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METALS MAGAZINE

INNOVATION AND TECHNOLOGY FOR THE METALS INDUSTRY

FOCUS

**ON DOWNSTREAM TECHNOLOGIES
FOR FLAT PRODUCTS**

MORE VALUE FOR CUSTOMERS

INTERVIEW:
A WELLSPRING OF SOLUTIONS
THROUGH VARIETY

KALEIDOSCOPE OF SOLUTIONS
FOR STRIP-PROCESSING LINES



Ideas

may change the world,
but it is the right solutions
that lead to progress.

Immunofluorescent light micrograph
of stained brain cells from the cortex (magnification: 615x)

EDITOR'S COLUMN



LAWRENCE GOULD

DEAR READER,

The average human brain consists of approximately 100 billion cells, otherwise known as neurons. Each of these neurons is connected via so-called synaptic gaps with roughly 10,000 other neurons. This gives an astronomical figure of $10^{11} \times 10^4 = 10^{15}$ or 1,000,000,000,000,000 (1 quadrillion) separate connections. This incredible network and interlinking of neurons is the source of individual personality, ideas, innovation, intelligence, knowledge, wisdom and memory. Weighing an average of between 1.3 and 1.4 kilograms, it has been said that the human brain is the most complex substance in the known universe.

Although incomparable with the human brain, a rolling mill or processing line is nevertheless a marvelous product of decades of experience and engineering excellence. A state-of-the-art hot-strip mill, for example, which includes the reheating furnace, roughing mill, finishing mill, descalers, coilers, motors, drives as well as the integrated electrical, automation, and media-supply systems, is comprised of approximately 250,000 individual parts and components. Each of these discrete elements must directly or indirectly interact with all other parts of the mill in order for the plant to efficiently transform a humble block of steel into a high-quality, value-added strip product that finds innumerable uses in society. Rolling mills are the most complex pieces of machinery in a steelworks. It is axiomatic that a vast amount of engineering competence is required to build a high-performance mill with a service life that extends over decades.

Through the formation of Primetals Technologies in January 2015, an unparalleled cornucopia of technologies in metals production has come together. This is not merely a merger of the process and plant-building expertise of the former Mitsubishi-Hitachi Metals Machinery and Siemens VAI Metals Technologies, it is the integration of the sum total of acquired knowledge and experience from dozens of legacy companies throughout the world – some of which date back well into the 19th century. While the brain serves as an example of an

astonishing, functional network of information nodes, the challenge that all technology-driven companies face today is how to combine and exploit existing know-how in order to develop and implement new solutions. Efficient knowledge management is the key, and it will become increasingly important as the quantity and complexity of information expands exponentially.

Yet it is exactly the broad spectrum of *available* know-how that is decisive for developing the solutions to meet the challenges that lie ahead. Ideas may change the world, but it is the right solutions that lead to progress. With its plethora of advanced technologies covering every step of the iron and steel production route, in addition to the rolling of nonferrous metals, Primetals Technologies can draw upon an immense knowledge database at sites throughout the world that are progressively being interlinked to support producers to rapidly respond to difficult and changing market conditions. Especially now, in times of global steelmaking overcapacity, support is increasingly being requested in connection with the manufacture of value-added metals products.

A recurring theme in this issue of Metals Magazine is therefore that – through the merger of two great companies with a long tradition of technological innovation – a complete product portfolio, particularly in the downstream area, is now offered to metals producers to improve operational efficiency, product quality and the value of metals products.

Yours sincerely,

Dr. Lawrence Gould

Managing Editor of Metals Magazine
Primetals Technologies, Limited



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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 Primetals Technologies magazine newsstand.

For iOS



For Android



MESSAGE

FROM THE CEO

DEAR CUSTOMERS,

Primetals Technologies came into being in January 2015 as a joint-venture company through the combined efforts of Siemens and Mitsubishi Heavy Industries (MHI) as a means of providing you, our customers around the globe, with even better service than was previously possible through two separate companies. The two parent companies brought together their activities in the metals business to form a new and even more powerful technology supplier, which is what Primetals Technologies is today. The distinguishing features of the new company include:

- 40 locations around the world in close proximity to our customers
- Technologies and services along the entire value chain
- Highly skilled in-house manufacturing expertise and capacities
- Two strong parent companies with the background to ensure financial stability and creditworthiness

Since accepting responsibility as CEO of Primetals Technologies, my first and foremost target was to ensure the timely and efficient integration of our new company, while focusing on providing cutting-edge technologies and services to customers today and in the future. Now, one year after the founding of Primetals Technologies, we have advanced quite far along the path of integration, and the main integration elements will be finalized by the end of this fiscal year in March 2016. But we are also aware that not all integration topics can be achieved overnight. So we are continuously working to further optimize our activities for the benefit of our customers. Our leading principle therefore remains as “best of both” and maximizing the synergies of technologies, R&D, resources, global presence and diverse cultural backgrounds.

All of our efforts in the end revolve around technology. Our company is a technology-focused enterprise and a full-line supplier of world-class, innovative solutions for all steps in the value chain of the metals industry. In addition to our specific industrial experiences and competences, we also can draw on the technological background of our

mother companies MHI and Siemens, including, but not limited to, production expertise and a broad selection of systems equipment in electrics, automation and drives.

Environmental technologies are also playing an ever-increasing role – especially in emerging markets. Primetals Technologies is well positioned to assist producers to reduce emissions, energy consumption and raw material usage. But even for manufacturers in mature economies, we offer technologies that help cut energy consumption and CO₂ emissions. A prominent example is the EAF Quantum electric furnace, which can provide a 30% reduction in CO₂ emissions.

In the future, we will also see a growing integration of IT in the metals industry, from Level 1 basic automation and Level 2 process optimization with improved sensor technology, all the way to central production and resource management on a plant-wide scale. We look forward to accompanying our customers on their journey to Industry 4.0 in the metals sector.

Especially in times of tough market conditions and financial challenges in the global steel markets, the comprehensive service portfolio that we provide to our customers is of vital importance. Primetals Technologies, with its worldwide network of service locations and workshops, offers a broad range of lifecycle services up to complete maintenance outsourcing for steel plants. On top of routine maintenance, our company excels at upgrading plant automation to improve and optimize plant efficiency.

Throughout 2015, I have talked with many of our customers in Europe, the United States, Japan, and other parts of Asia. At the Metec fair in June – the world’s largest trade fair for the metals industry – our new brand Primetals Technologies along with its complete product portfolio was prominently on display for the first time. A strong emphasis was placed on our technological competence and innovation power, which for me is the touchstone of



YASUKUNI YAMASAKI,
CEO and Chairman of
Primetals Technologies

how our company is perceived by the market. Encouragingly, most of the feedback that I received confirmed the positive attitude about our joint venture. The complementary product portfolios and the different cultures of the two former organizations is a benefit toward meeting the specific needs of steel producers at their individual locations. Primetals Technologies is ideally positioned to support its customers to successfully master the industrial challenges that lie ahead and to maximize product

value. This issue of Metals Magazine focuses on downstream technologies and state-of-the-art solutions to excel in the market. May I invite you to join us as we strive toward

“Creating the future of metals as one.” ●

Yasukuni Yamasaki
CEO and Chairman of Primetals Technologies, Limited

PRIMETALS TECHNOLOGIES

PROJECT AND COMPANY NEWS



1. Regina, Saskatchewan, Canada
2. Hollsopple, Pennsylvania, U.S.A.
3. Dillingen, Germany
4. Wetzlar, Germany
5. Riesa, Germany
6. Linz, Austria
7. Linz, Austria
8. Jesenice, Slovenia
9. Jesenice, Slovenia
10. Ereğli, Turkey
11. Kroman, Turkey
12. Karachi, Pakistan
13. Vijayanagar, Toranagallu, India
14. Rourkela, Orissa, India
15. Chonburi, Thailand
16. Tangshan, Hebei province, China
17. Changzhou, Jiangsu province, China
18. Zhanjiang, Guangdong province, China



Meltshop of Evraz Regina in Regina, Saskatchewan, Canada (photo: courtesy of Evraz Regina)

MAJOR STEEL MILL UPGRADE AT EVRAZ NORTH AMERICA

1. CANADA: Evraz Regina, a company of Evraz North America, placed a major order with Primetals Technologies to upgrade its steel mill in Regina, Saskatchewan, Canada. The project covers mechanical, electrical and automation solutions that extend from liquid-steel quality improvements to the finished coils. A new 135-ton, twin-vessel vacuum-tank degasser will be installed, and the existing slab caster and Steckel mill will be modernized. The slab caster mold will be upgraded with the DynaWidth hydraulic width-adjustment system. New Smart Segments will be installed to enable inline strand-thickness adjustments. The strand-guide system will be equipped with an enhanced spray-cooling system that will allow the strand thickness to be increased. Upgrading of the 4-high Steckel mill will allow positive roll bending, improved uncoiling and coiling, and higher rolling forces to be exerted. Level 1 basic automation and Level 2 process optimization will also be adapted to accommodate these and other plant modifications. The modernization at Evraz Regina will enable the company to produce API steel grades X70 and X80 at 1" (25.4 mm) and $\frac{3}{4}$ " (19.1 mm) thicknesses, respectively, for the production of pipes to serve the expanding Canadian market. The new equipment is scheduled to be installed during the fourth quarter of 2016.

With a cleaning capacity of 2.4 million cubic meters per hour, the supplied dedusting system counts among the largest of its kind in the world.

EAF CONDITION-MONITORING SYSTEM TO BE INSTALLED AT NORTH AMERICAN HÖGANÄS

2. U.S.A.: A new condition-monitoring system (CMS) developed by Primetals Technologies was purchased by North American Höganäs to monitor key parameters of their 50-ton electric arc furnace installed in Hollsopple, Pennsylvania, U.S.A. The order included system service in addition to an upgrade of the furnace electrode regulation system. Monitored EAF performance indicators comprise the utilization index, power-on times and energy consumption. The system also surveys the hardware and software of the electrode control system, the hydraulic system, furnace switchgear, transformer tap changer and other furnace components. Abnormal furnace parameters outside recommended ranges are reported to the supervisor through a mobile application dashboard application or by e-mail. Regular reports about furnace performance accompanied by a detailed trend analysis of furnace parameters are also provided, in addition to expert recommendations. This new system enables predictive as well as preventive maintenance to reduce the cost of regular maintenance cycles.



The condition-monitoring system includes a mobile dashboard application for the remote monitoring of key EAF performance figures.



Blast Furnace 4 at Rogesa, Dillingen, Germany. (photo: courtesy of Dillinger Hütte)

SUPPLY OF NEW EQUIPMENT DURING BLAST FURNACE RELINE AT ROGESA

3. GERMANY: An order was placed with Primetals Technologies by Rogesa Roheisengesellschaft Saar mbH (Rogesa) in Dillingen, Germany, for the modernization of the electrical, measuring, analytical and automation equipment in conjunction with the relining of Blast Furnace 4. The project involves equipping the blast furnace with a new control system based on Simatic PCS7 from Siemens, the installation of advanced automation systems, and renewal of the switchgear and cabling. The existing field devices will be replaced. The control system will incorporate an archiving and reporting system, a system for recording and analyzing measured values, and a network management solution. Primetals Technologies will also be responsible for planning the hardware and adapting it to the new structure.

NEW DEDUSTING SYSTEM FOR EAF STEEL MILL AT BUDERUS EDELSTAHL

4. GERMANY: A new combined primary and secondary dedusting system was installed by Primetals Technologies at the electric steel mill of the stainless steel producer Buderus Edelstahl GmbH (a company of the voestalpine Group) in Wetzlar, Germany. The dedusting system collects and filters the offgas from all metallurgical plants in the melting and casting sections of the steel mill. This comprises a 100-ton EAF, ladle furnace, vacuum-degassing plant, conditioning stand and two new ingot-casting plants. Ambient air in the hall is exhausted by means of a canopy extraction system with a total of 35 extraction points. Plant offgas and air from the steel-making/casting bay is cleaned by means of bag filters to achieve a clean-gas dust content of less than 1 mg/N³, which is considerably less than the legally specified limit. With a cleaning capacity of 2.4 million cubic meters per hour, the supplied dedusting system counts among the largest of its kind in the world. The entire dedusting unit is enclosed to minimize noise emissions.



Dedusting plant at Buderus Edelstahl, Wetzlar, Germany



Modernized 5-strand billet caster at the Elbe-Stahlwerke Feralpi (ESF) plant, Riesa, Germany

ELBE-STAHLWERKE FERALPI ISSUES FAC FOR BILLET CASTER

5. GERMANY: Primetals Technologies received the final acceptance certificate (FAC) from the German steel producer Elbe-Stahlwerke Feralpi GmbH (ESF) for the modernized 5-strand billet caster in Riesa, Germany. The targets of this project, which commenced in May 2014, were to improve the internal and surface qualities of the billets and to increase the production capacity by 20%. This was achieved by installing a new machine head equipped with DiaMold molds and retractable DynaFlex oscillators, as well as by optimizing the secondary cooling system. The retractable DynaFlex mold oscillators enable the caster molds to be individually exchanged for maintenance purposes without interrupting the casting process. This increases both the productivity and the flexibility of the billet caster. The installation of DiaMold molds allows the casting speeds to be increased. To ensure optimal cooling at higher casting speeds, the existing secondary cooling system was modified and enhanced with a fourth cooling zone. Thanks to the preassembly and workshop testing of system parts as well as the application of the proven "Connect & Cast" approach, all upgrading activities were completed quickly and efficiently during a scheduled caster downtime.

ROBOTS NOW USED IN CONVERTER STEELMAKING AREA OF VOESTALPINE STAHL

6. AUSTRIA: Primetals Technologies supplied, installed and put into operation robotic systems at the three 180-ton LD (BOF) converters of the Austrian steel producer voestalpine Stahl GmbH. The robots perform a variety of tasks such as automatic probe extraction from the magazine, placement of fresh probes onto the sublance, and removal and disposal of the used probes from the sublance following temperature measurements and/or steel sampling. Furthermore, the robots clean the contact rod, monitor the probe holder and, with the use of a camera, automatically recognize and select the required probe type.

