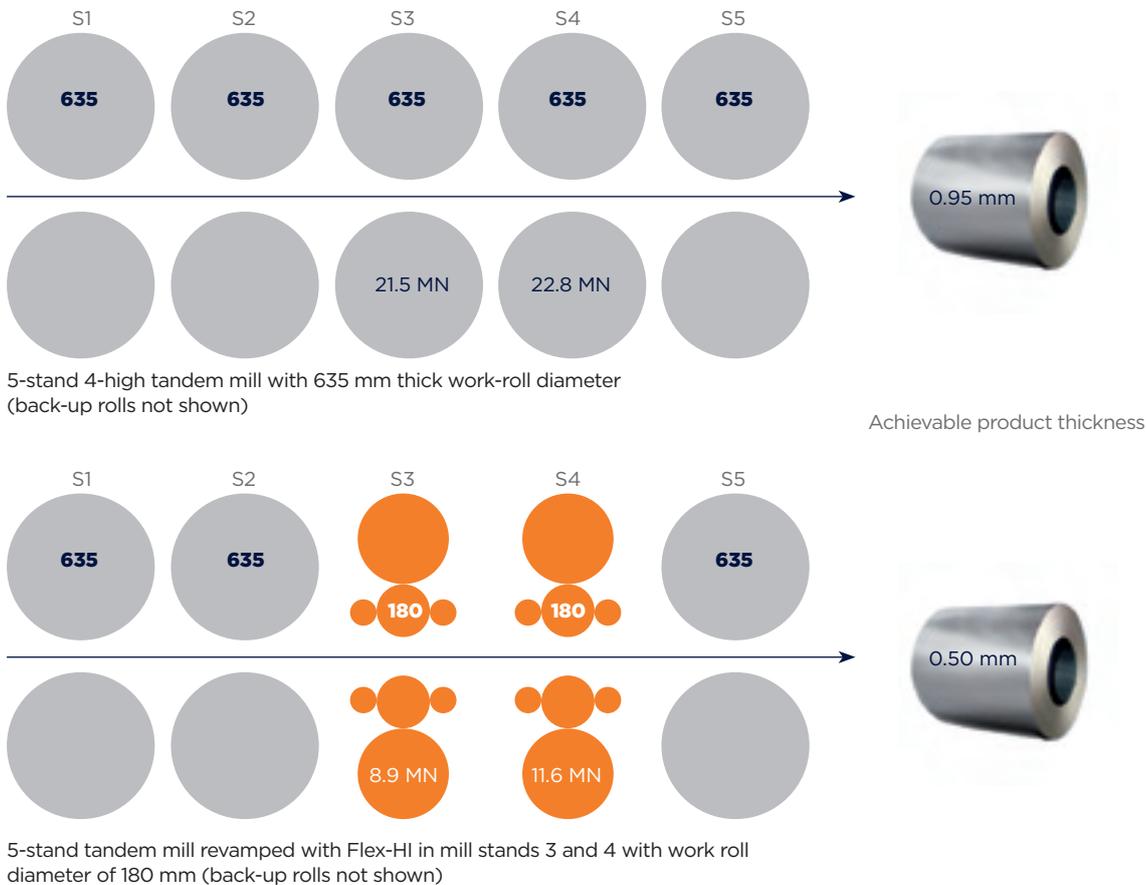
Flex-HI mill technology can be ideally installed in existing 4-high reversing mills and in tandem cold-rolling mills. In 5-stand tandem cold-rolling mills, for example, the intermediate mill stands (Nos. 2, 3 and 4) can be outfitted with a Flex-HI system. Reduction capability in the X-HI mode, especially in mill stands 3 and 4, is significantly greater than in the 4-high mode since the incoming strip into these mill stands is already work-hardened and thin.

### THE FLEX-HI MILL

The X-HI mill insert consists of driven intermediate rolls, small work rolls and lateral support rolls on both sides of the work roll. The lateral support rolls are mounted on movable arms, which are connected to the intermediate roll chocks. This simple cassette system makes it possible to change from the 4-high rolling mode to the X-HI mode and back without increasing work-roll change time. This elegant solution allows the highly flexible production of a wide range of steel grades. The back-up rolls remain unchanged and are used in both rolling modes.

Compared to traditional 4-high and 6-high technology, the work-roll diameters of the X-HI mill insert are much smaller, which results in significantly reduced rolling forces and rolling torques. Especially for the production of hard and thin products, the small work-roll diameter permits large thickness reductions without costly intermediate annealing treatment.

### Incoming hot band: DP980, 2.0 mm x 1,270 mm



**FIG. 3:** Comparison of achievable final strip thicknesses in a 5-stand 4-high tandem mill and in a 5-stand tandem mill equipped with two Flex-HI mill stands for a dual-phase 980 steel grade with an incoming hot-rolled strip thickness of 2.0 mm and width of 1,270 mm

Figure 3 illustrates an example of achievable product thickness after cold rolling for an incoming hot-rolled dual-phase 980 steel grade with a strip thickness of 2.0 mm and width of 1,270 mm produced on an Arvedi ESP line. For a 5-stand tandem mill with a classical work-roll diameter of approximately 635 mm and with all five stands working at the operating force limit (roughly 22 MN roll separating force), the achievable product thickness is approximately 0.95 mm. A simple mode change in mill stands 3 and 4 from 4-high to X-HI with a work-roll diameter of 180 mm allows the product thickness to be reduced to 0.5 mm at significantly lower rolling-force levels (9–12 MN roll-separating force).

Cooling and lubrication is provided by a water/oil emulsion. In the patented system of Primetals Technologies, the nozzles are mounted in the side support arms close to the work rolls. This ensures reliable roll-gap lubrication

and effective roll cooling to achieve rolling speeds in X-HI mode of up to 500 m/min.

### MEETING MARKET CHALLENGES

The Flex-HI solution from Primetals Technologies allows an existing cold-rolling mill to be operated in both the established 4-high configuration, and, after a roll-cassette change, in a 6-high cluster-mill configuration to extend the product mix to include new generations of high-strength steels. The described solution offers steel producers an attractive and cost-effective option to meet the increasingly demanding market challenges. The first engineering order for the supply of Flex-HI roll cassettes was received in June 2015 from a Midwestern U.S. steel producer. ●

**Dr. Konrad Krimpelstätter**, Head of Technology and Innovation, Hot and Cold Mills, Primetals Technologies Austria



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# LONG-TERM IMPROVEMENTS, **SHORT-TERM ROI**

## **MQL: ENHANCED LUBRICATION SOLUTIONS FOR COLD-ROLLING MILLS**

Demand for new steel grades and efforts to increase mill efficiency are driving advances in roll-gap lubrication. In cooperation with several industry partners, Primetals Technologies has recently developed Minimum Quantity Lubrication – a considerably improved lubrication solution that contributes to enhanced strip surface cleanliness, reduced rolling forces, lower electrical energy rates, and a decreased specific oil consumption.



**FIG. 1:** The MQL spray bar (left) with quick-change nozzles (right)

Optimized rolling processes and systems are necessary to maximize product quality, reduce operational costs and to extend the product mix to include new steel grades and thinner-gauge strip. Customized roll-gap lubrication and cooling solutions are also vital to achieve these targets. The lubricants must be optimized for all rolling applications and also have to fulfill the quality and quantity demands for a wide variety of steel grades. For these reasons, Primetals Technologies, Quaker Chemical Corporation, voestalpine Steel and Johannes Kepler University in Linz entered into an exclusive cooperation in early 2009 to pool their knowledge, experience and resources to acquire a better understanding of the complex tribological phenomena in the roll gap.

“Cooperation between rolling-mill suppliers, lubricant manufacturers and rolling-mill operators is an ideal way to develop oils and emulsions that meet all rolling requirements,” commented Peter Schellingerhout, Global R&D Manager at Quaker. “By pooling our forces and competencies, we can use our collective experience to develop specific market solutions.”

### THE MQL SOLUTION

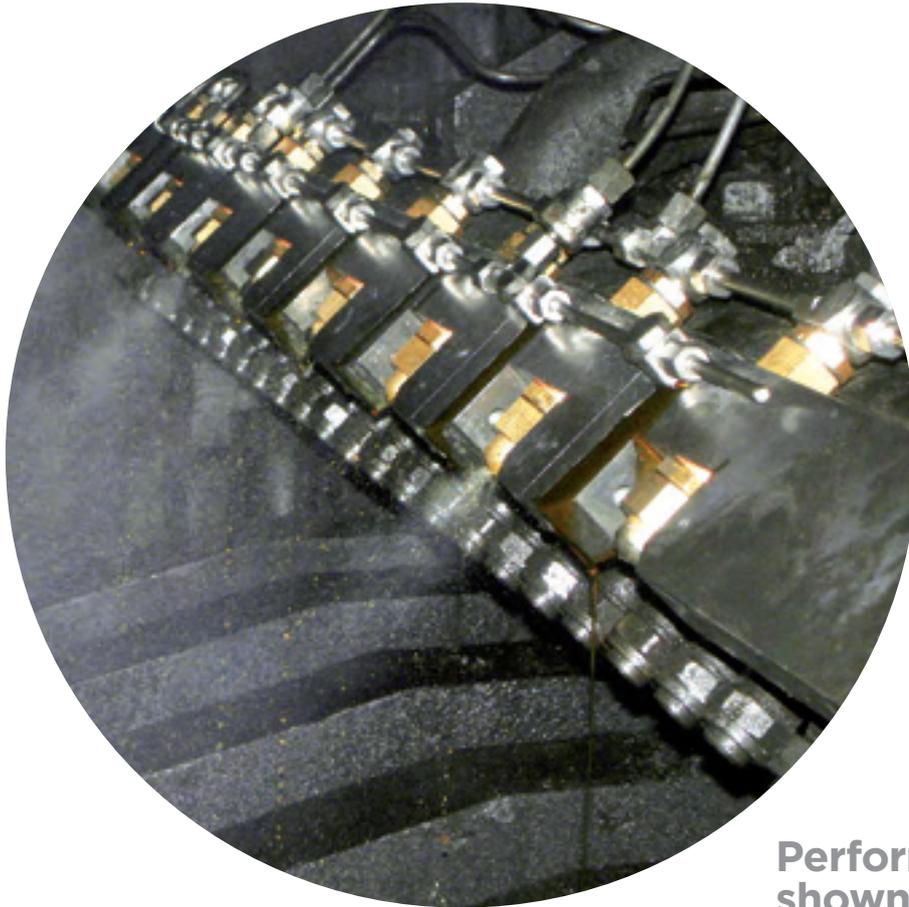
Minimum Quantity Lubrication (MQL) represents an outstanding example of a new generation of advanced roll-gap lubrication systems for cold-rolling mills that has

resulted from these efforts. The system applies pure rolling oil that is finely atomized with air directly onto the work-roll surfaces. This allows for an intelligent control of the oil-film thickness depending on the rolling process and product parameters. MQL not only ensures an optimum product-specific lubrication quantity, the rapid change of lubrication settings ensures a much higher degree of flexibility than had been previously possible with classical emulsion systems. Compared to conventional roll-gap lubrication with directly applied or recirculated emulsions – where the oil concentration inside the roll-bite is affected by plate-out and wash-off effects – MQL maximizes the level of oil concentration in the bite and therefore optimizes lubrication performance.