The project scope also included the supply of a probe magazine with three probe containers, each with 63 probes. Probe buffers, sublance centering devices and the LanceGuard measuring-system monitor were additionally provided. The latter automatically cleans, tests and verifies the entire measurement procedure at regular intervals. Primetals Technologies was also responsible for integrating the new systems into the existing automation environment. Use of the robotic systems at voestalpine means that operating personnel no longer have to manipulate probes in the hazardous converter area. In addition to increased personnel safety, other advantages offered by the robotic solution include lower maintenance requirements, systematic probe handling and reduced converter downtime for sampling procedures.



Eco Slide Discs mounted on the side beam in the entry section of a hot-strip mill at voestalpine Stahl, Linz, Austria

ADDITIONAL ECO SLIDE DISC BEAMS ORDERED BY VOESTALPINE STAHL

7. AUSTRIA: The Austrian steel producer voestalpine Stahl ordered additional Eco Slide Disc beams equipped with rotatable Eco Slide Discs for its hot-strip mill in Linz, Austria. The Eco Slide Disc system (patent pending) – a highly practical and cost-saving innovation from Primetals Technologies – substantially increases the wear resistance of strip-guidance components. The system has already been installed on one side of the entry section of Coiler 3 in the hot-strip mill where it has been successfully operating since August 2014. On the basis of the excellent results and the notable cost-saving potential, new Eco Slide Disc beams were installed at the entry section of Coilers 3 and 4. Eco Slide Discs are vertically mounted on the side beam. After a defined number of strip lengths have passed, the wear discs are automatically and synchronously rotated at a selectable angle. Contrary to conventional wear plates where the passing strip always cuts into the plates along the same line, wear on Eco Slide Discs is distributed across the entire disc surface. This elegant solution extends the service life of the wear discs during continuous operation from two or three days using conventional wear plates to up to approximately four weeks. If the exposed disc side is reversed and remounted on the side beam, the effective service life can be doubled to nearly two months. Another feature of the Eco Slide Discs is that they have an inherent self-cleaning effect, which reduces the risk of material deposits falling onto the strip where surface damage may occur.

Primetals Technologies supplied, installed and put into operation robotic systems at the three 180-ton LD (BOF) converters of the Austrian steel producer voestalpine Stahl GmbH.

ACRONI NOW PRODUCES X120 MN12 STEEL GRADES ON AN UPGRADED CASITER

8. SLOVENIA: Primetals Technologies carried out a major modernization on the single-strand slab caster belonging to Slovenian steel producer Acroni, d.o.o., located in Jesenice. The caster is designed to produce more than 500,000 tons of steel per year that include medium- to high-carbon, structural, peritectic, microalloyed, stainless and silicon steel grades. The slabs have thicknesses of 200 mm or 250 mm and widths from 800 mm to 2,120 mm. Since early 2015, the slab caster can also produce X120 Mn12 wear-resistant steels, which previously could only be manufactured in ingot-casting or vertical-casting machines. This new capability is the result of the plant modernization that comprised the replacement of the machine head and strand-guide system, and the installation of advanced technology packages, systems and components. This included the LevCon mold-level control system; use of closely spaced, small-diameter rolls in the strand-guidance system to minimize slab bulging; the Dynacs Level 2 secondary cooling model for calculating and controlling the required volumes of cooling water for a precise determination of the final solidification point of the strand; and the DynaGap Soft Reduction technology package to exactly regulate strand taper and thus avoid strand-center segregation. The latter is a crucial factor for the production of X120 Mn12 grades because these steels must pass an ultrasound test where center segregation is an exclusion criterion. These solutions were decisive to ensure the required high internal and surface quality of slabs for the production of critical steel grades.



The modernized slab caster of Acroni is now capable of casting X120 Mn12 steel grades



Charging of AOD converter
(reference plant of Primetals Technologies)

NEW AOD CONVERTER AND DEDUSTING SYSTEM FOR ACRONI

9. SLOVENIA: For another order from Acroni for the Jesenice site, Primetals Technologies was commissioned to supply a new 95-ton AOD (argon oxygen decarburization) converter and a dedusting system. Stainless steel is currently produced in the EAF (electric arc furnace) and VOD (vacuum oxygen decarburization) route, which represents a production bottleneck. The installation of an AOD converter will provide Acroni with an additional steel manufacturing option that will increase its output by more than 20%, improve product quality, and allow Acroni to expand its product portfolio. The reduced quantity of alloying elements lost during deslagging in the AOD process will cut production costs as well. Primetals Technologies is responsible for the design, manufacture and supply of the key components of the AOD converter and dedusting system. The project scope features a process-automation system specifically designed for AOD converters in addition to the installation of a drive-damper system that reduces vibrations caused by the injection processes. The patented system reduces wear and maintenance costs, and contributes to a substantially longer converter service life. The dedusting system will ensure that emissions are kept well below the allowable limits, thereby improving working conditions in the steel mill area. The project will be implemented in a consortium with the Slovenian company Esotech d.d., Velenje. The new plant equipment is scheduled to come on stream at the beginning of 2017.

The mill will have a design capacity of 400,000 tons of reinforcing steel and round bars per year, which will more than triple the current production output of Amreli Steels.

NEW CONTINUOUS GALVANIZING LINE TO BE INSTALLED AT ERDEMİR

10. TURKEY: The Turkish steel producer Erdemir awarded Primetals Technologies an order to supply a turnkey, continuous galvanizing line for its Ereğli Plant on the Black Sea coast. The line will process 350,000 tons of various steel grades per year that include commercial, interstitial-free (IF), high-strength, low alloy (HSLA), dual-phase (DP) and bake-hardening (BH) grades for use in the automotive and other industries. Strip widths range from 700 mm to 1,900 mm at thicknesses from 0.4 mm to 2.0 mm. The project is scheduled to be completed in the second quarter of 2018.

The project scope for Primetals Technologies includes project execution, engineering and the supply of the complete mechanical and electrical equipment, as well as automation and process technology for the galvanizing line. The mechanical equipment comprises the coil-feeding and entry section, mash lap welder, vertical strip accumulator, cleaning section, annealing furnace, galvanizing section, skin-pass mill and a tension leveler. This is followed by the post-treatment and exit sections, which will be outfitted with an electrostatic oiler, rotary shear, coiler, and coil-handling, -banding and -weighing machines. At the inspection station, the fully automatic SIAS surface-inspection system confirms that the strip has satisfied the required surface quality. The process sequence is monitored by the TCOptimizer tools, and PropertyMon performs inline analyses of the mechanical properties of the strip.



The No. 2 wire rod mill at Kroman, Turkey, will be equipped with advanced laying-head technology, including SR Series self-regenerating pipes for extended pipe life

WIRE-ROD MILL UPGRADE AT KROMAN

11. TURKEY: An order was placed with Primetals Technologies by Turkish steel producer Kroman Çelik Sanayii A.Ş. for the supply of advanced technology to enable the existing wire rod outlet of the No. 2 mill to process high-carbon wire rod. This will be achieved through the installation of the Morgan Intelligent Pinch Roll and the latest laying head technology featuring the SR Series self-regenerating pipe for longer pipe life. Modifications to the existing cooling conveyor will be carried out by integrating Optimesh technology, and the reform tub and ring distributor will be upgraded. A line speed of 110 m/s is guaranteed with the new equipment.



PQS heat-treatment system in multi-slit operation in a bar mill supplied by Primetals Technologies

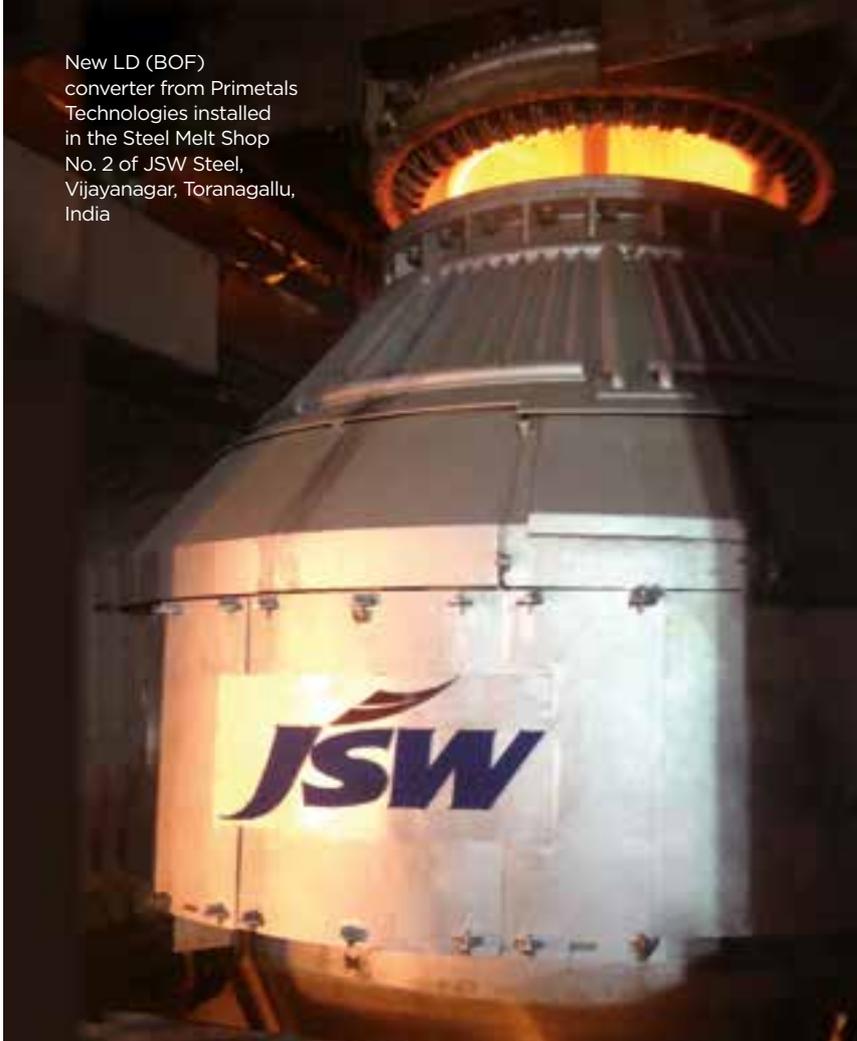
NEW BAR MILL TO BE INSTALLED AT AMRELI STEELS

12. PAKISTAN: In order to meet the increased domestic demand for structural steel, Pakistani producer Amreli Steels Ltd. ordered a new rebar bar mill from Primetals Technologies. The mill will have a design capacity of 400,000 tons of reinforcing steel and round bars per year, which will more than triple the current production output of Amreli Steels. Commissioning is scheduled for early 2017. The new mill will have a top rolling speed of 13 m per second. Billets with a square cross-section of 150 mm x 150 mm and a length of 12 m will be rolled to rebars with diameters ranging from 8 mm to 40 mm. Plant productivity is maximized by rolling bars with diameters of between 8 and 10 mm in the four-slit mode, and for bar diameters between 8 mm and 14 mm in the two-slit mode. Round bars will also be produced with diameters ranging from 16 mm to 60 mm. The rolling line consists of a roughing mill, an intermediate mill and a finishing mill. Each of these mill sections is equipped with six fifth-generation Red Ring stands. The scope of supply also includes hot cropping and emergency shears, a heat-treatment Pomini Quenching System (PQS) installed downstream of the last stand of the finishing mill, a pinch roll and hot-dividing shear in front of the cooling bed. This is followed by a cold dividing shear with a cutting force of 500 tons, in addition to machines to count, bundle, weigh and label the bars.

EXCHANGED LD (BOF) CONVERTER STARTED UP AT JSW STEEL

13. INDIA: In mid-September 2015, a new LD (BOF) converter supplied by Primetals Technologies was started up in the Steel Melt Shop No. 2 of Indian steelmaker Jindal South West Steel Ltd. (JSW Steel), located in Vijayanagar, Toranagallu, in the state of Karnataka. The project is part of an order received in September 2014 under which Primetals Technologies will replace a total of four steelmaking converters. The remaining steelmaking vessels will be consecutively substituted by mid-2016. Each converter will have a tapping weight of 180 tons. Primetals Technologies will supply the converter vessels, including the trunnion rings, suspension systems and bottom-stirring systems. The converters will be constructed of high-temperature creep-resistant materials in order to limit heat-related deformations, and they will be equipped with a specially designed combined air- and water-cooling system. As a result, they will have not only a long service life, but also reduced maintenance requirements. The scope of delivery also includes two new tilting drives, two sets of new quick-change couplings for top blowing lances, and the complete basic automation (Level 1) for the converters. JSW Steel is the leading steel producer in India with an installed capacity of 14.3 million tons per year. Of this total, 10 million tons are produced at the Vijayanagar steel works.

New LD (BOF) converter from Primetals Technologies installed in the Steel Melt Shop No. 2 of JSW Steel, Vijayanagar, Toranagallu, India



NEW HOT-STRIP MILL FOR THE SAIL ROURKELA STEEL PLANT

14. INDIA: As part of a campaign to increase the steel output at the Rourkela steelworks of Steel Authority of India Limited (SAIL) from 5.6 million tons to 10.8 million tons, a new hot-strip mill with an annual rolling capacity of 3 million tons will be supplied by Primetals Technologies. The order was placed with a consortium comprising Mitsubishi Corporation (MC) and Larsen & Toubro (L&T). MC will be responsible for the overall project management as consortium leader, and L&T will undertake civil construction, erection and local supply. Primetals Technologies will design and engineer the complete rolling mill as well as supply the main mechanical equipment. This includes a reheating furnace, a single-stand roughing mill, a 7-stand finishing mill, two down-coilers, auxiliary systems and equipment for the roll workshop. Four stands of the finishing mill will be equipped with Pair Cross technology for precise control of profile and flatness. The plant will produce a wide range of steels, including high-quality grades for use in the automotive and household appliance industries in addition to API (American Petroleum Institute) grades. The mill stands of the finishing mill are being equipped with Pair Cross technology for precise control of profile and flatness. The completed rolling mill is due to be handed over to SAIL at the end April 2018.



76-ton electric arc furnace at N.T.S. Steel Group Public Company Limited, Chonburi, Thailand (photo: courtesy of N.T.S.)

ELECTRIC ARC FURNACE MODERNIZATION AT N.T.S.