### DESIGNED FOR EFFICIENCY AND ROBUSTNESS

The oil is applied through robust spray bars that comprise spray nozzles and oil/air mixing headers specifically designed for low flow rates (Figure 1). The new technology is the result of extensive development activities to optimize nozzle design and to identify optimum process parameters to ensure a uniform and homogeneous distribution of oil droplets onto roll surfaces. The system features the use of simple quick-change nozzles for minimized maintenance work. Customers benefit from this technology through energy savings that arise from reduced rolling forces and rolling torques; improved »

**FIG. 2:** Spray bar in industrial operation at a European steelworks



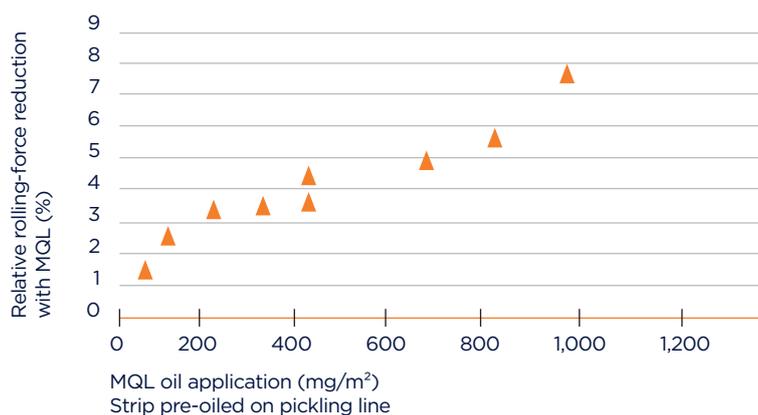
**Spray system off**

Performance tests have shown that the application of MQL extends plant capabilities, reduces opex and adds value to products.

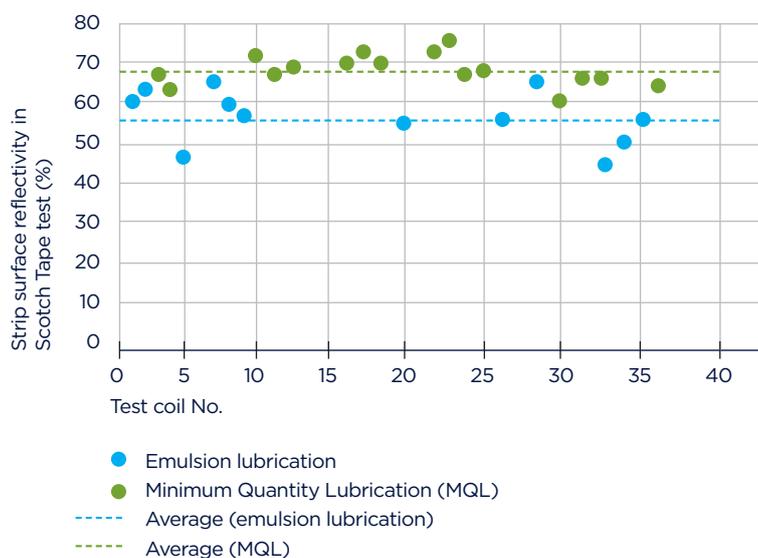


**Spray system on**

**FIG. 3:** Comparison of relative rolling-force reductions using MQL compared to entry-side emulsion with increasing lubrication quantities for the same steel grade and product dimensions



**FIG. 4:** Improvement of strip-surface cleanliness with MQL on stand 1 of a 4-stand tandem cold-rolling mill



strip surface cleanliness; extended work-roll lifetime; enhanced reduction capability of their rolling facility; and the possibility to extend their product mix.

### PROTOTYPE INSTALLATION AND RESULTS IN COLD-ROLLING MILLS

MQL was successfully installed and tested on two different industrial tandem cold-rolling mills in Europe (Figure 2). Both customers confirmed the industrial reliability and effectiveness of this new lubrication technology as demonstrated by significant improvements of strip surface cleanliness and roll-force reductions. In the first test series, more than 200 coils were successfully produced applying MQL instead of entry-side emulsion lubrication. In all cases, the observed rolling forces were lower with the use of MQL for the same steel grade and product dimensions. As expected, the rolling forces decreased with increasing oil application (Figure 3).

In subsequent test runs the influence of MQL on strip surface cleanliness was evaluated on the basis of the measured reflectivity from Scotch Tape tests (Figure 4). For these tests, MQL was applied only on stand 1 of a tandem cold-rolling mill. By improving the boundary

lubrication in stand 1, the strip wear could be significantly reduced. This resulted in fewer iron fines on the strip surface and an improved average reflectivity of about ten percentage points.

### THE MQL TECHNOLOGY PACKAGE

A pre-tested MQL technology package consisting of spray bars, an oil-supply unit and a process unit with a defined interface to the mill automation system is available to customers. The system can be easily installed on existing mills either as an additional lubrication system or to replace an existing roll-gap lubrication system. Performance tests have shown that the application of MQL extends plant capabilities, reduces opex (operational expenditures) and adds value to products.

A renowned European steel producer recently placed the first industrial order for the installation of MQL on the first two rolling stands of their tandem cold-rolling mill. ●

**Dr. Martin Bergmann**, R&D Project Manager, Cold Rolling

**Dr. Konrad Krimpelstätter**, Head of Technology & Innovation, Hot and Cold Mills

(Both with Primetals Technologies Austria)

# CHATTERBLOCK CONTROL

## A LOW-COST SOLUTION FOR HIGH-RETURN BENEFITS

### REDUCING MILL VIBRATION IMPROVES PRODUCTIVITY AND PRODUCT QUALITY

A destructive form of mill vibration known as third-octave chatter is a serious problem in most cold-rolling mills. It often leads to costly damage and reduced mill performance. Primetals Technologies has introduced a unique anti-chatter system to eliminate chatter. This allows a mill to operate at higher rolling speeds – even up to maximum mill speed.

Rolling mills are prone to many different vibration phenomena, especially when rolling high-strength steels in combination with thin product gauges and high rolling speeds. These vibrations can have a significant impact on quality and productivity in cold-rolling mills. The most destructive form of mill vibration, termed third-octave chatter, occurs in a frequency range between 90 Hz and 150 Hz. It is a self-excited vibration, meaning that once it commences, it can grow quickly and result in unstable and uncontrollable rolling conditions. Producers are often faced with financial loss due to a reduction in cold-rolling speeds, strip breakage, equipment damage and production downtime.

As a leading supplier of vibration consultancy services and solutions, Primetals Technologies has developed a unique anti-chatter system that is able to fully eliminate third-octave gauge chatter in cold-rolling mills.

#### START OF DEVELOPMENT ACTIVITIES

Primetals Technologies took on the challenge to find a solution to counter third-octave gauge chatter, a problem for which at that time it was thought that no solution

could be found. Only diagnostic aids, such as chatter-monitoring systems that passively detect mill vibrations, were available on the market. Solving the problem first required an in-depth root-cause analysis of the chatter phenomenon – from a physical and control/stability point of view. It could be determined that mill chatter represents a process-parameter-excited instability that is generated in the roll gap. The solution thus required a stabilizing system that brings the rolling mill back into a stable and controllable state. This is possible by actively exerting a damping effect on the powerful roll-force cylinders without hampering the automatic gauge-control (AGC) system of the mill.

Primetals Technologies therefore focused on the development of new controller algorithms and the use of completely new, highly dynamic servovalves and hydraulic design solutions to control vibration frequencies between 90 Hz and 150 Hz. Since the frequency range of strip-gauge control is typically less than 20 Hz, a negative influence of the anti-chatter system is avoided because it operates well outside the frequency range of the gauge-control system. »

**FIG. 1:** ChatterBlock  
Control system installed at  
Novolipetsk Steel, Russia



## Primetals Technologies has developed a unique anti-chatter system that is able to fully eliminate third-octave gauge chatter in cold-rolling mills.

### INITIAL LAB TRIALS CONFIRM SOLUTION CONCEPT

The anti-chatter solution concept was first investigated during lab trials at Johannes Kepler University (JKU) in Linz, Austria. The testing facility included hydraulic cylinders that could be actuated using a newly developed, highly dynamic servovalve from the company Moog Inc. During these trials, the pressure control on the rod side of the hydraulic cylinders was destabilized to generate vibrations, which were then stabilized by exerting a damping effect. The tests were successful and the next step was to find a steel producer where a pilot ChatterBlock Control system could be installed and investigated in an industrial environment.

### INVESTIGATION OF CHATTERBLOCK CONTROL IN AN INDUSTRIAL ENVIRONMENT

Russian producer Novolipetsk Steel (NLMK) agreed to cooperate with Primetals Technologies to implement ChatterBlock Control to suppress mill vibration in their rolling mill (Figure 1). One of the testing procedures applied was to modify existing AGC cylinders to obtain a dynamically suitable hydraulic inlet where the so-called chatter valve could be mounted. This required the availability of one or more spare AGC cylinders. The entire ChatterBlock Control installation was carried out quickly in three single-day steps during scheduled mill downtimes for backup-roll exchange. The work comprised:

- Installation of the electrical system (two electrical cubicles at the mill stand and one main cubicle in the automation control room)
- Exchange of the AGC cylinders
- Hydraulic modifications to connect the new hydraulic valves to the existing system

### SOLUTION BREAKTHROUGH

When the ChatterBlock Control system was activated for the first time, the controller gain was increased systematically by gradually intensifying system damping to stabilize the rolling process. By means of an online FFT (Fast Fourier Transform), system functionality could be continuously observed, which allowed mill speeds to be accelerated even above chatter-critical rolling speeds.