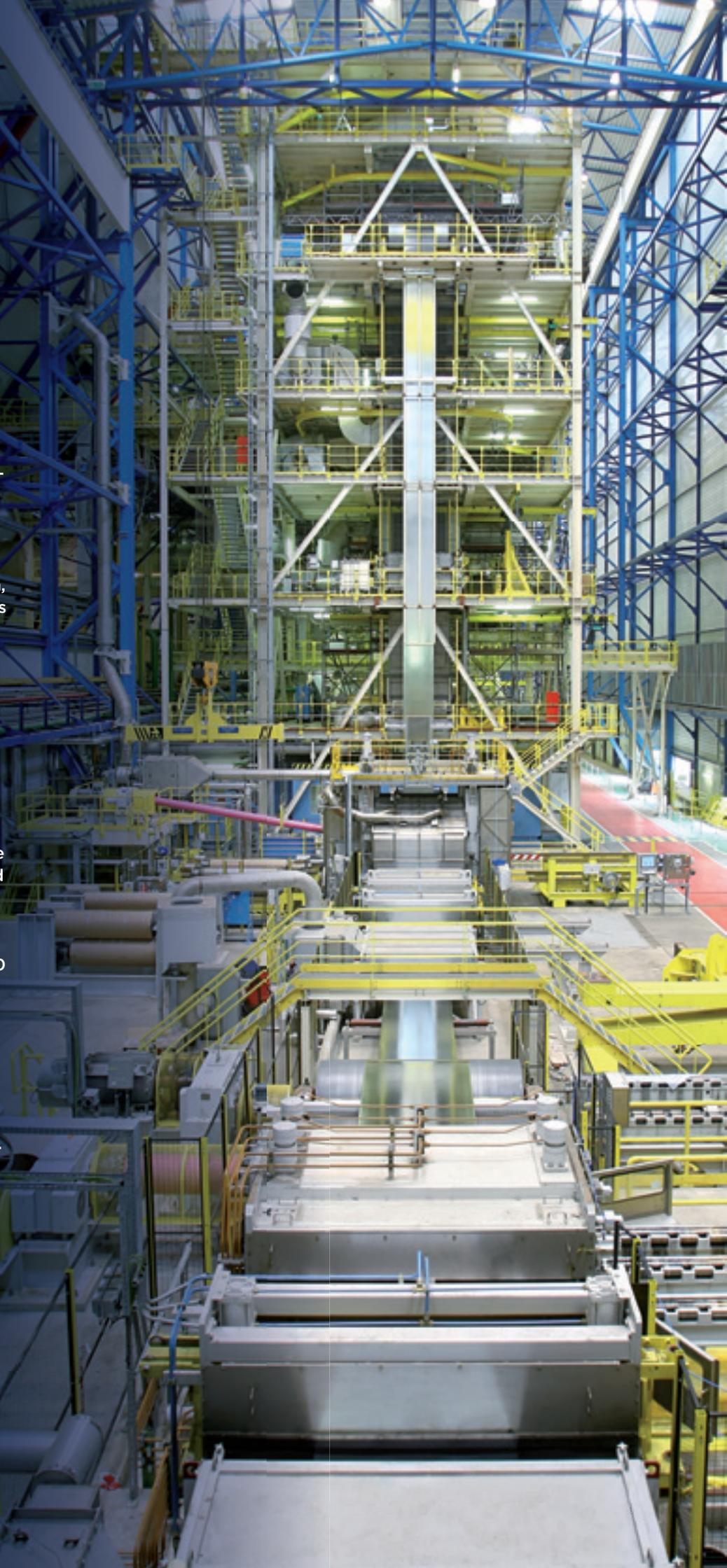
15. THAILAND: A 76-ton-capacity electric arc furnace (EAF) of N.T.S. Steel Group Public Company Limited is currently being modernized by Primetals Technologies at the steel producer's plant site in Chonburi, Thailand. The furnace is being equipped with a new electrode control system, the Foaming Slag Manager and a Refined Combined Burner (RCB) system. The target of the EAF upgrade is to reduce electricity consumption by 4% and the electrode consumption per ton of steel by 17%. The hydraulic system for the electrode lifting columns was also modified. Deployment of the Foaming Slag Manager allows the precise control of the height of the foaming slag, which optimizes the input of electrical energy into the steel bath. A more accurate electrode movement control will be achieved by applying the arc control optimizing system (Arcos) from Primetals Technologies. Arcos not only cuts energy consumption, but also increases the efficiency of the melting process. Process stability is also enhanced by continuously monitoring a range of parameters of the electricity supply system. All of these improvement measures contribute to a reduction of tapping times, increased furnace productivity and lower specific production costs.

The plant will produce a wide range of steels, including high-quality grades for use in the automotive and household appliance industries in addition to API grades.

TANGSHAN ORDERS TWO NEW CONTINUOUS GALVANIZING LINES

16. CHINA: Primetals Technologies received an order from Chinese steel producer Tangshan Iron and Steel Group Co. Ltd. (Tangshan Steel) for the supply of two continuous galvanizing lines, which will be installed in Cold Rolling Mill No. 2 of the Tangshan plant in Hebei province. The new equipment will increase the production capacity of high-strength, coated metal sheets by 650,000 tons per annum. The sheets will mainly be used by the automotive industry. The galvanizing lines (Nos. 5 and 6) will be constructed in a new hall alongside the existing cold-rolling mill, which was also supplied by Primetals Technologies and has been in operation since the beginning of 2015.

Primetals Technologies is responsible for the engineering, manufacture and supply of the mechanical, electrical and process technology equipment for the lines. Galvanizing Line No. 5 will have a capacity of some 250,000 tons per year and will process cold strip in widths ranging from 850 mm to 1,300 mm at thicknesses from 0.18 mm to 1.5 mm. Galvanizing Line No. 6 will galvanize 400,000 tons of steel strip per annum in widths ranging from 850 mm to 1,600 mm and at thicknesses from 0.5 mm to 3 mm. A special aluminum-silicon coating technology package will be implemented on one line. The new galvanizing lines are scheduled to commence operation in 2017.



The Mulpic system ordered by Baosteel is the most advanced supplied to date



ROD OUTLET REVAMPED AT ZENITH STEEL

17. CHINA: The outlet of the wire-rod mill at Zenith Steel (Changzhou Zhongtian Iron & Steel) in Changzhou, Jiangsu province, China, is being revamped with technology from Primetals Technologies to improve the quality and range of the rolled products. The existing Morgan Stelmor conveyor will be equipped with the first Optimesh system in China to enable accelerated and uniform cooling of high-carbon products. This technology is decisive for achieving consistent mechanical properties and metallurgical structure.

The scope of this upgrading project also includes the supply of a prefinishing mill, shear, Morgan Vee No-Twist Mill, a Morgan Intelligent Pinch Roll, laying head and water boxes. An integrated solution for the electrical and automation mill upgrade is also being provided. The revamped mill will be capable of rolling rod ranging in diameter from 5.5 mm to 20 mm at operating speeds of up to 110 m/s.

MULPIC INTENSIVE COOLING SYSTEM INSTALLATION AT BAOSTEEL ZHANJIANG

18. CHINA: Chinese producer Baosteel Zhanjiang Iron & Steel Co. Ltd. (Baosteel Zhanjiang) ordered a new Mulpic (Multi-Purpose Interrupted Cooling) system from Primetals Technologies that will be installed in the company's existing plate-rolling mill. The mill is currently being relocated from Shanghai to Zhanjiang, Guangdong Province, and is scheduled to be restarted in March 2016. The Mulpic system imparts considerably higher cooling rates and more accurate cooling control to produce plates with uniform metallurgical properties and fewer flatness defects.



Mulpic (Multi-Purpose Interrupted Cooling) system from Primetals Technologies

The Mulpic system ordered by Baosteel is the most advanced supplied to date and will incorporate the latest Mulpic control software along with advanced flow-control valves. The Mulpic system will also incorporate individual header control for both direct quenching (DQ) and accelerated cooling (ACC) modes of operation along the complete length of the cooling machine. Primetals Technologies will supply the complete mechanical, electrical and automation equipment for the Mulpic system.

SPOTLIGHT



Mick Steeper, Technology Manager and External R&D Facilitator, Primetals Technologies UK

MICK STEEPER APPOINTED IOM3 STEEL DIVISION CHAIR

The prestigious Iron and Steel Society of the Institute of Materials, Minerals and Mining (IoM3) has elected Mick Steeper of Primetals Technologies UK as its new chairman for a four-year term that extends until August 2019. The main activity of the society is the planning and organization of steel-related conferences in the U.K. and internationally. It also engages in a full range of cooperative activities with the steel industry and its value chain that include:

- Education and skills development
- Pre-commercial and collaborative research
- Provision of expertise, publications and other forms of knowledge dissemination
- Serving and supporting the collective interests of the technical steel community

The IoM3 itself is a learned society and the professional institution for industrial metallurgists (among other material scientists) in the U.K. The work of its divisions is not commercially oriented. Up until now, it had been customary for senior figures in steel companies to chair the Steel Division, with a few exceptions from academic disciplines. As far as is known, Mick Steeper's appointment is the first time that an employee of a steel industry supplier has taken this position.

NEWS FLASHES

voestalpine Stahl GmbH

Austria

On June 16, 2015, the Austrian steel producer voestalpine Stahl and Primetals Technologies signed a contract to build a prototype dry slag granulation (DSG) plant on an industrial scale on the site of Blast Furnace A in Linz. The combined engineering and installation costs are being roughly shared between the two companies with financial support from the Austrian government. The decision to build a full-scale plant was made on the basis of previous experience acquired from successful laboratory and large-scale trials.

Aperam Stainless Belgium N.V.

Belgium

An order was received from Aperam Stainless Belgium for the upgrading of the twin drives, edger drive and auxiliary systems of the company's hot-rolling mill located in Châtelet. Primetals Technologies will convert the existing DC drive systems of the hot-rolling mill stands to AC drive systems in six execution phases between 2016 and 2020.

Baosteel Zhanjiang Iron & Steel Co., Ltd.

China

Two slab casters were successfully started up in September 2015 by Primetals Technologies at Baosteel's steelworks in the port city of Zhanjiang, Guangdong province.

TKAS (ChongQing) Auto Steel Co., Ltd.

China

The first coated coil was produced in June 2015 on a continuous galvanizing line supplied by Primetals Technologies. This line combines three coating types: CI, GA and Al-Si – a first for a Chinese plant – which are foreseen for use in the automotive industry.

ArcelorMittal Florange and Dunkirk, Aperam Stainless Belgium N.V.

**France
Belgium**

In July and August 2015, a total of five drive systems, each with 12 MW of installed power, were successfully commissioned at the hot-rolling mills of ArcelorMittal Florange, France; ArcelorMittal Dunkirk, France; and Aperam Stainless Belgium. These projects are part of a total upgrade of the hot-rolling mills in which the existing DC drive systems were replaced with new AC technology.

BMM Ispat Ltd.

India

Primetals Technologies received the provisional acceptance certificate (PAC) from BMM Ispat Ltd. on August 12, 2015, following the tapping of the first heat from the new electric arc furnace installed at Danapur Village in the state of Karnataka. The project scope also included the supply of the ladle furnace, dedusting facilities and the material-handling system.

Jindal Steel and Power Limited (JSPL)

India

At the new steelworks of JSPL in Angul, Odisha, Primetals Technologies will supply the complete automation system for the raw-material-handling system in the new coke oven plant.

Kalika Steel & Alloys Pvt. Ltd.

India

Following the successful commissioning of a new 250,000 t/a bar mill at Kalika Steel & Alloys in Jalna, Maharashtra, the PAC was issued to Primetals Technologies by the customer.

Steel Authority of India Limited (SAIL)

India

On July 28, 2015, Primetals Technologies received the commissioning certificate for the new coupled pickling line and tandem cold mill (PLTCM) installed at SAIL's Bokaro Steel Plant.

Steel Authority of India Limited (SAIL)

India

On August 13, 2015, Primetals Technologies received an order from SAIL to upgrade the sinter cooler of Sinter Plant No. 3 at the company's integrated steelworks in Bhilai in the state of Chhattisgarh. The project also includes increasing the sinter cooling capacity from 800 t/h to 850 t/h.

Tata Steel Ltd.

India

A second gas-cleaning plant is being supplied by Primetals Technologies for the E Blast Furnace of Tata Steel in Jamshedpur.



FIG. 1: New Primetals Technologies-supplied blooming stand at Acciaierie Venete S.p.A., Camin, Italy

Acciaierie Venete S.p.A.

Italy

The Italian specialty steel company Acciaierie Venete S.p.A. issued the final acceptance certificate (FAC) to Primetals Technologies following the completion of an extensive modernization of a blooming mill in Camin, Italy (Figure 1). Within the scope of the project, a new blooming stand was installed and integrated into the existing line. The main target of this turnkey project was to improve the quality of blooms with the option of entirely or partly dispensing with downstream processing steps.



Fig. 2: Ribbon-cutting ceremony for the new North American headquarters of Primetals Technologies in Alpharetta, Georgia, U.S.A. Pictured left to right: Jack Mueller, Executive Vice President and CFO, Primetals Technologies USA LLC; Doug Keith, U.S. Lead, Large Drives Business Unit, Siemens; David Belle Isle, Mayor of the City of Alpharetta; Satoru Iijima, President and CEO, Primetals Technologies USA LLC; Jagannath Rao, U.S. Head, Customer Services, Siemens; and Ralf Hanneken, Executive Vice President and Head of Operations, Primetals Technologies USA LLC

ArcelorMittal Poland

Poland

Two contracts were signed with ArcelorMittal Poland for the supply of complete sets of tuyere stocks and staves in connection with the relining of Blast Furnace No. 5 in Kraków, which will take place in 2016.

Novolipetsk Metallurgical Combine (NLMK)

Russia

Production record: A total of 110 steel heats were successfully produced and cast with one tundish at the mini-mill of NLMK Kaluga (a company of NLMK Group Long Products Division) in the time period from May 18 to 21, 2015. This is one of the best figures in the world for a long-product minimill. In an uninterrupted casting sequence that lasted for 77 hours and 6 minutes, a total of 13,000 billets were produced. The average heat weight was 126.4 tons and the achieved hourly productivity rate was 180.6 tons. During this record heat series, the specific energy of the EAF was 354.1 kWh/t of product, which is in line with best global practices. Primetals Technologies supplied the 120-ton Ultimate EAF that features a high specific electrical power input and a single-bucket charging practice; the 8-strand billet caster – the first in Russia; and a twin-stand ladle furnace.

ArcelorMittal Asturias

Spain

In August 2015, Primetals Technologies finalized the last phase of the pickling line revamping project to improve strip quality and increase the line output to 1,800,000 t/a.

Dragon Steel Corporation

Taiwan

In February 2010, the No. 1 Blast Furnace at the Taichung Works of Dragon Steel Corporation was put into production.

Designed and supplied by Primetals Technologies, the furnace is rated at 2.5 million tons of hot metal per year. After more than 5 years of consistent, trouble-free operation, more than 14 million tons of iron have been dispatched to the steel plant to date. Complemented by the similar-sized No. 2 Blast Furnace commissioned three years after the first furnace, both ironmaking plants continue to exceed their rated production capacity.

U.S. Steel Corporation Granite City Works

U.S.A.

The first heat of the relocated slab caster CC1 was successfully cast on October 2, 2015, at U.S. Steel's Granite City steelworks in southwest Illinois. The slab caster produces a wide range of steel grades at widths up to 87 inches (2,210 mm) in the single-slab casting mode and at widths of 47 inches (1,194 mm) in the twin-slab casting mode. The slab thickness is 9.1 inches (231 mm).

New North American Headquarters

U.S.A.

On September 11, 2015, Primetals Technologies USA LLC held a ribbon-cutting ceremony for the company's new North American headquarters in Alpharetta, Georgia (Figure 2). The 35,000-square-foot facility (3,252 m²) houses a total of 140 employees, including engineers, engineering managers and technicians, as well as personnel involved in project execution, sales and support. During the event, Satoru Iijima, President and CEO of Primetals Technologies USA LLC, stated that the new office will allow employees to innovate to their highest potential. "This state-of-the-art facility will enable all of us to collaborate in new and exciting ways as we support our customers in the Americas as one united team," he said.





MORE VALUE FOR CUSTOMERS

**ENHANCED ROLLING AND PROCESSING
PORTFOLIO OF PRIMETALS TECHNOLOGIES
FOR THE PRODUCTION OF FLAT PRODUCTS**



The combination of advanced technology and state-of-the-art automation solutions is the basis for outstanding, value-added products.

The merging of the former Mitsubishi-Hitachi Metals Machinery and Siemens VAI Metals Technologies in January 2015 to become Primetals Technologies considerably enlarged the company portfolio of downstream technologies in the flat-product sector. This feature article presents an overview of the extensive scope of rolling and processing solutions offered to producers of steel and nonferrous metals.



PRIMETALS TECHNOLOGIES CENTERS OF COMPETENCE FOR DOWNSTREAM FLAT-PRODUCT PRODUCTION

1. Sheffield, U.K.

- Plate, Steckel and plate-Steckel mills
- Hot- and cold-rolling mills for aluminum

2. Montbrison, France

- Processing lines for carbon and stainless steel
- Cold-rolling mills for stainless steel

3. Erlangen, Germany

- Electrics, Level 1 and Level 2 automation for all types of rolling mills and processing lines

4. Linz, Austria

- Arvedi ESP (endless strip production)
- Hot-strip mills for carbon steel
- Cold-rolling mills for carbon steel, including pickling lines

5. Hiroshima/Tokyo, Japan

- Plate and Steckel mills
- Hot-rolling mills for strip and aluminum, as well as Steckel mills
- Cold-rolling mills for carbon steel, stainless steel and aluminum
- Processing lines and furnace technology for carbon steel, silicon steel and stainless steel

Shortly after the start of operations of Primetals Technologies, an extensive review of the combined product portfolio was performed by the company's centers of competence for downstream technologies located in Austria, France, Germany, Japan and the U.K. (Figure 1). The respective strengths and features of available process solutions were compared, and the results showed that while certain technologies were better suited for new plant installations, the strengths of others was particularly applicable for modernization steps. Above all, it was clearly recognized that the full scope of existing company solutions is needed to ideally serve the international metals market. A technology exchange program is now underway to maximize the joint venture's product-synergy effect

as well as the capability and skills of the company's expert personnel. A global Intranet communication platform is therefore being established to share accumulated experience and project results.

The target is to supply the best solutions available from the different centers of competence on a local level to meet specific market requirements. Furthermore, the worldwide network of sales offices, engineering locations, workshops, service centers and maintenance outposts of Primetals Technologies ensures a close relationship with customers for fast supply and support. Key elements of the company's combined downstream portfolio for flat products are presented in the following. »



ARVEDI ESP - ENDLESS STRIP PRODUCTION FROM CASTER TO COIL

In the Arvedi ESP process, coiled hot-rolled strip is produced in a combined, continuous and uninterrupted casting and rolling line. Energy consumption and the associated costs and CO₂ emissions are reduced by up to 45% compared to conventional casting and rolling processes. With a length of just 180 m, the plants are also considerably more compact than conventional casting and rolling mills. A wide range of high-quality and ultra-thin steel grades can be produced for demanding steel applications.



HOT-STRIP MILL - HIGH PERFORMANCE FOR NEW AND MODERNIZED MILLS

The demand for advanced, high-strength steel grades is continually growing, as are the requirements placed on product quality, mill productivity and plant availability. In order to remain competitive, new and existing steel plants must meet this challenge in the best-possible way. A wide range of solutions for hot-strip mills is offered to meet specific customer demands.



PLATE MILL - POWERFUL SOLUTIONS TO MEET INDIVIDUAL REQUIREMENTS

Immense power combined with precision rolling, accelerated cooling and thermo-metallurgical conditioning are decisive factors for meeting the ever-increasing demands placed on plates for consistent high quality, uniform mechanical properties and dimensional perfection. Primetals Technologies assists producers to meet the highest plate standards with specialized solutions, all the way to the supply of complete plants.



STECKEL MILL - PRODUCTION EFFICIENCY FOR SMALL CAPACITIES

Unique and totally optimized solutions offered for new Steckel mills are based on decades of experience in supplying metallurgical plants. Plant modernization combines vast experience and innovative solutions, which enables customers to improve product quality, increase operational efficiency in coil production and serve specialized niche markets.



PLATE-STECKEL MILL - ROLLING A BROAD RANGE OF STEEL PRODUCTS AT LOW COSTS

Highly efficient plate-Steckel mills combine the full asset utilization of the strip-rolling process with the grade and width range of a reversing plate mill. Innovative engineering assures high productivity, metallurgical precision during cooling, and operational reliability. Plate-Steckel mills provide the flexibility to roll plates or coils as required in order to quickly respond to changing market demands.



PICKLING LINES - PROVEN SOLUTIONS FOR CLEAN AND SCALE-FREE STRIP SURFACES

Modularly designed continuous and push-pull pickling lines from Primetals Technologies are characterized by their efficiency, economic operation and use of advanced technologies such as compact scale breakers, state-of-the-art welders and turbulent pickling systems. Customers have the choice of different well-proven pickling concepts that include iBox, turbulent tank and shallow-bath tanks to meet specific requirements or preferences.





The demand for advanced, high-strength steel grades is continually growing, as are the requirements placed on product quality, mill productivity and plant availability.



**A comprehensive range
of cold-rolling solutions
is available from
Primetals Technologies
to satisfy all market
demands for high-quality
strip products.**



TANDEM COLD MILL - EXCELLENT TECHNOLOGY, EXCELLENT PRODUCTS

Tandem cold-mill solutions are the key for achieving high product yields, low operational costs and reduced maintenance. The latest solutions provide maximum added value for customers. Depending on the product mix, the annual production capacity typically exceeds 1.2 million tons. Both 4-high and 6-high mill stands equipped with advanced mill-stand actuators are supplied following detailed analyses of product and customer requirements. Primetals Technologies applies the experience acquired from hundreds of mill installations across the world.

SKIN-PASS MILL - FOR SUPERB FLATNESS AND A PERFECT FINISH

The advantages of skin-pass mills include full compliance with tight strip elongation tolerances; excellent flatness performance; uniform surface roughness for coating applications; and the availability of wet and dry skin-passing modes. Both stand-alone and inline skin-pass mills are supplied in either single- or 2-stand design for adjusting the final mechanical properties, flatness and surface finish of cold-rolled strip.



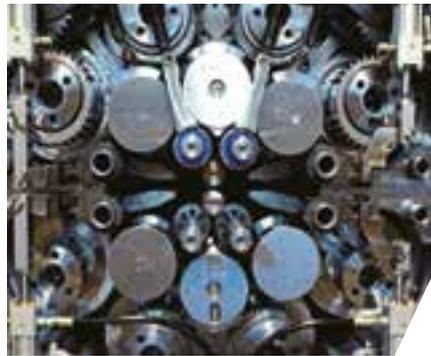
COUPLED PICKLING LINE AND TANDEM COLD MILL - CONTINUOUS STRIP ROLLING

For numerous product applications, the required strip thickness, flatness and surface quality can be achieved more economically by coupling the pickling and cold-rolling processes. This results in significant improvements with respect to mill productivity, yield and production cost savings due to the elimination of strip-threading and tailing-out operations. Maintenance, roll consumption and manpower requirements are also lowered. The use of speed-optimization systems ensure the highest throughput rates under all operating conditions.



REVERSING COLD MILL - FLEXIBLE ROLLING OF SMALLER ORDER LOTS

Advanced reversing cold-mill technology is an ideal solution for small- to medium-sized production capacities, or for the rolling of smaller order lots of special steel grades. Depending on the product mix and quality demands, both 4-high and 6-high mill stands are offered by Primetals Technologies to meet the respective product and customer requirements.



SPECIAL STEEL MILL - EFFICIENT ROLLING OF RIGID MATERIALS

Special steel mills are chiefly designed for the rolling of stainless steel, electrical steel and other special-purpose steels. The most common configuration is the single-reversing mill type. Various mill designs are offered from Primetals Technologies that include 6-high UCMs (universal crown control mill), 20-high ZR mills and 12-high cold-rolling mills with small-diameter work rolls for the rolling of materials with high hardness.

CONTINUOUS ANNEALING LINES - HIGH-END SOLUTIONS FOR DEMANDING PRODUCTS

Advanced annealing lines are essential for ensuring precisely controlled metallurgical properties - as required for high-end steel applications - and for fast processing speeds. Supplied annealing lines feature a flexible, multi-zone furnace design to produce a broad range of steel grades and dimensions at very high process speeds. Line equipment also includes fully automatic coil feeding, mash-lap or laser welders, strip-cleaning sections, and state-of-the-art drive and automation solutions.





The combined downstream product portfolio of Primetals Technologies means that the finest rolling and processing technologies in the world are available for customers.

METALLIC COATING LINES – MORE ADDED VALUE FOR A WIDE RANGE OF APPLICATIONS

A general trend in the steel industry today is the greater emphasis placed on product value and thus the profit margin for rolled products with the use of special coating techniques. A broad range of solutions are offered for the metallic coating of both hot-rolled and cold-rolled strip in continuous hot-dip galvanizing or electrolytic tinning lines. The value-added, high-quality material is extensively used in construction, appliance, automotive and packaging applications.

CONTINUOUS STAINLESS STEEL ANNEALING & PICKLING LINES – EFFICIENT AND ECONOMIC

Stainless steel annealing and pickling lines from Primetals Technologies link the traditionally separate processes of rolling, annealing, pickling, skin passing and leveling into one fully integrated rolling and processing plant. An efficient cleaning section ensures that the required strip cleanliness prior to annealing is achieved. A tunnel furnace is installed in the annealing section, and acid pickling is applied in the pickling sections.

ALUMINUM HOT-ROLLING MILL – HIGH PRODUCT QUALITY, YIELD AND PLANT FLEXIBILITY

A complete range of aluminum hot-rolling mills is supplied for both new and revamp projects. With a flexible mill configuration, high-quality strip can be rolled in capacities between 100,000 t/a and 800,000 t/a. Advanced solutions feature a synthesis of mechanical actuators, electrical and automation control systems, and applied process know-how to deliver gauge, profile/flatness, temperature and surface quality with the highest level of consistency.



ALUMINUM COLD MILL – A SINGLE MILL FOR BOTH BREAKDOWN AND FINISHING

The aluminum cold-rolling portfolio offers a unique blend of innovative design and proven technology for both new and existing plants. Strip is produced with very tight tolerances at high productivity levels and with maximum yield. An accurate mill setup is crucial for meeting quality requirements. Supplied solutions from Primetals Technologies include physical on-line process models, integrated process control and drive systems that employ industry-standard platforms to ensure optimum rolling results at all times.

ALUMINUM FOIL MILL – EFFICIENT PRODUCTION OF HIGH-QUALITY, LOW-COST FOIL

Primetals Technologies supplies the world's most advanced foil-rolling mills in the world. They combine the latest developments in automated foil feed and process control to enable producers to achieve the best-quality foil at the lowest costs. Increasing demands on the quality of aluminum foil applications mean higher demands for production equipment. At present, rolling mills are expected to produce foil of less than six microns in thickness at widths of up to 2 m, and at speeds in excess of 2,000 m/min.



COPPER FOIL ROLLING MILL – UC-MILL OR X-MILL TECHNOLOGY FOR THINNER-GAUGE ROLLING

The UC-Mill or X-Mill, featuring intelligent shape control with Sheetflat technology, is designed for ultra-thin rolling of strip or foil. Thanks to their high degree of shape controllability, UC-Mills are particularly suited for copper foil production. The rolls are arranged in an X shape in which a pair of parallel backup rolls support the small-diameter work roll to prevent horizontal deflection. Stable and reliable thin-gauge rolling is the result. Narrow-width UC-Mills are also available for copper finish rolling to foil-gauge thicknesses.



THE FUTURE IS VALUE-ADDED

The combined downstream product portfolio of Primetals Technologies means that the finest rolling and processing technologies in the world are available for customers to add the finishing touch to metal products. Decades of plant-building experience and the acquired know-how from thousands of successfully implemented projects add up to superb production facilities, outstanding products and new market opportunities. ●

Gerlinde Djumlja, Vice President, Head of Hot and Cold Mills, Primetals Technologies Austria

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



A WELLSPRING OF SOLUTIONS THROUGH VARIETY

**INTERVIEW WITH DR. ETSURO HIRAI,
CHIEF TECHNOLOGY OFFICER OF PRIMETALS TECHNOLOGIES**





Primetals Technologies is characterized by a broad technological, geographical and cultural diversity that serves as a catalyst for the generation of new ideas and solution approaches. In this interview with Metals Magazine editor Dr. Lawrence Gould, CTO Hirai underlines the advantage that the extensive company background offers for technological evolution. He also emphasizes the role that proper knowledge management and people management play in driving technology forward.