Figure 2 illustrates what happened when the ChatterBlock Control was switched off at high mill speed. Immediately, mill chatter appeared and rapidly increased. The operator had to react quickly to reduce mill speed and bring the system back into a safe operating mode. This trial represented a major breakthrough for ChatterBlock Control.

Figure 3 shows further impressive results that were achieved during the final acceptance tests of the ChatterBlock Control system at NLMK. The maximum mill speed with and without ChatterBlock Control switched on was compared. With the system turned off, the maximum possible mill speed for a particular rolled-steel product was approximately 1,300 m/min. With the anti-chatter system activated, it was possible to accelerate the mill up to the maximum mill speed of 1,450 m/min without the occurrence of any excessive vibration or negative strip-quality effects, such as chatter marks or out-of-tolerance thickness variations.

### DECISIVE BENEFITS FOR PRODUCERS

This first industrial installation at NLMK clearly demonstrated the reliability and effectiveness of ChatterBlock Control. Investigation results showed that a 10% increase in maximum mill speed is possible, which converts into an impressive increase in plant productivity and additional product sales earnings. ChatterBlock Control is available as an autonomous technology package that can be modified to meet the individual vibration-solution requirements of both new and existing mills. Through the suppression of unwanted mill vibration, producers also benefit from prolonged equipment lifetime, improved product quality and higher profit margins. ●

**Georg Keintzel**, Senior Expert, Mechatronics, R&D Project Manager

**Dr. Konrad Krimpelstätter**, Head of Technology & Innovation, Hot and Cold Mills

(Both with Primetals Technologies Austria)

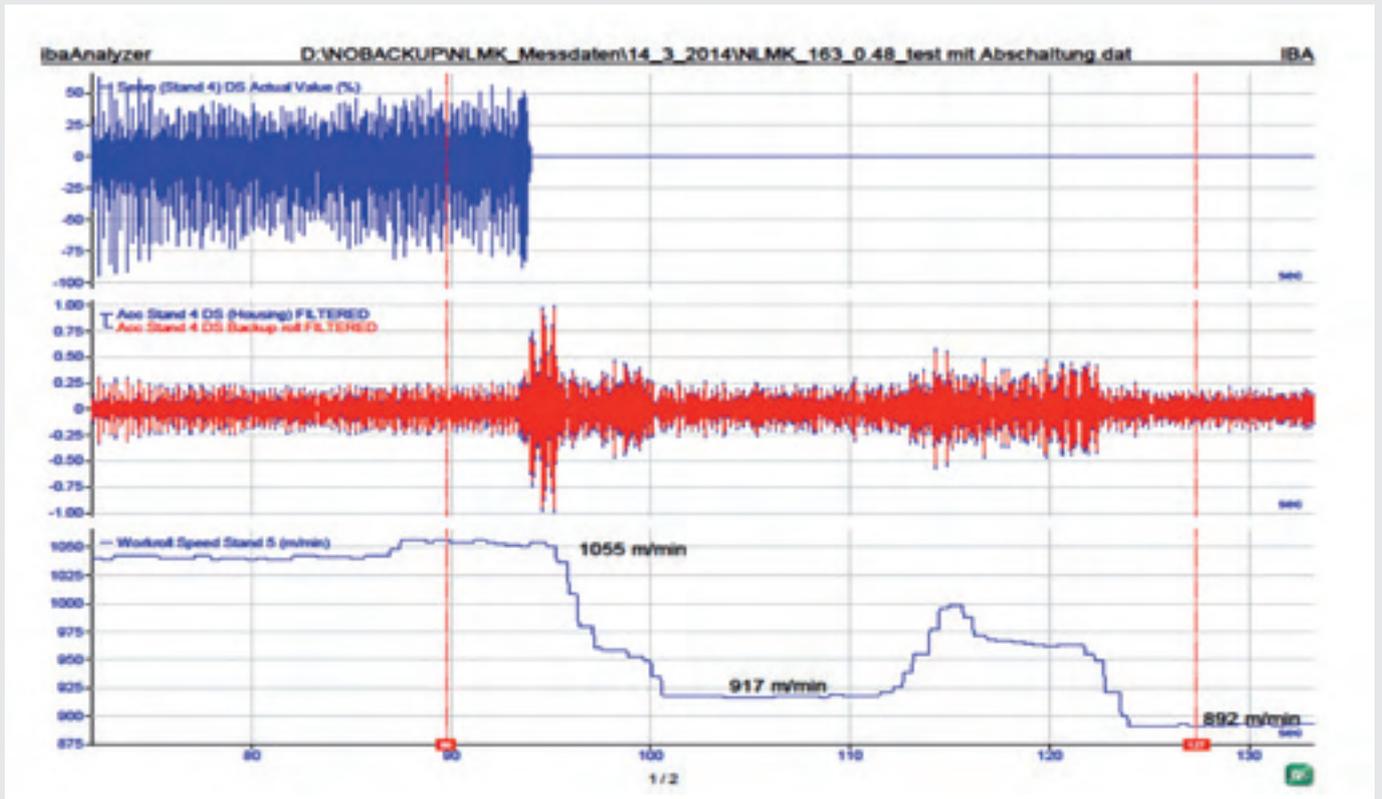


FIG. 2: Chatter arising after damping was shut off required a quick reduction in mill speed (iba measurement system print-out)

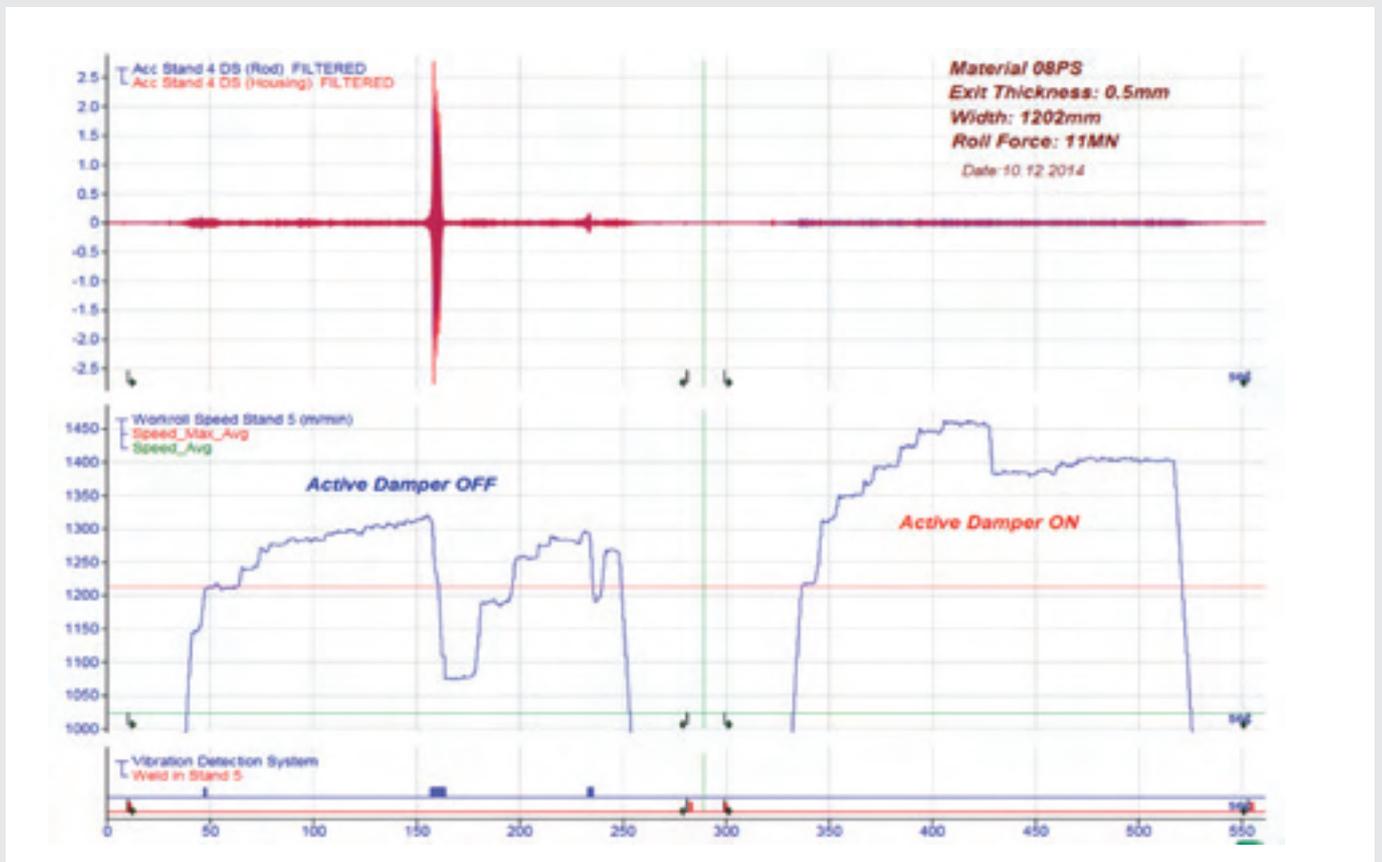


FIG. 3: Anti-chatter mode allows higher and more consistent mill speeds (iba measurement system print-out)



# ROLLING FOR **THE FUTURE**

## **THE NEW COLD-ROLLING COMPLEX AT TOSYALI-TOYO CELIK A.Ş., TURKEY**

In autumn 2014, Tosalı-Toyo Celik A.Ş. awarded Primetals Technologies a contract for rolling facilities that included a coupled pickling line-tandem cold mill (PL-TCM), a tin-plated steel-sheet continuous annealing line (Tin-CAL) and a temper double-cold-reduction (DCR) mill for a new cold-rolling complex in Osmaniye, Turkey. Installation of the mill complex commenced in March 2016, and progress is advancing smoothly in accordance with the project time schedule.