“ We are aiming to be a perfect and comprehensive supplier of metals technologies with manufacturing expertise.”

What do you see as the main technological benefit resulting from the merger of MHMM [Mitsubishi-Hitachi Metals Machinery] and Siemens VAI to form Primetals Technologies?

Etsuro Hirai: We are aiming to be a perfect and comprehensive supplier of metals technologies with manufacturing expertise. The former MHMM was primarily involved in downstream rolling and processing activities. In fact, it had always been our intention to expand to become a full-line supplier company, which was strongly supported by our CEO, Yasukuni Yamasaki. This led to the joint venture and the birth of Primetals Technologies.

What goals or what strategy do you have for integrating and advancing the level of technological competence offered by Primetals Technologies?

Hirai: A unifying strategy is now necessary and the technology must be balanced. We have to identify the key

technologies that can best serve the metals business. The direction that we take must be based on customer requirements and the general trends in steelmaking. A key challenge will be to maximize the synergy effect of the two joint-venture companies. The technologies of both companies can directly complement one another right now. On top of this, the technologies of both parent companies can be applied. For example, Mitsubishi Heavy Industries offers chemical plants and power stations with downstream DeNO_x and CO₂-reduction solutions, so the same technology can be made available for upstream processes. The E.U. has set very high targets regarding CO₂ emissions – an 80% reduction compared to 1990 levels – so a strong focus will be placed on CO₂-reduction solutions and the development of the related technologies. There will be an increased integration of technology, electrics and automation in downstream processes. The emphasis will be placed on using electrical energy more efficiently and »



“ The evolution of technology is accelerated by the availability of a wide range of technologies – and this variety is now in a single hand.”

lowering energy consumption, especially through the application of IT solutions, such as in Industry 4.0 concepts. In the areas of rolling and processing, MHMM and Siemens VAI do have a few overlapping products, although this is not necessarily negative. In fact, the evolution of technology is accelerated by the availability of a wide range of technologies – and this variety is now in a single hand. The goal will therefore be to combine technologies and define their future direction. In some cases certain technologies will become obsolete and others will complement one another.

The engineering and R&D competence of Primetals Technologies is based in different locations throughout the world. Do you see this as an advantage or disadvantage?

Hirai: In a similar way that a variety of technologies leads to technical evolution, a variety of locations with their different cultures and environments can also have a positive impact on the evolution of technology. It's helpful to have different R&D groups concentrated at different locations, but the issue is to properly manage and direct this R&D competence. Primetals Technologies currently has some 300 R&D specialists working at ten locations throughout the world. People need to discuss and share ideas. A common Internet platform now serves as an important means for communicating between our Linz,

Erlangen and Japanese sites. Everyone who has access can view the profile and status of projects and share information using the installed tools. Toward the end of the current fiscal year, a common communication tool will be available for all of our R&D centers worldwide.

What is the role of knowledge management at Primetals Technologies?

Hirai: This is a key issue. With so much data available today, my view is that knowledge lives in people, so if you want to manage technology, you need to manage people. To do this, you have to know which technology belongs to whom, what its level is, the degree of know-how and where it is based. Another key issue is the vast metallurgical know-how that is available at Primetals Technologies, which significantly distinguishes us from the competition. As new steel grades develop faster than ever before, proper knowledge management and people management are vital.

Primetals Technologies has signed an agreement to participate in K1-Met [Competence Center for Metallurgy] to improve existing metallurgical processes and to develop the technologies of tomorrow. What benefits do you see in such industrial and scientific partnerships?

Hirai: A scientific partnership is very important for our company because good ideas also come from outside

sources. Again, it is this variety of people, companies and organizations that can result in a wellspring of solution approaches that a single company may not think of on its own.

What potential do you see for the strip-casting technology offered by Primetals Technologies?

Hirai: If a customer wants to minimize financial expenditures yet needs to cast a specific steel grade at a certain production capacity, strip casting offers an attractive option. This technology is not just limited to steelmaking but can also be applied in a wide range of other metal-producing sectors. We have the experience to build and install strip-casting plants. We are aiming to be a supplier that offers a variety of casting technologies for customers.

As far as breakthrough technologies go, do you see any ahead in the iron and steel industry?

Hirai: It is said that iron and steelmaking technology is very mature today and that the fundamental chemical and metallurgical reactions are well known. It is therefore quite difficult to identify radical new approaches or implement groundbreaking developments. But there are still some areas where exciting things are happening, such as in connection with continuous production. The casting and rolling processes have been linked as highlighted by the Arvedi ESP process for the endless production of hot-rolled coils directly from liquid steel. Such technologies are increasingly being combined with IT solutions to correspond to real-time production and market needs. Steel-making processes will one day be seamlessly connected to the upstream and downstream steps. Due to steel-making overcapacity, there will be an increasing abundance of scrap, which calls for more advanced melting furnaces and improved refining processes.

One last question: The company slogan of Primetals Technologies is “Creating the future of metals as one.” What do you understand under this phrase?

Hirai: “As one” is a key word in Japanese society. We say “一心同体 (isshin-doutai).” It means that one spirit lives in one body, which is to say that everybody has the same objective and vision and that we all are in the same boat. There may be different approaches and different ways of doing things, but the overall objective for us is to be a full-line supplier in our field so that we can offer the best-possible solutions to meet the needs of our customers. We respect free thinking, but the overall target has to be the same. We also have to think about the procedure and necessary steps to create the future. This can be achieved on the basis of excellent metallurgical processes and machinery, which can contribute to positive developments in the steelmaking business and to society as a whole.

Above all, technological developments must be customer focused and provide added value. This means that we need to closely work together not only with our own employees but also with our customers to create the future of metals as one. ●



DR. ETSURO HIRAI

CTO OF PRIMETALS TECHNOLOGIES

PASSION FOR TECHNOLOGY

Dr. Etsuro Hirai joined Mitsubishi Heavy Industries (MHI) in 1983 and first worked in the company’s R&D center in Hiroshima in connection with steelmaking machinery and chemical engineering technology. With his background in heat transfer and fluid dynamics, he was heavily involved in numerous furnace and pickling line projects. This eventually expanded to include R&D activities in the areas of casting and rolling, lubrication and solidification.

A technological highlight was his participation in the development of a jet-pickling process, which evolved to the iBox system that allows for more efficient and faster pickling – especially with interstitial-free steels. Another technological feat was the implementation of a non-contact air-floating system for steel in the galvanizing furnace and for silicon steel in the annealing furnace.

In January 2015, at the founding of Primetals Technologies, Dr. Etsuro Hirai was appointed Chief Technology Officer (CTO).



THE CAMERA-BASED LIQUIROB ROBOTIC SYSTEM installed in a steelworks environment: the product of an innovative development in the R&D testing and optimization facilities of Primetals Technologies

TRIED, TESTED **AND TRUE**

**GLOBAL R&D TESTING AND OPTIMIZATION FACILITIES
OF PRIMETALS TECHNOLOGIES AND ITS COOPERATION PARTNERS**



As a world-leading engineering and plant-building enterprise for the metals industry, Primetals Technologies places the highest priority on ensuring that all supplied plants, equipment and technology are fully proven and meet contract specifications and project requirements. To this end, the company – together with its cooperation partners – has at its disposal some 60 well-equipped testing and optimization facilities located at 23 sites worldwide. All steps of the iron and steel production route as well as nonferrous technologies are covered.

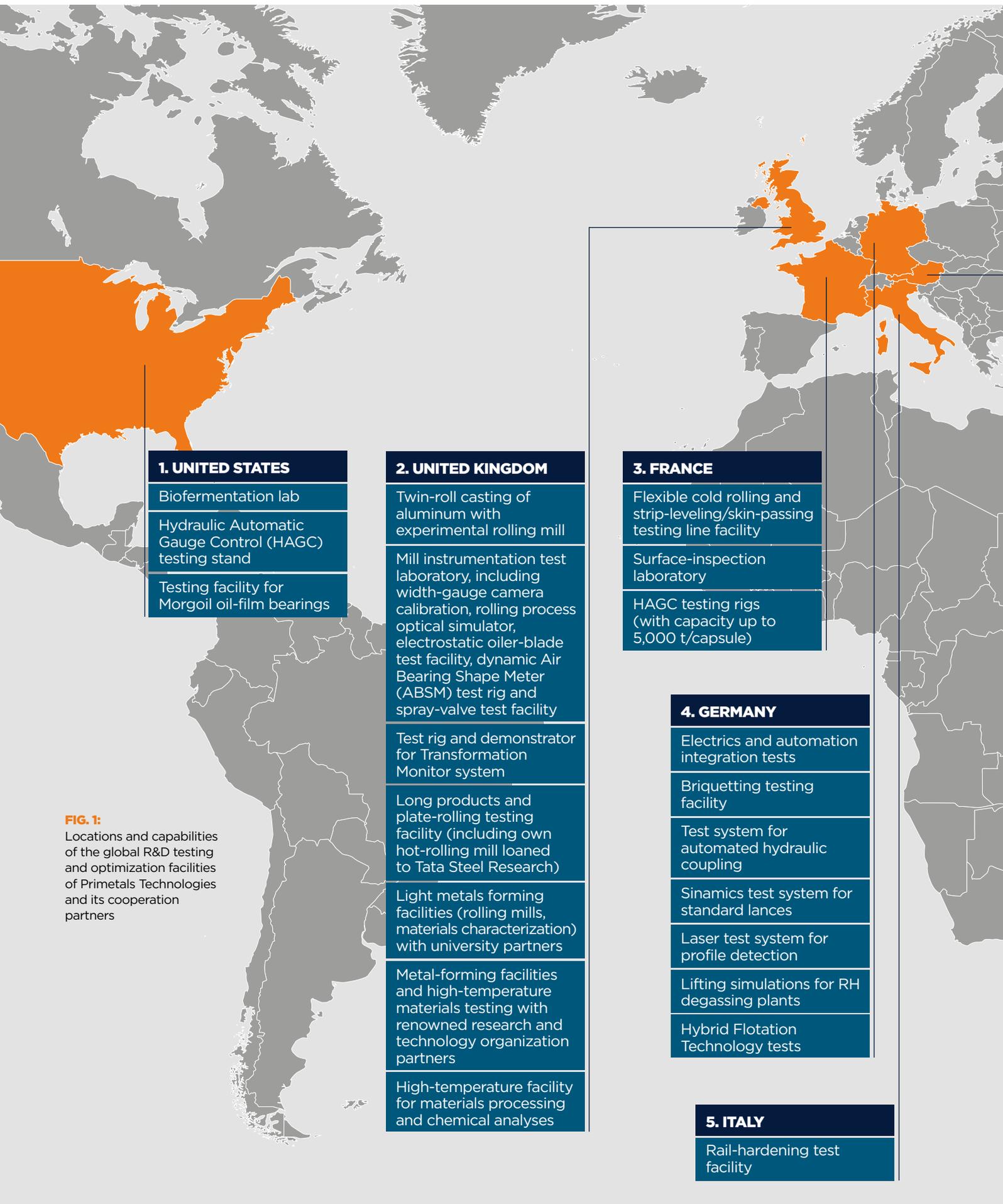


FIG. 1: Locations and capabilities of the global R&D testing and optimization facilities of Primetals Technologies and its cooperation partners





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Before a technical product can be useful to industry, certain attributes have to be met and proven. A product needs to perform repeatedly. It must withstand the environmental conditions in which it operates for as long as possible. New equipment and components require exhaustive testing and certification to ensure that they are reliable and safe to use. Testing is fundamental to engineering. It does not just apply to a final product ready for dispatch to a customer, but also encompasses the integration of product systems. Testing covers all stages in the development of a technology as well as all stages of manufacturing.

Primetals Technologies is involved with complex engineering tasks on a daily basis. Testing is a cornerstone for much of the company's business, from proving performance to assuring the quality of supplied equipment and plants. Testing is needed to optimize a process and to find out how well new concepts actually work. The expertise that is required to test a complex engineering system, such as a steelmaking converter, a rolling mill or processing facility, is very broad and highly diverse. The test

equipment itself is often customized and usually expensive. All of this leads to the requirement for a cooperative approach to testing in which in-house facilities are combined with those of external partners.

The overriding goals include the development of new technologies; optimization of metallurgical processes; confirmation of the functionality, efficiency, practicality and economy of new equipment designs; and the flawless integration of all associated electronic, mechatronic, automation and environmental systems. In the following, the numerous optimization and testing facilities that are at the disposal of Primetals Technologies are reviewed (Figure 1). These extend across the entire metals value chain, from ore beneficiation facilities to the processed metal product.

IRONMAKING

Investigations related to the processing of carbon-bearing materials, ore treatment, product improvements and the suitability of refractory materials are carried out in the area of ironmaking. This includes ore flotation tests; iron ore reduction tests; and cold briquetting of coals, ores, sinter

FIG. 2:

Hybrid Flotation
Technology testing
rig of Primetals
Technologies



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4.



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6.

FIGS. 3-6, FROM LEFT TO RIGHT:

Intensive mixer for fine coal and binder used in briquetting tests; briquette roll press; results of cold-formed, coal-briquetting tests; and an agglomeration testing facility. All photos were taken at ARP in Leoben, Austria.

finer, pellet fines and sludges for subsequent use in metallurgical facilities (Figures 2-6).

Hybrid Flotation Technology: The efficiency of the flotation process has a decisive impact on the profitability of a mine. Primetals Technologies introduced so-called Hybrid Flotation Technology, which is based on the combination of 1) pneumatic injection of an ore slurry into the upper zone of a flotation cell for fine and ultrafine ore-particle separation and recovery, and 2) air injection into the lower portion of a flotation cell for coarse ore-particle separation and recovery.

In a Hybrid Flotation Technology testing rig of Primetals Technologies, process aspects and design features are investigated and optimized to achieve a more efficient concentration of metals from sulfidic ores. A reverse flotation process can also be applied using the testing facility for silica removal from iron ore. The unit has a volume of 30 l and a throughput capacity of 0.72 m³/h. It is well suited for a quick evaluation of various ores, flotation chemistry, process parameters and flotation cell design.

Agglomeration pot tests: The new pellet pot test facility of Primetals Technologies was built and commissioned in Leoben, Austria, at ARP (Aufbereitung, Recycling, Prüftechnik) Ges.m.b.H. in 2015. This facility allows fast and comprehensive testing of various pellet-feed mixtures and/or concentrates to determine their suitability for use in the pelletizing process. In combination with beneficiation tests, calculations and CFD simulations, an optimum induration machine design can be engineered. Furthermore, fundamental research on material and process behavior can be performed using this fully automated agglomeration pot test facility.

Sinter pot tests are also conducted at the R&D facilities of voestalpine Stahl Linz, including the preparation of raw materials for the Intensive Mixing and Granulation System (IMGS). Furthermore, Selective Waste Gas Recirculation (SWGR) tests are carried out to determine the ideal selection of recirculation windboxes used in the SWGR process. Full chemical and physical analyses are done to optimize the sinter raw mix recipe and process parameters. »



FIG. 7:
Mercon pilot plant -
maximized emission
reduction and energy
recovery in converter
steelmaking



FIG. 8:
Pilot plant for investigating the use of molten salt for the intermediate storage of thermal energy from EAF offgas



FIG. 9:
Strip caster trials in Hiroshima, Japan

Blast furnace dry-slag granulation: The feasibility of recovering the heat energy of liquid blast furnace slag for the generation of steam and electricity will be determined in a prototype dry-slag granulation plant (DSG) that is currently being installed on an industrial scale at the voestalpine steelworks in Linz. Previous DSG test were successfully performed on a laboratory scale with cooperation partners at the University of Leoben, Austria.

CONVERTER STEELMAKING

Lime solubility tests can be carried out when lime is added to converter slag. These tests show how quickly lime is dissolved with different slag compositions. The tests have the purpose of more accurately determining the dynamic behavior of the converter process and better predicting the end of the oxygen-blowing phase in LD (BOF) steelmaking. Simulations are also performed at Johannes Kepler University (JKU) in Linz related to the vibration behavior of AOD stainless steelmaking converters. On the basis of these results, a hydraulic vibration damper was developed to suppress AOD converter vibrations. This unit was installed and is now successfully operating at Taiyuan Iron and Steel Corp. (TISCO). A subsequent order was received from North American Stainless for a similar AOD converter vibration-damping system in September 2015.

Mercon: A new dry-type converter offgas dedusting system is currently being developed jointly with a European steel producer (Figure 7). The dedusting system is referred to as Mercon, which is an acronym for maximized emission reduction and energy recovery in converter steelmaking. An inert material is injected into the offgas stream to avoid

the risk of dust reoxidation during the non-blowing phase. Investigations are being carried out to optimize the materials used in the advanced bag filters with respect to high-temperature stability and maximum gas-cleaning efficiency, especially with regard to ultra-fine particulates. Emission values of less than 5 mg/Nm³ are targeted.

ELECTRIC STEELMAKING

Primetals Technologies has at its disposal a pilot plant facility that is available for investigating the use of molten salt as an intermediate heat-storage media for thermal energy contained in the EAF offgas (Figure 8). The unit was exhaustively tested at Stahlwerk Thüringen, Germany, where key process parameters and suitable corrosive-resistant materials were determined. The heat energy released as the molten salt solidifies can be used for the generation of steam for energy savings. The pilot plant is now installed at the Technical University of Vienna, Austria, and it is available for further process optimization work in collaboration with potential customers.

At the Willstätt-Legelshurst site of Primetals Technologies Germany, numerous tests are underway to improve EAF and vacuum degassing equipment and processes. Examples of these include:

- Testing of a laser-based system for scrap-profile detection for use in automated scrap bucket loading
- Automated hydraulic coupling of the scrap bucket used in shaft-type EAFs
- Application of a Sinamics system for testing standard lances
- Vacuum degassing vessel-lifting simulations





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FIGS. 10-11:

Optimization of
spray-nozzle design
for secondary cooling
in continuous casting
plants, Linz, Austria



11.

CONTINUOUS CASTING

In the field of continuous casting, a strip-casting process for both steel and nonferrous metals is being further developed at the Hiroshima site of Primetals Technologies (Figure 9). Complementary processes for the strip casting of aluminum are under development at Brunel University in the U.K. Promising research results can be transferred to Hiroshima for in-house refinement of potential commercial technologies.

At the company's nozzle testing stand in Linz, the design and control of nozzles used for the secondary cooling of the cast strand are continually being enhanced, and the complete nozzle characteristics are measured to fully optimize strand-cooling parameters (Figures 10-11).

Continuous casting trials and tests are performed at customer plant sites in order to investigate measures to increase the casting speed, improve product quality and optimize equipment design. Furthermore, the thermodynamic properties of different steel-grade compositions during the solidification process are measured in the laboratory at the University of Leoben, which extends the knowledge base of proprietary Level 2 process-control packages such as DynaPhase, Dynacs 3D and DynaGap 3D.

LONG ROLLING

Primetals Technologies and the Italian technical center Centro Sviluppo Materiali (CSM) jointly developed the idRHa+ system for improving hardness distribution across rail crowns. This is especially important for heavy-haul and high-speed railways. idRHa+ was developed on the basis of thermal, mechanical and metallurgical models, which were validated by experimental trials conducted in an industrial pilot unit (Figure 12). This solution provides tailored inline cooling protocols that allow an accurate fine-pearlitic microstructure and hardness distribution across the rail crown to be achieved. idRHa+ rail-hardening technology was installed for the first time at the Baogang Rail Mill in Baotou, China.

FLAT ROLLING

Hot-rolling tests, including welding trials, are performed in Hiroshima, Japan, on a small-size, 4-high hot-rolling mill with a rolling load capacity of 300 MN (Figure 13). Extensive tests related to the joining of transfer bars for continuous hot rolling are also carried out. In addition to further improving rolling parameters, design enhancements and trials using the so-called Mill Stabilizing Device (MSD) serve to minimize vibrations in the finishing train of hot-strip mills.

An experimental rolling mill owned by Primetals Technologies UK is currently in use at Tata Steel's Swinden Technology Centre (Figure 14). The mill is shared by Tata Steel and Primetals Technologies to further improve the hot-rolling process. The R&D collaboration between a steel producer and technology supplier provides an ideal platform to develop, optimize and implement rolling mill solutions. »



FIG. 12:
The idRHa+ pilot plant at the CSM laboratory of RINA in Dalmine, Italy

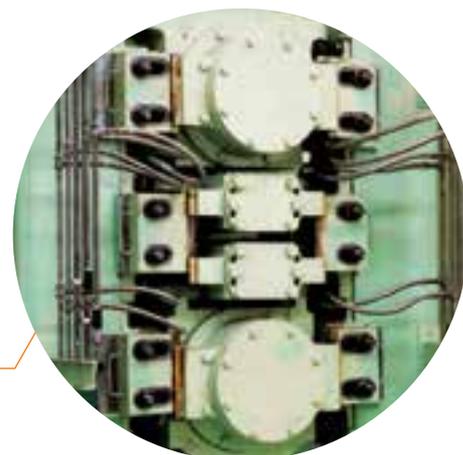


FIG. 13:
Hot-rolling mill testing facilities, Hiroshima, Japan



FIG. 14:
Experimental hot-rolling mill of Primetals Technologies at Tata Steel's Swinden Technology Centre, U.K.



15.

For the hot rolling of flat or long steel products, a universal technology is being researched under the direction of Primetals Technologies at the U.K. Universities of Manchester and Warwick to allow inline measurements of the transformed fraction and characterization of grain structure (size and texture) to be performed. In-house instrument testing and calibration for commercial use of this technology are conducted at the Christchurch, U.K., location of Primetals Technologies. Trials are underway at the voestalpine steelworks in Linz to achieve highly precise water-flow control in the laminar-cooling section of the company's hot-strip mill. The target is to ensure that water flow is simultaneously turned on or off without post-flow or post-dripping, which is particularly important for special steel grades such as electrical steels. Furthermore, oil-film bearing tests as well as Hydraulic Automatic Gauge Control (HAGC) trials are done at various workshops and competence centers of Primetals Technologies (Figure 15).

COLD ROLLING

At the Hiroshima site of Primetals Technologies, a full-size, 6-high Hyper Universal Crown Control Mill (Hyper UCM) is installed to enable extensive cold-rolling tests and equipment optimization work to be executed. The mill includes an edge-drop control system that prevents excessive strip-thickness reduction at the strip-edge area, which is particularly important for advanced steel grades (Figure 16). Primetals Technologies also has a rolling testing facility in Montbrison, France, (Figure 17) where process parameters are examined and equipment improvements are implemented for improved rolling of different steel grades. The new Cross Seam Welder is also being further optimized for use in pickling and tandem cold-rolling lines, in particular for the welding of high-strength steels (Figure 18). Finally, on the anti-chatter test stand in Linz, the chatter phenomena in cold-rolling mills and various chatter-suppression solutions are studied. »

At the Hiroshima site of Primetals Technologies, a full-size, 6-high Hyper Universal Crown Control Mill (Hyper UCM) is installed to enable extensive cold-rolling tests and equipment optimization work to be executed.

FIG. 15:
HAGC cylinder testing stand,
Shanghai workshop of Primetals
Technologies China



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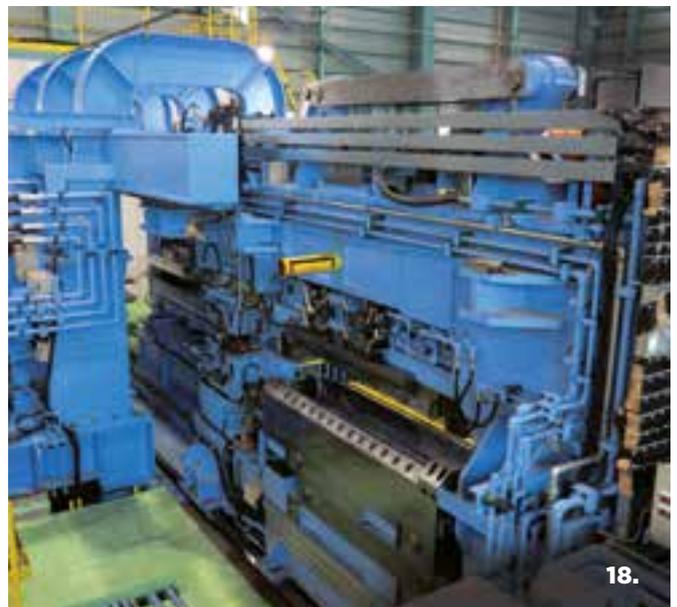


17.

FIG. 16:
6-high Hyper Universal Crown
Control Mill (Hyper UCM), Hiroshima,
Japan

FIG. 17:
Flexible cold rolling and
strip-leveling/skin-passing testing
line facility, Montbrison, France

FIG. 18:
Cross Seam Welder in the
continuous cold-rolling verification
facility of Primetals Technologies
Japan



18.

ALUMINUM ROLLING

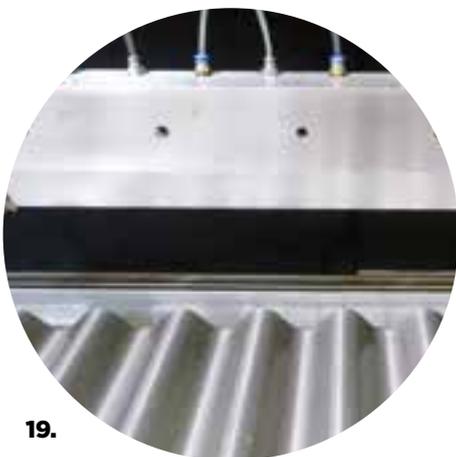
In the U.K., Primetals Technologies makes use of an electrostatic oiler test facility to evaluate and further develop different contract-specific electrostatic oiler blades. The test rig is very flexible and allows the spraying ability of a blade as well as the distribution of oil across the width of the product to be quantified and assured. It can also be used to verify that a customer's oils are suitable for strip application using electrostatic methods (Figure 19).

PROCESSING LINES

Company testing and inspection facilities for strip processing are located in Montbrison, France (Figure 17); Hiroshima, Japan; and Linz, Austria (Figure 20). At these sites, key equipment components used in coating, annealing, surface quality monitoring and treatment are improved and optimized with the goal to find and develop the best solution for different applications and steel grades (Figure 25). Using these facilities saves time and costs in the development of new steel grades compared to trials on an industrial annealing or galvanizing line.

MECHATRONICS

State-of-the-art solutions for metals production processes are unthinkable today without mechatronic products. Primetals Technologies and its parent companies have the world's largest staff of mechatronic specialists dedicated to improving metallurgical equipment, processes and results. Experienced specialists from different fields cooperate closely together to create optimized systems, from stand-alone measurement devices up to fully integrated mechatronic packages. The spectrum of solutions includes highly sophisticated robotic applications for dangerous areas of a steelworks – particularly where liquid metal is manipulated – noncontact measurement and inspection systems, offline simulations, condition monitoring and other diagnostic techniques, and inline measurement tools to determine the mechanical properties of steel strip. Mechatronic products substantially contribute to improvements in product quality, personnel and equipment safety, and environmental protection (Figure 21). >>



19.



20.

FIG. 19:
Electrostatic oiler blade test facility, Christchurch, U.K.

FIG. 20:
Annealing line simulator, Linz, Austria

FIG. 21:
Camera-positioning system of the LiquiRob robotic system, Linz, Austria



Primetals Technologies and its parent companies have the world's largest staff of mechatronic specialists dedicated to improving metallurgical equipment, processes and results.



**FIG. 22:**

Electrics, electronics and automation integration testing facility, Erlangen, Germany

FIG. 23:

Biofermentation lab facility of LanzaTech, Skokie, Illinois, U.S.A.

FIG. 24:

Micrographic analyses and micro-hardness testing in the Shanghai workshop laboratory facilities of Primetals Technologies

FIG. 25:

SIAS (automatic surface-inspection system) surface-quality monitoring laboratory, Montbrison, France

AUTOMATION

The proper functionality of electric, electronic, automation and software packages are exhaustively tested at the automation competence centers of Primetals Technologies before they are supplied to customer production sites. In a first step, the tests are performed on discrete automation modules, and in a second step, integration tests are carried out to ensure the overall interfunctionality of the various automation packages and interfaces (Figure 22). In this way, on-site system start-up times are significantly reduced according to the principle of “connect & produce.”