In 2012, Tosalı-Toyo Celik was officially inaugurated as a company with the signing of a joint-venture agreement between Tosalı Holdings of Turkey and the Japanese company Toyo Kohan Co., Ltd. The new cold-rolling complex is designed to produce cold-rolled steel sheet, tin-plated steel sheet, hot-dip galvanized steel sheet and painted steel. Primetals Technologies was selected as the main contractor for the supply of all equipment, including the most advanced technological mechanical equipment, the electrical equipment and automation systems, as well

as the field engineering, supervision of installation and commissioning, and training for operating personnel in Osmaniye. The PL-TCM will feature the patented iBox pickling process and a 5-stand 6-high Universal Crown Control Mill (UCM) for all stands. The stands will be driven by an all-digital AC drive system and the high-response hydraulic gauge control (HGC) system Hyrop-F. A new state-of-the-art automatic gauge control (AGC) system will be installed to ensure highly precise rolled strip thicknesses. With this equipment, the PL-TCM is designed to

roll 1 million tons of high-quality, cold-rolled steel strip and black plate per year. Furthermore, the technology will help increase production efficiency and improve production yield and quality, and thereby obtain a higher return on investment. Table 1 shows the main design specifications of the PL-TCM. The Tin-CAL will have an annual production of 240,000 tons. The vertical-type annealing furnace will consist of pre-heating (PHS), heating (HS), soaking (SS), first-cooling (1CS), second-cooling (2CS) and third-cooling (3CS) sections, all developed by Primetals Technologies. The annealing furnace is designed to flexibly produce T1 through T5. A compact-type tension leveler will be installed after the cleaning section in order to correct material strip-shape deviations. This is important to ensure smooth and reliable operation in the annealing furnace, even at a maximum line speed of 500 m/min. Table 2 shows the main design specifications of the Tin-CAL.

The temper DCR mill will consist of a two-stand UCM and is designed to perform double-cold reduction as well as two-stand temper rolling. In the DCR process, the annealed strip, after reduction in a tandem cold mill, is reduce rolled on the No. 1 stand and temper rolled on the No. 2 stand. This process imparts the strip with its prescribed mechanical strength. In two-stand temper rolling, the strip is temper rolled in both stands 1 and 2 to the prescribed elongation ratios to obtain the desired mechanical characteristics.

### PROGRESS ACCORDING TO PLAN

Almost all mechanical and electrical equipment has been delivered to the Osmaniye site. Installation work is now progressing smoothly. Primetals Technologies has already dispatched some field-service engineers to supervise site installation and will dispatch more engineers as the project moves forward. The hot run of the facilities is scheduled for late 2016, which will be carried out jointly with Tosyali-Toyo Celik personnel. ●

**Ichiro Maeno**, Senior Vice President,  
Head of Portfolio Management for  
Downstream Technologies

**Yoichi Kai**, Expert, Portfolio Management,  
Processing Lines  
(Both with Primetals Technologies)

**TABLE 1:**

### MAIN SPECIFICATIONS OF THE PL-TCM

<b>Capacity</b>	1 million t/a
<b>Entry strip gauge</b>	1.6 mm to 4.0 mm
<b>Entry coil weight</b>	30,000 kg
<b>Exit strip width</b>	700 mm to 1,300 mm
<b>Exit strip gauge</b>	0.16 mm to 2.0 mm
<b>Exit coil weight</b>	30,000 kg
<b>Material grades</b> - Cold rolled - Black plate	ULC (IF), HSLA DD11-DD14 (DI EN 0111)
<b>Line speed at mill exit</b>	1,440 m/min. max.

**TABLE 2:**

### MAIN SPECIFICATIONS OF THE TIN-CAL

<b>Capacity</b>	240,000 t/a
<b>Entry strip width</b>	700 mm to 1,300 mm
<b>Entry strip gauge</b>	0.16 mm to 0.8 mm
<b>Entry coil weight</b>	30,000 kg max.
<b>Exit strip width</b>	700 mm to 1,300 mm
<b>Exit strip gauge</b>	0.16 mm to 0.8 mm
<b>Exit coil weight</b>	30,000 kg max.
<b>Products</b>	T1, T2, T3, T4, T5
<b>Line speed (center)</b>	500 m/min. max.

**TABLE 3:**

### TEMPER DCR MILL SUMMARY OF SPECIFICATIONS

<b>Annual capacity</b>	303,000 tons
<b>Entry strip width</b>	700 mm to 1,300 mm
<b>Entry strip gauge</b>	0.16 mm to 1.2 mm for temper-rolled strip 0.18 mm to 0.4 mm for DCR-processed strip
<b>Entry coil weight</b>	Max. 30,000 kg
<b>Exit strip width</b>	700 mm to 1,300 mm
<b>Exit strip gauge</b>	0.16 mm to 1.2 mm for temper-rolled strip 0.12 mm to 0.3 mm for DCR-processed strip
<b>Exit coil weight</b>	Max. 30,000 kg
<b>Material grade</b>	T1-T5, DR6-DR10
<b>Line speed (center)</b>	Max. 1,500 m/min

# VALUE-ADDED STRIP

## FOR THE AUTOMOTIVE MARKET

### CONTINUOUS GALVANIZING LINE SUPPLIED TO JFE STEEL GALVANIZING INDONESIA

Primetals Technologies, a leading supplier of strip-processing lines, started up a new continuous galvanizing line (CGL) at P.T. JFE Steel Galvanizing Indonesia (JSGI) in Bekasi, Indonesia. The facility, which has an annual production capacity of 400,000 tons, is an investment by JFE Steel Corporation to supply advanced steel grades to the automotive market (Figure 1).

**FIG. 1:** View of the continuous galvanizing line facility of JFE Steel Galvanizing Indonesia





**TABLE 1:****MAIN TECHNICAL SPECIFICATIONS OF THE CONTINUOUS GALVANIZING LINE**

<b>Strip thickness</b>	0.4 mm to 2.3 mm
<b>Strip width</b>	800 mm to 1,850 mm
<b>Coil weight</b>	30,000 kg
<b>Welder type</b>	Mash seam welder
<b>Furnace type</b>	Vertical
<b>Coated material</b>	Galvanized and galvanized
<b>Additional equipment</b>	Skin-pass mill, side trimmer



2.



3.

**FIG. 2:** The continuous galvanizing line in operation at JSI**FIG. 3:** Entry section of the continuous galvanizing line

## The facility is designed to produce a wide range of high-quality exposed automotive products in a combination line for annealed or galvanized strip.

The CGL at JSGL has performed reliably since its start-up in January 2016, 29 months after the contract signing. The facility is designed to produce a wide range of high-quality exposed automotive products in a combination line for annealed or galvanized strip (Figure 2). Strip thicknesses extend from 0.4 mm to 2.3 mm at widths between 800 mm and 1,850 mm. Processed strip grades include commercial quality (CQ), drawing quality (DQ), deep-drawing quality (DDQ), extra-deep-drawing quality (EDDQ), super-extra-deep-drawing quality (SEDDQ) and high-strength steels (HSS) for automotive applications. Table 1 shows the main technical specifications of the CGL. The features of the different sections, products and benefits are described in the following.

### ENTRY SECTION

Dual pay-off reels and associated equipment are installed in the entry section (Figure 3) of the galvanizing line to allow continuous strip feeding. The vertical entry looper after the entry section ensures sufficient strip storage in the tower so that continuous uninterrupted operations can take place in the process section while the strip is stopped for welding in the entry section. This is possible even at maximum process line speed. Removal of strip-surface impurities takes place in the cleaning section, which consists of a series of alkali dip-cleaning tanks, a brush scrubber, an electrolytic cleaning section, as well as auxiliary circulation systems to achieve superior cleaning results.

### CENTER SECTION

The advanced continuous annealing furnace is distinguished by its strip-heating and cooling system, thermal crown control of the furnace rolls, and stable strip speed. The vertical-type annealing furnace consists of a preheating zone, radiant tube heating, a soaking zone, rapid cooling and a turndown section. As the strip passes through the annealing furnace, defined heating and cooling steps (thermal cycles) are carried out depending on the strip grade to be produced.

Thermal crown control of the furnace rolls, accurate strip-tension control, optimum positioning of the steering

and bridle rolls, and precise roll crown and surface roughness are the key factors to ensure fine strip quality, stable line operation and steady strip speed. In order to produce galvanized strip, a coating pot with a channel-type induction-heating system, a galvannealing induction-heating furnace, as well as up- and down-leg cooling equipment is provided.

A vertical-type center looper is installed after the pot-cooling area and skin-pass mill to enable uninterrupted continuous operation in the process section. The 4-high wet-rolled skin-pass mill enhances the mechanical properties of the strip, ensures excellent strip flatness and imparts the required strip-surface roughness.

### DELIVERY AND INSPECTION SECTIONS

After passing through a chemical treatment section and delivery looper, the galvanized strip edges are trimmed by a highly accurate side trimmer. Together with fully automated parameter setup, high-yield side trimming is assured. The scrap baller winds trimmed scrap into a scrap ball, which is subsequently transferred to the scrap buckets by the scrap conveying system.

After inspection in the delivery inspection station, the strip is oiled, cut on the fly and then coiled by a tension reel. A quick sample gate is installed behind the flying shear. When a coil is wound completely, the reel mandrel collapses and a coil car takes the coil off the mandrel for placement onto the exit coil saddle. The coil is then picked up and transferred to the coil unloading position by the exit coil transfer car. Load cells on the skid measure the coil weight.

### A PROMISING OUTLOOK

The line was successfully started up in January 2016 following hot-run tuning of the annealing furnace and other equipment. The line now produces high-quality steel products for automotive customers in Southeast Asia. ●

**Hiroshi Watanabe**, General Manager, Process Line Project Division, Project Management Department, Hiroshima Works, Primetals Technologies Japan

# SERVICING PROCESSING LINES THROUGH REMOTE ACCESS

**DRAMATIC ADVANCES IN IT AND DATA-MANAGEMENT TECHNOLOGIES  
ENABLE A NEW DIMENSION OF SERVICE SUPPORT**



**FIG. 1:** The TCOptimizer software tool processes massive volumes of data to generate relevant-only manufacturing events and just-in-time warnings

A new period of big data and knowledge management has dawned. Besides the traditional services dedicated to equipment and hardware lifecycle management, new opportunities have arisen as a result of the digital revolution. Advancements in IT and communication systems are now being leveraged to fulfill the ever-increasing demands for production-plant efficiency.