Industry 4.0: Primetals Technologies is intensively working on the development and implementation of Industry 4.0 solutions in the steel industry. Equipment and machines within a plant complex are digitally networked with one another, and decisions regarding, for example, production planning or timely maintenance activities are automatically and independently made. Industry 4.0 will advance process optimization to a new level of sophistication with considerably reduced costs.

ECO SOLUTIONS

LanzaTech and Primetals Technologies have signed an exclusive cooperation agreement to develop, optimize and market LanzaTech’s biofermentation process. This solution features microbial fermentation of carbon- and hydrogen-rich offgases such as coke oven gas, blast furnace top gas, direct-reduction gas and LD (BOF) converter gas to produce ethanol or other basic chemicals – accompanied by a major reduction in CO₂ emissions. Company tests related to the transformation of CO₂ into chemicals and fuels such as ethanol, 2,3-Butanediol and others by means of a bacteria culture are carried out at a purpose-built laboratory of LanzaTech in Skokie (near Chicago), Illinois, U.S.A. (Figure 23). On the basis of the test results it will be possible to specify and optimize the respective equipment and process parameters for individual customer plants.

QUALITY CONTROL

Of course, the R&D solutions, processes and products developed in the R&D testing and optimization facilities of Primetals Technologies are subject to rigid and exhaustive quality-control investigations before they are marketed and installed for industrial application (Figures 24 and 25). Dedication to quality is a company commitment and an obligation.

FOR THE BENEFIT OF THE CUSTOMER

Cooperation with partners in the field of testing is not just a necessity borne of the expense of installing and using highly specialized facilities; it is also a platform for collaborative research, development and process improvements. It involves suppliers and customers, among which are some of the world’s most prestigious engineering organizations and metals producers. All areas of the value chain – extending from raw and input materials to the finished metal product – profit from such cooperations. Experience tells us that shared ideas are more viable and better aligned to real industrial needs. The path to their successful application is also shorter.

The R&D work carried out in the numerous testing and optimization facilities available to Primetals Technologies has one main objective – to develop, optimize and implement solutions that ultimately benefit our customers. This is the basis for viable, sustainable and competitive metals production, and for creating the future of metals as one. ●

Dr. Franka Leitmeier, Technology Management

Dr. Lawrence Gould, Editor of Metals Magazine

(both with Primetals Technologies Austria)

The authors wish to express their gratitude to all joint-cooperation partners for the excellent collaboration and for making available their site-testing facilities, materials, equipment and staff of experts and specialists for numerous R&D projects.



READY FOR **THE FUTURE**

**INTERVIEW WITH DR. FRANZ ANDROSCH,
HEAD OF RESEARCH & DEVELOPMENT AT VOESTALPINE AG**

“For more than 15 years now, the voestalpine Group has been following a consistent downstream strategy of focusing on high-quality products. This has proven to be the key to differentiating us from the competition.”

CONTRACT-SIGNING CEREMONY

at the Primetals Technologies Metec stand for a blast furnace dry-slag granulation project (Düsseldorf, June 16, 2015). Dr. Franz Androsch (left), voestalpine AG, and Dr. Etsuro Hirai, CTO of Primetals Technologies

What are the main challenges that your company is currently facing?

Dr. Franz Androsch: One of the challenges is to follow our customers globally in order to meet their demand for an increased local presence. Our goal is to be able to serve our main customers worldwide, for example in the premium segment of automotive applications with the high-quality products they are accustomed to. voestalpine is well positioned because our products are at the top of the quality pyramid. And we are increasingly becoming a global company, as shown by our new GoWest direct-reduction plant under construction in Texas.

How do you see the future of the steel industry in your market areas, and what factors need to be taken into consideration?

Androsch: The steel industry is growing only slightly at the moment. There is a much greater growth rate for higher-value products such as HSS [high-strength steels], which is expected to increase some 200% during the next ten years. There is also an increasing substitution of lower-grade steels with higher-grade steels. Therefore, greater emphasis will have to be placed on quality, not capacity, which will be reflected by the associated change in our product portfolio. For more than 15 years now, the voestalpine Group has been following a consistent downstream strategy of focusing on high-quality products. This has proven to be the key to differentiating us from the competition.

What major activities, efforts or investments are planned by the voestalpine Group to meet the challenges that lie ahead?

Androsch: Innovation is the key word for voestalpine's worldwide success and for meeting the challenges that lie ahead. The current record-breaking budget of more than €140 million shows clearly that research, development and innovation have top priority at voestalpine Group. Consistent investment in this key sector is essential, as it

is clear to everyone at voestalpine that we can only ensure our future as an international player in sophisticated product segments by specializing and maintaining our technology and quality leadership.

What do you see as the main areas for further research and development to improve production operations, costs and market opportunities at voestalpine?

Androsch: Three areas: The first is that we work closely with the K1-Met* competence center with the goal of improving process steps and energy efficiency, increasing the value of byproducts and reducing CO₂ emissions. The second area is related to the manifold properties of steel. Research is ongoing and we are stepping up efforts to improve steel's strength and formability, also at higher-strength levels. A lot will take place in the next 10 to 15 years. Thirdly, we are pushing smart production as part of the Industry 4.0 initiative, which is often referred to as the Internet of Things. In fact, an Industry 4.0 platform is being planned for group-wide application. Industry 4.0 is more evolutionary than revolutionary. We need to take a fresh look at this topic in order to apply the latest process models, interconnect our complete technology spectrum, improve statistical process models, and increase efficiency and productivity. Developments in automation are also continuing.

voestalpine Stahl and Primetals Technologies recently signed a contract for the installation of a prototype plant on an industrial scale for the dry granulation of blast furnace slag. The plant will be built at the voestalpine steelworks in Linz. What targets have to be met with this project for it to be successful? And what is the estimated payback period for this worldwide unique DSG [dry slag granulation] plant?

Androsch: In order for this project to be successful, the slag granulate has to meet the requirements for its use as a cement clinker substitute. Secondly, an off-air »

“Innovation is the key word for voestalpine’s worldwide success and for meeting the challenges that lie ahead.”

ARCHITECTS OF THE DSG PROJECT

From left to right:

Dr. Etsuro Hirai, Primetals Technologies;
 Dr. Walter Gebert, Primetals Technologies;
 Dr. Franz Androsch, voestalpine AG;
 Thomas H. Bürgler, voestalpine Stahl GmbH;
 Dr. Alexander Fleischanderl, Primetals Technologies;
 Andreas Flick, Primetals Technologies; and
 Joachim Schnalzger, Primetals Technologies



temperature in the range of 600°C has to be achieved to efficiently generate superheated steam. The payback period depends on the energy costs when the plant is started up. However, we expect that the DSG plant with an average slag-flow rate of 2 t/min and which includes a boiler system will have a payback period in the range of three years. As we go along in the project, we will be able to better define the payback period. Don’t forget – this is a development project and not an investment project, so payback is still a moving target.

What could be the energy savings with a fully installed DSG plant at the voestalpine steelworks?

Androsch: We estimate approximately 1.5% of the specific energy per ton of steel, or around 1.5 GJ per ton of blast furnace slag. We need about 500,000 tons of steam per year in the Linz steelworks and 75% of that could be produced with the DSG process – which means huge energy



savings. Energy-efficiency laws will also become more and more important, which means that the payback period could actually be shorter.

In your opinion, what will be the focus of future environmental developments within a steelworks?

Androsch: Increased recycling of byproduct materials, such as sludge, dusts and slag in a closed-loop cycle. A lot also depends on E.U. legislation regarding CO₂. The use of natural gas to produce DRI [direct-reduced iron] at our DR plant in Texas for reduction work will be a step toward lowering CO₂ emissions in iron- and steelmaking. Increasing the portion of electric arc furnaces that we use to produce steel might be an option for the future. A key topic for us within the E.U. is to ensure that there is a level playing field in connection with CO₂ tax costs. But we are now a global company and more flexible, so we have the possibility to adapt accordingly.



A prototype DSG plant is being installed at Blast Furnace A of voestalpine Stahl GmbH, Linz, Austria, for the dry granulation of blast furnace slag on an industrial scale.

What are the main criteria that you consider when selecting a technology supplier, and which factors do you value most when dealing with business partners?

Androsch: Business has to be a win-win situation for all parties involved. voestalpine relies on long-term cooperations to sustainably build up its know-how. Suppliers should also keep in mind that they have to invest in research on a long-term basis.

One final question: how would you characterize the business relationship with Primetals Technologies and its former companies?

We have a lot of trust. It's a long-term relationship and a win-win situation. There is a common commitment to research and long-term development. voestalpine and Primetals Technologies have a decades-long history in cooperative developments – for example with Meros,

Selective Waste Gas Recirculation or Liquirob [robotic solutions] applications during the past years, and now with the DSG project and also with fines briquetting for the GoWest DR plant project in Texas. The joint establishment of the K1-Met* competence center of metallurgy represents another milestone for the development of future-oriented technologies. The DSG project exactly fits into this footprint and serves as another example of where both parties are willing to invest and take risks. ●

*K1-Met, which comprises industrial and scientific partners, is a publicly funded competence center that focuses on the modeling, simulation and automation of metallurgical processes; on valuation and optimization of metallurgical raw materials and refractories; on development and optimization of processes and key components used in metallurgical plants; and on the implementation of solutions to improve product quality, achieve zero-waste processing in metallurgy, and minimize energy and raw material consumption.

ARVEDI ESP PLANT COMPLEX COMMENCES OPERATION AT RIZHAO STEEL

SETTING NEW STANDARDS IN HOT-STRIP PRODUCTION

The Chinese producer Rizhao Steel ordered a total of five Arvedi ESP lines from the former Siemens VAI (now Primetals Technologies) in 2013 and 2014. In the meantime, three of the lines have been started up. With a project execution time of only 20 months to the rolling of the first coil, this remarkable plant complex has set new milestones in the steel world.

FIG. 1:
Overview of the Arvedi
ESP Line No. 1 –
endless production
from casting to coils

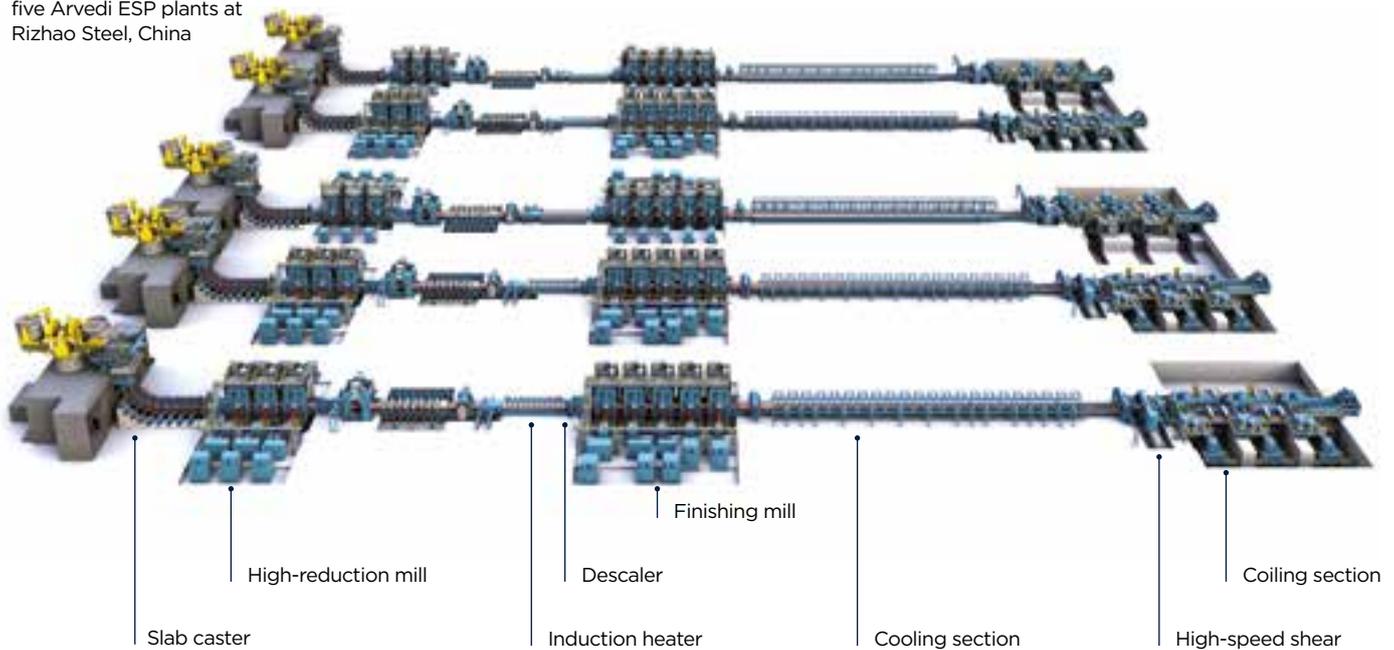




Executing a project of this complexity, which features five casting-rolling lines and an incredibly short start-up time of only 20 months for the first line, is a masterpiece of project management.

FIG. 2:

Arrangement of the five Arvedi ESP plants at Rizhao Steel, China



Eleven million tons of annual production capacity is the impressive figure for the new ESP complex now under construction at Rizhao Steel Holding Group Co., Ltd. (Rizhao Steel) in China. Lines 1 to 3, each with a strip width of 1,600 mm and a design capacity of 2.55 million tons, are already in operation – less than two years after the original order was placed (Figures 1 and 3). Lines 4 and 5 with strip widths of 1,300 mm and an annual design capacity of 1.7 million tons will be started up in 2016. A schematic overview of the Arvedi ESP complex is displayed in Figure 2. In all five lines, strip will be rolled to a minimum thickness of 0.8 mm. A wide variety of steel grades will be produced for a broad spectrum of steel products and industrial sectors. Liquid steel for the wider ESP lines will be supplied from new LD (BOF) meltshops with 300-ton converters. For the narrower lines, the steel will be delivered from existing converter meltshops equipped with 63-ton converters.