Many aspects of steel production have changed dramatically with increasing levels of digitalization and data-management systems. This also applies to metallurgical plant service. For more than ten years now, Primetals Technologies has been focusing on having the necessary hard- and software in place to be able to efficiently provide digital-based remote services. Activities include setting up the right software functionalities and establishing dedicated service expert teams. As such, it has been possible to respond to customer requests in a timely manner to avoid production disruptions and to sustain quality levels. The merits of remote servicing of processing lines to create value for customers has already been demonstrated by Primetals Technologies.

#### **QUALITY MONITORING SYSTEMS AND SERVICES**

To assist steelmakers in quality and process optimization across the entire steel production chain, and also to effectively handle important data from different automation and monitoring systems, Primetals Technologies offers a through-process quality-control system (TPQC). This know-how, rule-based system for metallurgical plants can

be steadily extended and upgraded with additional know-how rules derived from operational data and experience, such as metallurgical, numerical and process-related rules.

Another product that can be integrated in the TPQC as well as installed as a stand-alone solution is the TCOptimizer (total condition optimizer). This unique and advanced software is used for just-in-time warnings and features computing intelligence that highlights relevant events without overwhelming users with gigabytes of data (Figure 1). This central expert system collects data and signals from all parts of the production chain by means of the embedded Business Rule Management System (BRMS). The BRMS is based on simple logical expressions and decision trees to allow non-IT specialists to handle the incoming signals and to manage the generated relevant-only manufacturing events and just-in-time warnings.

Designed for enabling remote access, in-line functionalities can be accessed directly from offices of Primetals Technologies and their network of experts. Of course, remote activities are only carried out with the prior authorization of the customer. The BRMS is used to pre-analyze the selected data so that only the relevant information and alarms are transmitted to the connected expert. Through this approach, timely answers to specific issues can be provided, even via lower-speed Internet connections. In processing lines, for example, pre-processing of data is based on 10 m long coil segments for addressing quality-tracking requirements and optimizing data volumes to be loaded.

Technical assistance through remote access is usually provided to help diagnose process deviations and to tune business-rule parameters, such as alarm thresholds. With this approach, additional assistance in the metallurgical field can be provided in a very efficient manner to determine the possible root causes of deviations. »

**The merits of remote servicing of processing lines to create value for customers has already been demonstrated by Primetals Technologies.**



# HEARING IS BELIEVING

## THE NEW ACOUSTIC EXPERT SYSTEM FACILITATES PLANT MONITORING AND MAINTENANCE WORK

Primetals Technologies introduced a unique acoustic monitoring system known as Acoustic Expert. The system detects sound deviations from the normal state and allows condition-based maintenance activities to be initiated before potential damage can take place. In combination with a new cloud service, evaluation of the sound emitted from steel-plant equipment is carried out, and this information can be accessed at the touch of a finger – 24 hours a day, 7 days a week. In 2016, the Acoustic Expert system was put into operation for the first time in a dedusting plant at voestalpine Stahl GmbH in Linz, Austria (Figure 1).



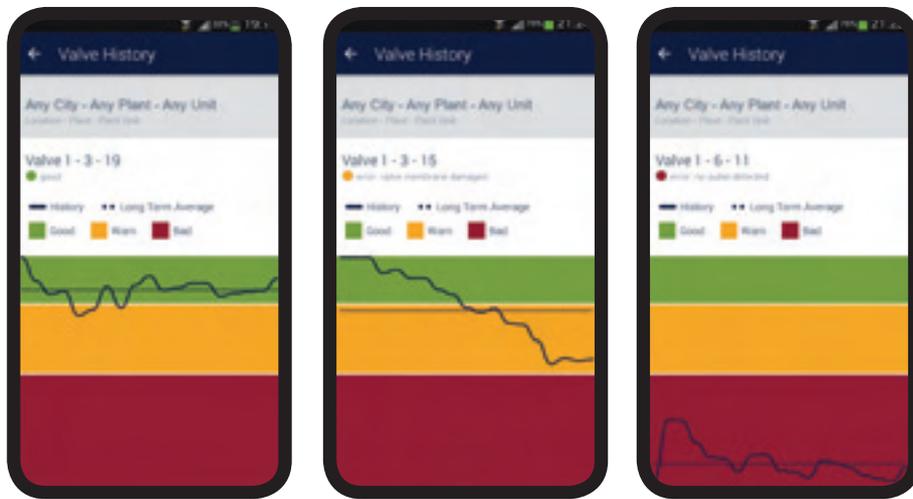
**FIG. 1:** Installation of the Acoustic Expert system in a dedusting plant at voestalpine Stahl, Austria

Designed on a bionic basis, Acoustic Expert is capable of continuously monitoring all plant equipment and components that emit a specific sound spectrum. Plant noise is generated, for example, by electric arc furnaces, the nozzles of torch-cutting machines in continuous casting plants, motors, drives, switching relays and valve stations.

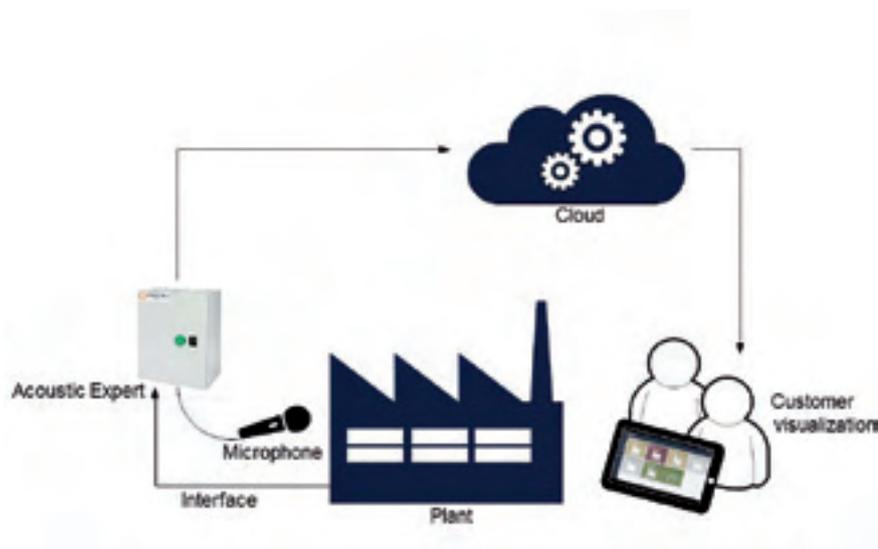
Whereas people find it difficult to detect gradual wear, Acoustic Expert makes this possible through long-term analyses of emitted sound. The system employs an industrial microphone, a monitoring system and an evaluation system.

### FIRST APPLICATION

Acoustic Expert was put to the test for the first time ever in the dedusting system of a secondary metallurgical plant. In this application example, Acoustic Expert monitors the sound caused by the cleaning valves of a pulse-jet bag-filter plant. The profile of each cleaning pulse is recorded in 500 ms long intervals and evaluated immediately afterwards. Audio data is recorded for analysis only and subsequently deleted after processing. Furthermore, Acoustic Expert does not identify human voices. Following data evaluation, the results are visualized in the customer's HMI (human-machine interface).



**FIGS. 2A TO 2C:** Visualization of performance of three different valves



**FIG. 3:** Acoustic Expert integrated within a cloud-service topology

## Acoustic Expert was put to the test for the first time ever in the dedusting system of a secondary metallurgical plant.

### EXAMPLE OF ACOUSTIC MONITORING AND EVALUATION RESULTS

The condition of three pulse-jet bag-filter valves that were sound-monitored with Acoustic Expert is depicted in Figures 2a to 2c. In the first case, the valve is working within an acceptable range, while the center picture shows a decreasing performance trend suggesting gradual wear on the valve membrane. Gradual equipment wear is particularly difficult to detect and in some cases it is discovered too late – namely once the problem becomes evident. With the online Acoustic Expert monitoring system, such wear can be detected earlier through historic trend analyses and interpretation. The third screenshot shows a valve operating at only 40% of its performance capability.

### SYSTEM FLEXIBILITY

In combination with an online connection, it is also possible to utilize Acoustic Expert as a cloud-based service. In this case, the system can be separated from the local IT network to enable a fully stand-alone monitoring solution. All in all, the system increases the plant-information level and contributes to increased plant productivity through the avoidance of equipment failure (Figure 3).

### SUCCESS STORY

Acoustic Expert was installed and put into operation in a secondary dedusting plant of voestalpine Stahl in Linz, Austria, in January 2016. The sound spectrum emitted by the pulse-jet valves during cleaning of the bag filter is analyzed, and any deviation from normal plant operation is detected by the acoustic system. Condition-based maintenance instructions are submitted to maintenance personnel on mobile devices. The Acoustic Expert system implemented at voestalpine was installed in one day without any plant stoppages, optimized in just two days, and brought into operation two months before the scheduled date. ●

**Andreas Rohrhofer**, Product Development, Electrics and Automation, Primetals Technologies Austria

### CLOUD-BASED SERVICES

Primetals Technologies has recently developed a new cloud-based data-monitoring and evaluation system. With this system, monitoring information from a steel plant can be merged within a single database and analyzed off-site. Advanced calculation algorithms are applied to provide detailed fault information on the basis of root-cause analyses. The results are made available to maintenance or management personnel with an intuitive app, which can be installed on mobile devices such as tablets and smartphones (Figure 4). Historical trend analyses improve the predictability and scheduling of maintenance requirements.

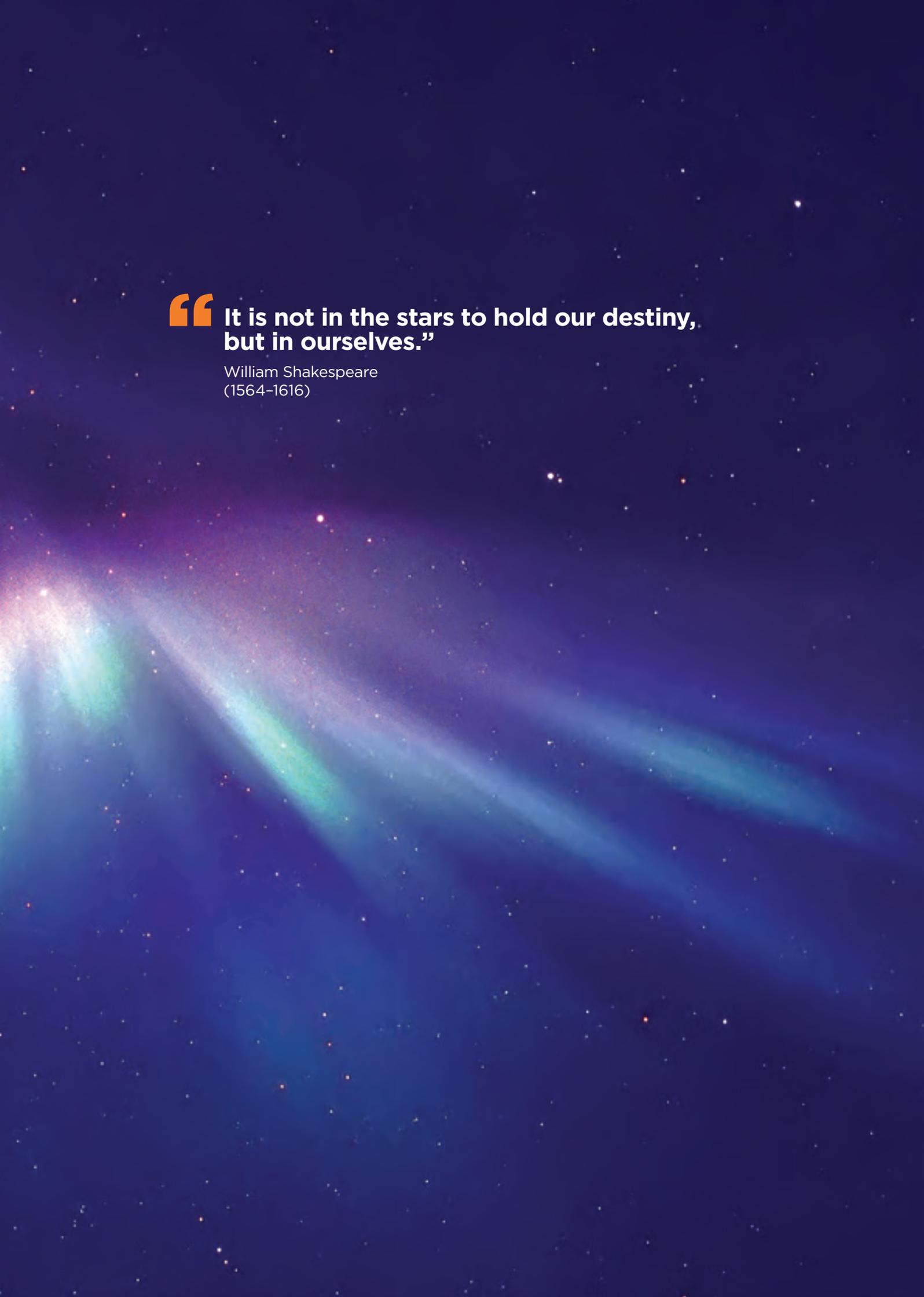
On-site monitoring equipment, which typically includes a server and the associated hardware components, can be minimized. Only a simple machine-to-machine (M2M) communication module with an interface to the customer's plant is required. Raw measurement data is sent to the cloud for analysis, and equipment investment costs can be notably reduced. Another highlight is that system updates and revisions can be carried out remotely without the need for local personnel or hardware modifications.

Acoustic Expert is the first monitoring system from Primetals Technologies to be integrated within a cloud-based service environment.



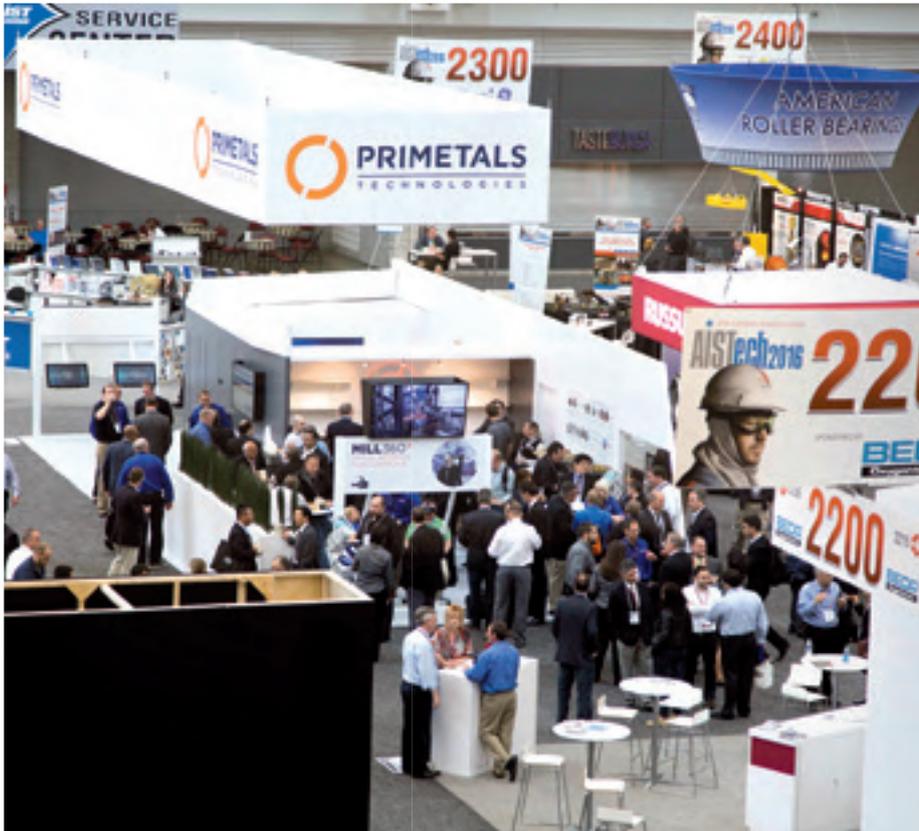
**FIG. 4:** Monitoring and maintenance data tracking with standard handheld devices





**“ It is not in the stars to hold our destiny,  
but in ourselves.”**

William Shakespeare  
(1564-1616)



Left: The company booth was highly visible in the exhibit hall

Top: With Mill360°, visitors experienced the latest technologies and reference plants in a 360-degree virtual-reality environment

## AISTECH 2016

### PRIMETALS TECHNOLOGIES USES INTERACTIVE DISPLAYS AND TECHNICAL PRESENTATIONS TO PROMOTE ITS PRODUCT PORTFOLIO

The AISTech 2016 Conference and Exposition took place May 16–18 in Pittsburgh, Pennsylvania, U.S.A. The event attracted some 7,800 producers, suppliers, corporate leaders and academics from 41 countries to exchange technical information, build professional networks, and learn about new process and product technologies. AISTech is organized by the Association for Iron and Steel Technology (AIST).

At the conference part of the event, technical sessions, paper presentations and panel discussions provided insight into the technologies and trends that are shaping the future of iron and steel production. Specialists from Primetals Technologies held 27 of the 471 technical papers that were presented at the conference and participated in two panel discussions with a combined audience of more than 1,200 professionals.

The AISTech exposition featured 542 exhibiting companies. At the 1,000 square-foot (93 m<sup>2</sup>) booth of Primetals Technologies, several interactive exhibits provided a unique experience for visitors. Satellite touch screens allowed customers to view slide shows and videos of the products, solutions and services that comprise the

Primetals Technologies portfolio. Another interactive touch screen showed interested visitors a simulation of the Arvedi ESP process.

Of all the exhibits, it was the Mill360° virtual-reality experience of Primetals Technologies that attracted the most attention. This tool allowed booth visitors to see 360-degree views of the EAF Quantum furnace, a combination rod and bar mill, and several ECO solution technologies. Large overhead monitors displayed what Mill360° users were experiencing, which attracted even more attention. The response to this innovative exhibit has been overwhelmingly positive, and the scalability of the platform ensures that AISTech attendees will have something new to see at AISTech every year. ●

**Tom Suski**, Communications, Primetals Technologies USA



Link to Mill360° at AISTech 2016

## 16TH CHINA INTERNATIONAL METALLURGICAL INDUSTRY EXPO

### METALS MAGAZINE WINS GERMAN BRAND AWARD 2016

*Metals Magazine* recently won the bronze medal at the prestigious German Brand Award (GBA) 2016 in recognition of its striking graphic design, text composition and introduction of the new brand of Primetals Technologies. Prof. Thomas Rempen, head of the jury, clearly stated the factors that qualify for receiving a prize: “uniqueness, likability, usability, credibility and trust.”

Miguel Micaelo, who is the brand designer at Primetals Technologies, accepted the award at the ceremony in Berlin on June 16, 2016. After receiving the certificate, he said: “Everybody at our company and at the agency Feedback who was involved with *Metals Magazine* has instilled all their passion into this magazine issue, which we are very proud of. To our knowledge, no customer publication within the steel industry has ever received a design award like this – thanks to everyone in the marketing team who worked so hard to make the new brand design of Primetals Technologies a success!” ●



Miguel (Mike) Micaelo, brand designer at Primetals Technologies, proudly displays the award he received at the German Brand Award 2016



The exhibition stand of Primetals Technologies

A comprehensive range of future-oriented environmental solutions and services was introduced by Primetals Technologies at the 16th China International Metallurgical Industry Expo (CIMIE) that took place in Beijing from May 17–20, 2016. Primetals Technologies also participated in the 9th China International Steel Congress at which Dr. Etsuro Hirai, Board member and CTO of Primetals Technologies, delivered a keynote speech.

#### SAVING RESOURCES, CREATING VALUE

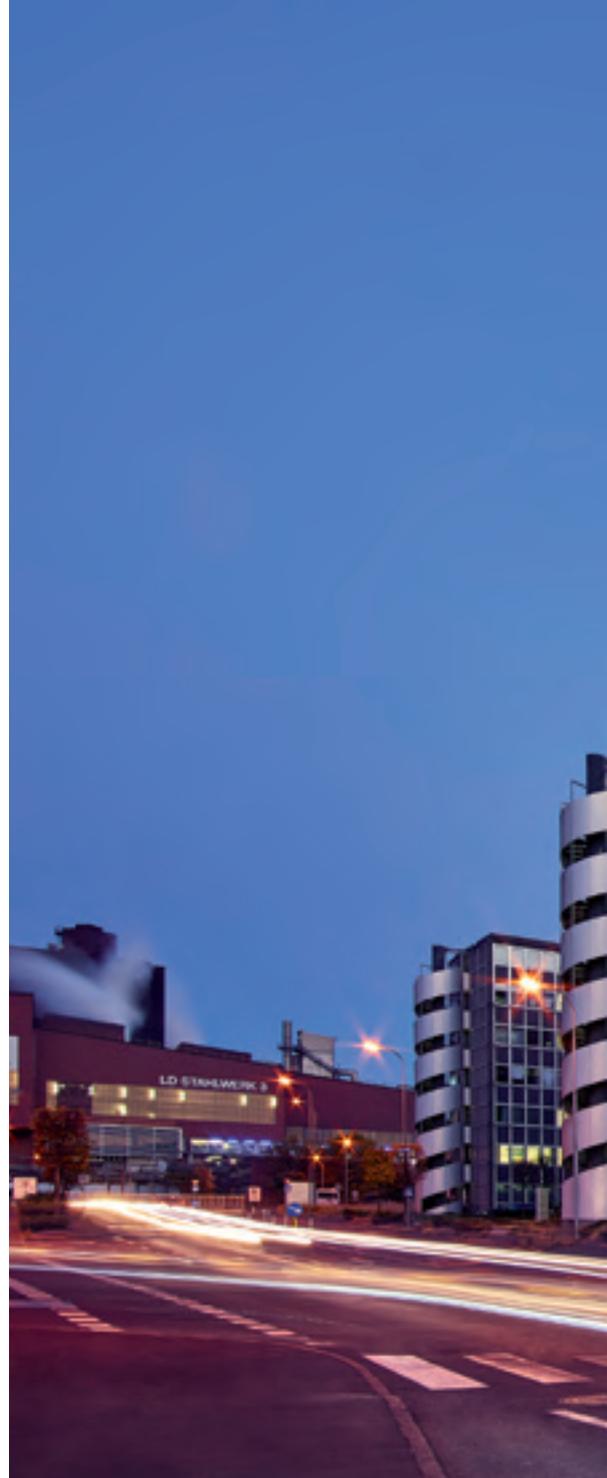
The Chinese metals industry has entered a period of overcapacity and stagnant growth. Most manufacturers are focusing on investments with short returns and on solutions to maximize energy recovery and energy savings as well as on measures to reduce overall production costs. In the meantime, the government is implementing increasingly stringent environmental regulations to control air pollution. Considering the challenging conditions confronting the Chinese metals industry, Primetals Technologies highlighted its ECO portfolio at CIMIE. Steel manufacturers were presented with intelligent and innovative revamping solutions to minimize the environmental impact of steelmaking. Examples of such technologies include Selective Waste Gas Recirculation (SWGR) for sinter plants, which can help to reduce atmospheric emissions by up to 50%, and DeNO<sub>x</sub> solutions for sinter and coke oven plants to reduce NO<sub>x</sub> emissions to below 100 mg/Nm<sup>3</sup>. Application of a new blast furnace dry-slag granulation technology allows up to 400 kg of steam per ton of slag granulate to be generated for use in a steelworks and also for the generation of electrical energy. Wet electrostatic precipitators for LD (BOF) converters reduces the dust content of emissions to less than 10 mg/Nm<sup>3</sup>. These future-oriented solutions can be individually tailored to China-specific requirements in order to provide added value and quick return on investment for customers. ●

**Wang Shi Yi**, Communications, Primetals Technologies China

# BACK TO THE ROOTS

## 2016 MARKS THE 60TH ANNIVERSARY OF THE FOUNDING OF VAI AND 60 YEARS OF PLANT-BUILDING ACTIVITIES IN LINZ

Sixty years ago, on June 6, 1956, the plant-building department of VÖEST (now voestalpine) received its first order from outside Austria for the construction of a brand new LD steelmaking plant in the Indian city of Rourkela. This event marks the birth of the company that eventually became known as Voest-Alpine Industrieanlagenbau (VAI), which is now part of Primetals Technologies. Today, LD steelmaking and its process variants account for nearly 75% of all steel produced in the world. The story starts in Linz ...



### NECESSITY IS THE MOTHER OF INVENTION

At the end of the Second World War, much of Europe lay in ruins. In addition to bricks, roofing material, glass and cement, there was one commodity that was particularly in demand for reconstruction: steel. The reemerging Austrian iron and steel industry had at its disposal sufficient iron ore reserves from its Styrian siderite mine in Eisenerz. Metallic scrap, however, was scarce. Steel had been previously produced in Linz by means of two Siemens-Martin open-hearth furnaces and four electric arc furnaces. Together, they were capable of a combined annual output of only around 200,000 tons of steel. As such, the rapidly increasing domestic demand for steel could not be guaranteed on a long-term basis by relying on these scrap-intensive production processes. Necessity demanded a unique solution, and the development of a new steelmaking technology was called for.

### INITIAL LD STEELMAKING INVESTIGATIONS

The original Bessemer idea of blowing air into a bath of molten iron to decarburize the iron and produce steel served as the starting point of investigations. Now that industrial oxygen had become far cheaper to produce than in the days of Henry Bessemer during the second half of the 19th century, research efforts were initiated to develop an oxygen-blowing steelmaking process. On June 3, 1949, the initial trials started at the Linz steelworks to convert liquid iron into steel with the use of oxygen in a reconstructed 2.5-ton Bessemer converter. The positive and highly promising results led to the bold decision on December 9, 1949, to build a new steel plant in Linz on the basis of a completely novel technology that eventually became known as the LD steelmaking process. Following three-and-a-half years of engineering and construction work, the first of three LD converters with



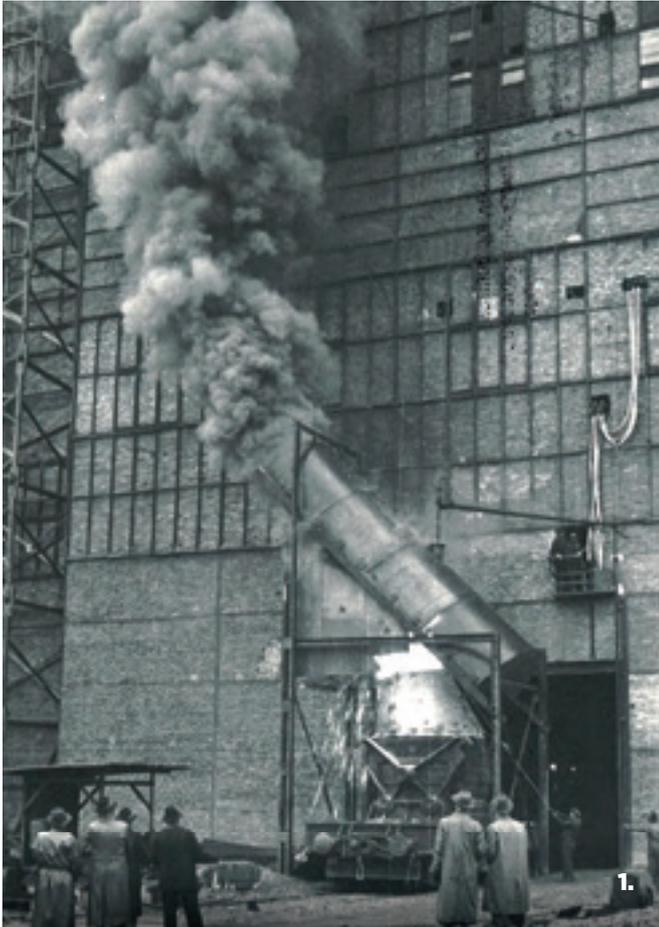
Linz Headquarters of  
Primetals Technologies,  
Austria

**Since the birth of VAI and the start of metallurgical plant-building activities in Linz 60 years ago, the company that is now called Primetals Technologies can point to more than 4,500 successfully completed plant references throughout the world.**

a tapping weight of 30 tons was started up in the new LD Steelworks No. 1 of VÖEST in Linz, Austria, on November 26, 1952. This was a momentous occasion for all of those who had helped to implement this groundbreaking technical achievement in the post-war years. Following the subsequent start-up of the other two 30-ton converters, a 1 million t/a steelmaking plant was fully operational in Linz by 1956.

At the same time, oxygen steelmaking was also being investigated at the Donawitz steelworks. This led to the start-up of the second LD steel plant in Austria at Donawitz on May 22, 1953. Already by December of the same year, steel output at this site exceeded 250,000 tons. “LD” is derived from Linz and Donawitz, the two Austrian cities where steel was first produced with the new oxygen-blowing steelmaking process. »

**It all began in Linz – with the revolutionary development and implementation of the LD steelmaking process.**



1. Initial oxygen-blowing attempts in Linz, Austria (October 1949)
2. The No. 2 30-ton LD converter at VÖEST (now voestalpine) prior to installation (1952)
3. First charging of the 30-ton No. 2 LD Converter in the No. 1 steelworks of VÖEST (December 5, 1952)
4. 150-ton LD converter in operation today at SAIL's Rourkela Steel Plant, India

Photographs 1-3: courtesy of voestalpine Geschichtclub Stahl  
 Photograph 4: courtesy of Rourkela Steel Works (SAIL)



## The initial decisions made in Linz and in India to introduce oxygen steelmaking technology changed the world forever, and set the cornerstone for the future of metals.

### BENEFITS OF THE NEW PROCESS

The introduction of LD steelmaking technology in the 1950s eventually resulted in a dramatic increase in steel-making productivity and output. LD converters are capable of converting molten iron into crude steel in less than 40 minutes, compared to 10–12 hours that is required using Siemens-Martin furnaces. The new oxygen-blowing process also reduced investment and operating costs by 50% compared to the open-hearth route. Other decisive benefits included the superior steel quality, 100% recyclability and the far lower prices that could be offered. LD steelmaking therefore soon began to replace the existing Siemens-Martin furnaces as well as the remaining Bessemer and Thomas converters still in use. LD converters with capacities exceeding 400 tons were eventually built and put into operation.

### INDIA CHARTS THE FUTURE COURSE OF STEELMAKING

On the basis of the well-documented successes in Linz and Donawitz, the LD process soon captured the attention of the international iron and steel industry. This was particularly true in India in the 1950s, which had developed an enormous appetite for steel. The then young country, which had at its disposal a wealth of raw materials, was preparing its next five-year plan to progressively build up its steel industry in order to reduce imports and become more self-sufficient. A comparison of the LD steelmaking process with the production results from Russian- and U.K.-built steelworks in India clearly highlighted the potential benefits offered by LD steelmaking. The decision was therefore made to construct the first steel plant with LD converters in Rourkela, Odisha state, where there are abundant deposits of iron ore. The contract was signed on June 6, 1956, and implemented on behalf of Hindustan Steel Ltd. by a consortium comprising VAI and Krupp Industrieranlagenbau.

By March 1963, the Rourkela steelworks met its targeted monthly production goal of 91,000 tons of crude steel, and in 1965 Rourkela's steel output exceeded 1 million tons, which was 18% more than India's five-year plan had called for. Today, the steel mill is operated by Steel Authority of India Ltd. (SAIL) and is capable of producing more than 4 million tons of crude steel per annum. Current plans call for an increase in the yearly steel output at Rourkela to nearly 11 million tons by 2025.

### STEEL GOING ON

A brief review of the history of LD steelmaking, the first LD order received outside Austria from India, the origin of VAI, and 60 years of plant-building activities in Linz is presented in *Steel Going On*. This 100-page book, authored by Dr. Thomas Duschlbauer, will be available soon and can be ordered under:

[contact@primetals.com](mailto:contact@primetals.com).

### FROM THE ROOTS TO THE FRUITS

The founding of the company that eventually became known as VAI can be traced to the development of the LD steelmaking process and the courageous decision made in India during the 1950s to adopt this technology. This sparked a chain reaction of orders placed with VAI for the engineering and installation of LD steelmaking converters throughout the world. VAI gradually expanded its technological capabilities to include continuous casting of steel and built the world's first slab caster in Linz in 1968. In time, thanks to its continuous technological development and various mergers with other leading companies, VAI expanded its supply portfolio to cover every step of the value-added production chain, from raw materials to the finished steel product. Since the birth of VAI and the start of metallurgical plant-building activities in Linz 60 years ago, the company that is now called Primetals Technologies can point to more than 4,500 successfully completed plant references throughout the world.

It all began in Linz – with the revolutionary development and implementation of the LD steelmaking process. The subsequent immense increase in global steel output and affordable steel products benefited all of society and dramatically improved the living standards of billions of people. Seen in this light, the initial decisions made in Linz and in India to introduce oxygen steelmaking technology changed the world forever, and set the cornerstone for the future of metals. ●

**Dr. Thomas Duschlbauer**, Freelance editor and journalist

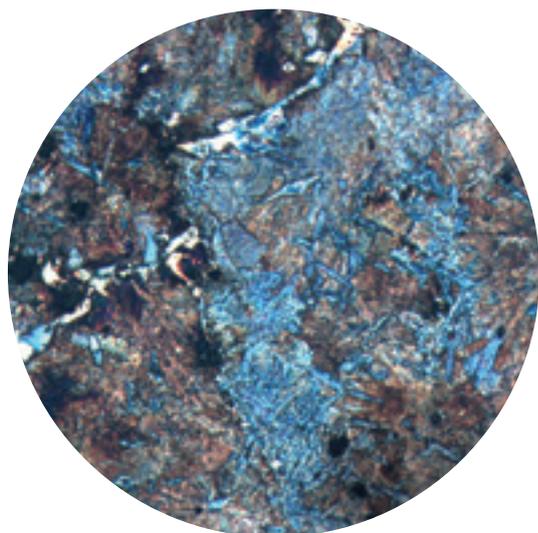
**Dr. Lawrence Gould**, Primetals Technologies Austria

**DR. DENISE LODER** at work in the lab studying an advanced HSLA steel grade using an optical microscope



# RESEARCHING THE **FUTURE OF METALS**

**THE MONTANUNIVERSITÄT LEOBEN, AUSTRIA,  
IS ACTIVELY INVESTIGATING THE DEVELOPMENT  
OF IMPROVED STEEL GRADES FOR USE IN  
THE METALS INDUSTRY**



Example of a microscopic metallographic photo of a high-strength low-alloy (HSLA) steel grade showing an acicular ferritic-pearlitic microstructure (0.23% C, 1.50% Mn and 0.05% Ti)

**Non-metallic inclusions can contribute to the optimization of material properties.**

The photograph shown on the back page of this magazine is an example of a high-strength low-alloy (HSLA) steel with 0.23% C, 1.50% Mn and 0.05 % Ti that was produced under laboratory conditions. Using an optical microscope, the photograph was taken of a sample that was etched in two steps: step 1 with structure etching using the Vilella method, and step 2 with color etching using the modified Lichtenegger and Bloech method. The objective of this special etching procedure was to achieve a clearly visible contrast of the acicular ferrite in the steel microstructure in order to apply image-analysis software to automatically determine the acicular ferrite fraction.

### WHAT IS ACICULAR FERRITE?

Acicular ferrite is a needle-shaped ferrite modification that nucleates intragranularly between the austenite grains on non-metallic inclusions, thereby creating an interwoven, chaotic microstructure with outstanding toughness properties. Because of its excellent toughness, steel manufacturers have increasingly focused their attention on acicular ferritic steels over the past few years. The factors contributing to the formation of acicular ferrites are not yet entirely understood, which is why more detailed investigations are of great importance for the industrial application of these materials. The Chair of Ferrous Metallurgy at the Montanuniversität Leoben has been investigating acicular ferrites since 2012 in the scope of the FWF (Förderung der wissenschaftlichen Forschung) project TRP 266-N19. Research activities have led to the development of a computer-aided method of analyzing the acicular ferrite content which, when compared to the former manual measurement method, results in a significant reduction in personnel effort and expense as well as improved objectivity.

### TURNING A DISADVANTAGE INTO A BENEFIT

For a long time, non-metallic inclusions were considered a negative material constituent of steel. A new field of research was created in the 1990s that focuses on oxides metallurgy (first described in 1990 by J. Takamura and S. Mizoguchi). This research area involves the targeted modification of non-metallic inclusions in order to use them to influence metallic microstructures, for example, as nucleation sites for the formation of acicular ferrite. Thus, non-metallic inclusions can contribute to the optimization of material properties.

Because ultraclean steel with an extremely low inclusion content is now produced by steel manufacturers, a further reduction of inclusions is hardly possible. In such cases, oxides metallurgy (also referred to as inclusion metallurgy) presents an opportunity to put any remaining inclusions still contained in the steel to positive use. This is why inclusion metallurgy (and thus acicular ferrite) has a highly promising future potential to improve steelmaking. ●

**Ao. University Professor Dr. Christian Bernhard**, Head of the work group "Continuous casting: Metallurgy and Materials"

**Dr. Denise Loder**, Research associate

**Assistant Professor Dr. Susanne Michelic**, Head of the work group "Inclusion Metallurgy"

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**Special note:** On May 10, 2016, on the occasion of the ASMET\* Forum for Metallurgy, Dr. Denise Loder received the esteemed Inteco ASMET Award for her doctoral thesis entitled "On the systematic investigation of acicular ferrite formation on laboratory scale." She was granted her PhD "with distinction" from the Montanuniversität Leoben.

\*The Austrian Society for Metallurgy and Minerals

# PASSION FOR PHOTOGRAPHY



**SAULI KOSKI,**  
Finnish photographer -  
in his element  
Contact:  
<https://www.instagram.com/sauli.koski/>

Sauli Koski is the photographer whose pictures of northern lights are used in this magazine. Born in Finland in 1962, Koski first discovered his passion for shooting pictures when he was only eleven years old. His photos were initially printed in magazines and books. He has since specialized in capturing nature and animal scenes with his camera - in particular night skies, halo effects, northern lights, moonlight and clouds. Today, Koski is increasingly involved with architectural, advertising and product photography, and he also teaches and shares his pic-

ture-taking skills with others. At home in sparsely populated Lapland, the wild north of Finland, Sauli Koski enjoys his dogs, snow scooting and fishing. His dream for the future is quite simple:

“ I want to have a large garden with plenty of apple trees and a glasshouse full of tomatoes in a place where there are no mosquitoes.”

## AND ONE FINAL PREDICTION ...

Because the appearance of northern lights generally reaches a maximum during a three-year period before and after the 11-year-cycle peak in solar activities, as manifested by sunspots and solar flares, scientists are predicting an increased occurrence of the aurora borealis throughout the winter of 2016-2017.

## Personal note from the Managing Editor of Metals Magazine:

I first saw a selection of the spectacular northern light photographs of Sauli Koski at the Helsinki Marathon in August 2004. Since then, it has been a dream of mine to include a few of his pictures in some way in one of the corporate magazines that I have been involved with. With this issue of Metals Magazine, a 12-year-old dream has come true. ●



“ The future starts today,  
not tomorrow.”

Pope John Paul II  
(1920–2005)

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For inquiries and more information:  
**primetals.com**

The background of the entire page is a high-magnification microscopic metallographic photograph of a high-strength low-alloy (HSLA) steel. The image shows a complex, interlocking acicular microstructure, which appears as a dense network of fine, needle-like or lath-like structures. These structures are primarily dark blue and black, with some lighter, brownish-grey regions interspersed. The overall texture is highly textured and fibrous, characteristic of a ferritic-pearlitic microstructure. The lighting is somewhat uneven, with brighter areas where the structures are more densely packed and darker areas where they are more sparse or oriented away from the viewer.

## THE FUTURE OF METALS

### HSLA STEEL GRADE WITH ACICULAR MICROSTRUCTURE

Example of a microscopic metallographic photograph of a high-strength low-alloy (HSLA) steel grade with an acicular ferritic-pearlitic microstructure (0.23% C, 1.50% Mn and 0.05% Ti)

(courtesy of Montanuniversität Leoben,  
Austria)