PROJECT EXECUTION

Executing a project of this complexity, which features five casting-rolling lines and an incredibly short start-up time of only 20 months for the first line, is a masterpiece of project

management. Perfect cooperation between the customer, Rizhao Steel, the main contractor, suppliers and the construction company was a decisive factor for this success. As the new plants 1 to 3 are almost identical to the Arvedi ESP “master plant” in Cremona, Italy, many of the drawings could be directly sent to the manufacturers within the first weeks following the contract signature. This approach allowed the project teams to rigidly adhere to the very tight time schedule. By employing many of the same manufacturers that had built the plant in Italy, a smooth project execution was assured. Furthermore, because manufacturing of the Rizhao ESP plants took place primarily in China, transport times could be kept to a minimum. The construction company under the guidance of Rizhao Steel achieved the nearly impossible by installing the entire plant from groundbreaking to completion within 12 months. In parallel to the commissioning of Line 1, installation of Line 2 was already close to completion when groundbreaking for Line 3 took place at the end of 2014. Project work for Lines 4 and 5, which are in the second plant complex, is progressing right on schedule. Rolling of the first hot coil on Line 4 is scheduled for mid-2016 (Figure 4).



FIG. 3:
High-reduction stands of Arvedi ESP Line No. 1

BENEFITS OF ENDLESS CASTING AND ROLLING TECHNOLOGY

- Superior geometrical strip quality and flatness
- High strip homogeneity along its entire length (no strip head or tail ends)
- Considerably extended work-roll lifetime
- Reduced consumption of alloys for the production of advanced steel grades
- Excellent process stability

SUCCESSFUL START-UPS

After a project period of only 20 months, the first coil on ESP Line No. 1 was produced in February 2015. Drawing on the experience of the Arvedi ESP line in Italy, the caster was put into operation in combination with the high-reduction mill and pendulum shear to initially produce plates, which were pushed from the line and separately piled. After fine-tuning the coupling of the caster and the high-reduction mill, in the next step the finishing mill, laminar-cooling section and downcoiler were simultaneously started up. This allowed the plant to produce initial coils in semi-endless and endless mode only six days after the line entered service. Thanks to the well-trained Rizhao operators, production was ramped up quickly. Minimum gauges below 1 mm were reached after two months of operation, and the first 0.8-mm coil was produced just three months later in July 2015 (Figure 5). »

Start-up of Line 2 followed on the heels of Line 1 and its completion was ahead of the contract date. The ramp-up was highly successful and already in month four line performance exceeded expectations by far. On September 26, 2015, six weeks ahead of schedule, Line 3 commenced operation. Thanks to the outstanding geometric, mechanical and surface-quality parameters of the strip material, the coils produced on the new ESP production lines were quickly accepted in the Chinese and worldwide markets. This allowed Rizhao Steel to rapidly increase its steel production in the saturated Chinese steel market to full industrial operation.

COMPREHENSIVE TRAINING AS A KEY FACTOR FOR SUCCESS

Quick ramp-up of the new ESP lines to their designed production capacity can also be attributed to the comprehensive training of Rizhao operational and maintenance personnel. Basic training comprised theoretical training at Primetals Technologies in Linz and Erlangen for mechanical, electric and automation equipment. This was followed by three weeks of theoretical and practical instruction at the Arvedi ESP plant in Cremona. In an optional program with hands-on training, operators were involved with routine operational and maintenance practices for two months at the Arvedi plant in Cremona. With this experience, production ramp-up of the fully automatic plant was even easier, which is a decisive factor for a fast payback on the investment.

HIGH-QUALITY STEEL GRADES, FROM THICK TO THIN

The product mix of the ESP plants comprises low- and ultra-low-carbon steels, medium-carbon steels as well as high-strength, low-alloyed (HSLA) and dual-phase steel grades. Endless operation also leads to a number of operational and production advantages. For example, strip threading and the related roll shocks are avoided. Work-roll life is increased, and crop-cut losses at the head and tail ends are eliminated. No line speed-ups create transient operation conditions. Thanks to uniform and constant rolling conditions, precise geometrical and mechanical strip properties are achieved along the entire strip length. Rolling of the lowest strip thicknesses is particularly attractive, since this commands the highest profit margins. In the endless mode it is no problem to produce at thinnest-gauge levels for hours at full strip width and line productivity. The constant process parameters in the endless operating mode, particularly with respect to the strip-temperature profile, enable advanced steel grades to be produced at a far higher degree of accuracy compared to conventional casting-rolling processes. For example, overalloying is avoided during the production of HSLA and pipe grades, which results in considerable cost savings for producers. And finally, quick development of new grades is supported by constant operational conditions, which means that operational parameters are easily reproducible. ●

Andreas Jungbauer, Sales Manager, Endless Strip Production

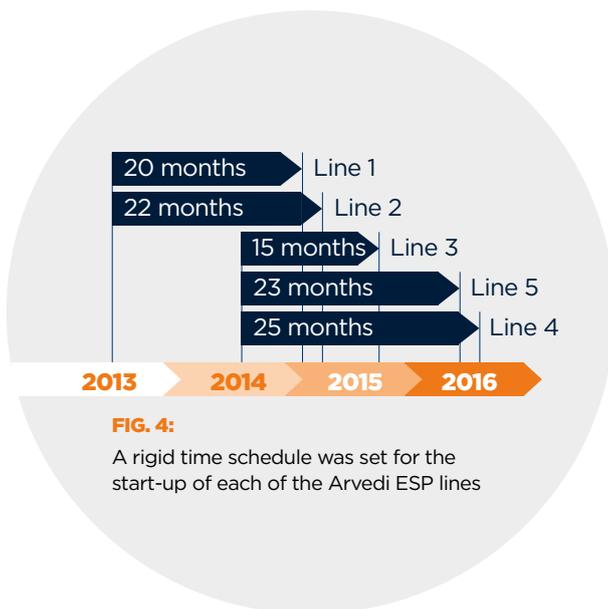


FIG. 4:

A rigid time schedule was set for the start-up of each of the Arvedi ESP lines

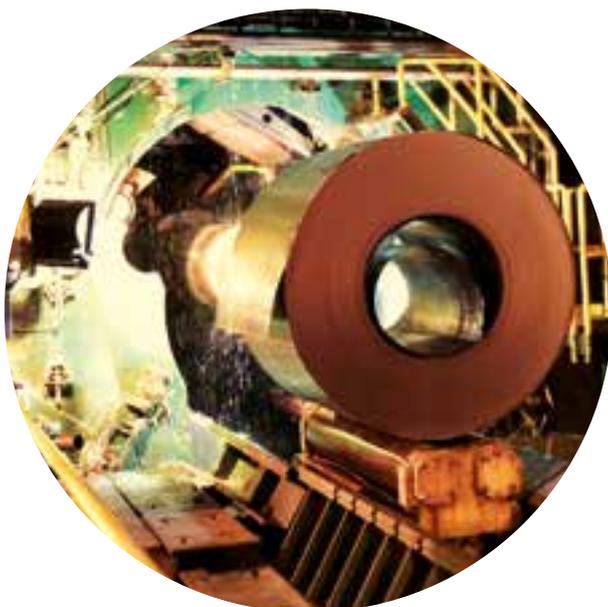


FIG. 5:

First 0.8-mm coil rolled on Rizhao Steel's ESP Line 1

A CLEAR VIEW AHEAD

INTERVIEW WITH GIOVANNI ARVEDI, INVENTOR OF THE ARVEDI ESP PROCESS AND FOUNDER OF ACCIAIERIA ARVEDI S.P.A., CREMONA, ITALY

Yasukuni Yamasaki,
CEO of Primetals Technologies, and
Giovanni Arvedi at Metec 2015



What are the main challenges that your company is currently facing?

Giovanni Arvedi: In my opinion, the challenges are the situation of the European market and overall steel consumption in the E.U. We are also facing ever-increasing competition from Asian companies and the greater quantities of steel sold in Europe by Asian producers. Other challenges include the devaluation of certain currencies and the associated consequences, fluctuating exchange rates and deteriorating economies.

How do you see the future of the steel industry in your market areas, and what factors need to be taken into consideration?

Arvedi: We expect increased growth in the European automotive market, which is a positive sign. The future of our company is directed toward Eastern Europe and the Maghreb countries [Algeria, Libya, Mauritania, Morocco and Tunisia].

What major activities, efforts or investments are planned by Arvedi to meet the challenges that lie ahead?

Arvedi: We are focusing on reducing costs. We also have plans to install a new galvanizing line for the automotive market and a new painting line.

What are the main criteria that you consider when selecting a technology supplier, and which factors do you value most when dealing with business partners?

Arvedi: Reliability, overall responsibility and the capability of a supplier to provide mechanical parts, hydraulics, electrics and automation from a single hand. Also, a supplier must think strategically and work for the future.

Arvedi ESP technology is now accepted worldwide. What visions do you have for the future development of your process?

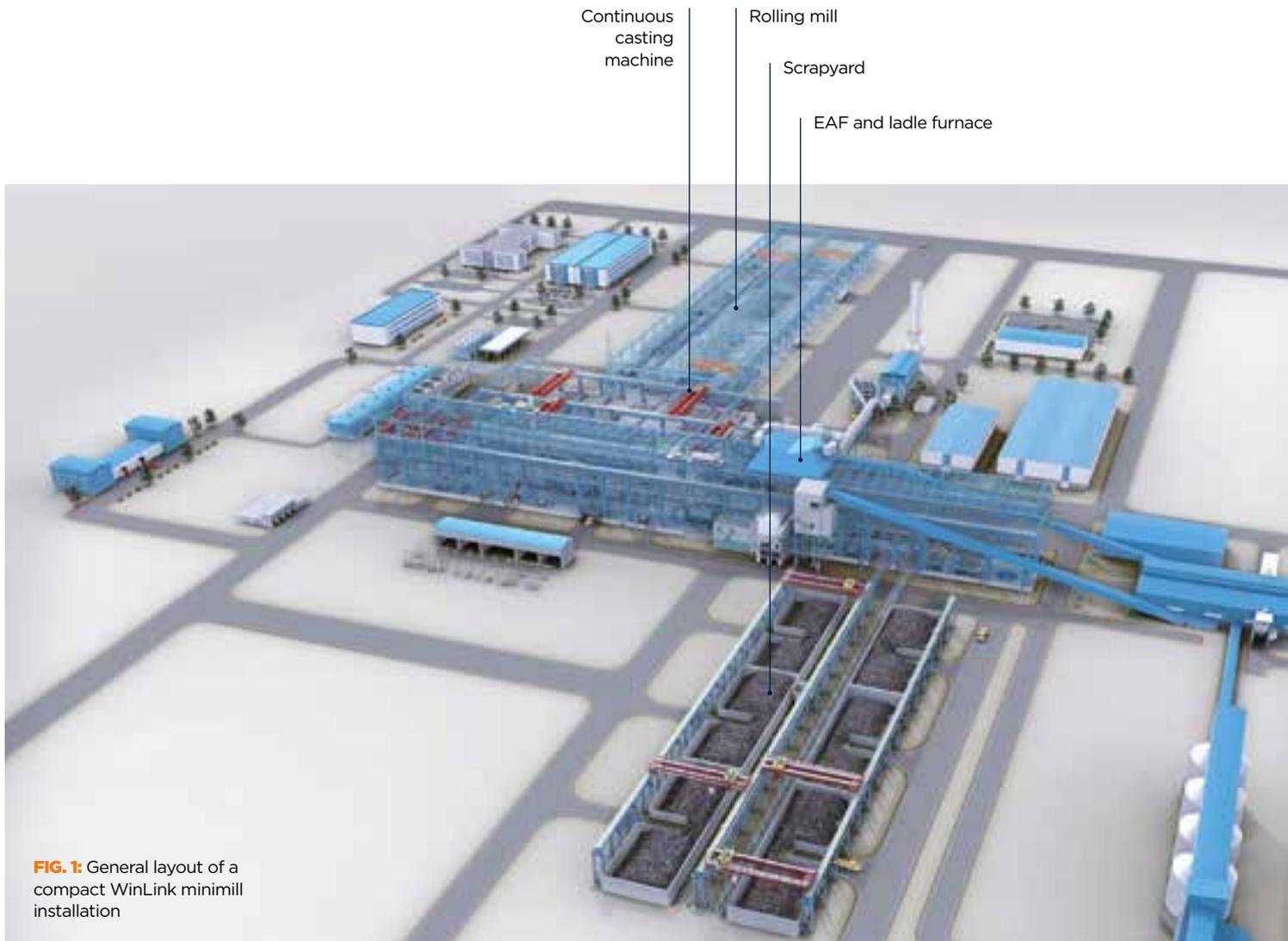
Arvedi: We are trying to further develop our technology and implement even better solutions for the Arvedi ESP process. We have to follow the trend for higher quality and a longer lifetime of the final product.

On the basis of six years of operational experience with the Arvedi ESP line in Cremona, can you tell us what you consider to be the main advantages of your process compared to conventional casting and rolling plants?

Arvedi: The advantages include a reduction in costs related to energy and the transformation costs from liquid steel to the hot-rolled product. Furthermore, we produce a special mix of products that is unique worldwide – and which cannot be duplicated by other traditional plants.

Finally, how would you characterize your business relationship with Primetals Technologies and its former companies?

Arvedi: We have a really good business relationship and cooperation with your company. And we value the high degree of professionalism and competence of your people. ●



THE INNOVATIVE MINIMILL

WINLINK – FLEXIBLE SOLUTIONS FOR PROFITABLE DIRECT ROLLING OF BARS

WinLink is a pioneering technology from Primetals Technologies that allows both endless and semi-endless production of long products from liquid steel without interruption. The solution directly links a high-speed billet caster to a high-availability rolling mill. Depending on production requirements, profitable WinLink solution variants are offered for production capacities up to 750,000 t/a of rolled products.

The conventional minimill is characterized by capacities ranging from 300,000 t/a to 600,000 t/a, use of locally available scrap, low impact on the electricity grid, a high degree of flexibility and low investment expenditures. However, the relatively long payback period of a standard minimill is a disadvantage for smaller production capacities. As an answer to this situation, Primetals Technologies has introduced WinLink (Figure 1). This directly linked caster-rolling mill solution reduces total final product costs in a highly competitive product-cost-based market by minimizing capital and operational expenditures (capex and opex), as seen in Figure 2. Savings are achieved through the use of innovative technologies. Thanks to the resulting cost advantages, WinLink production lines are even competitive starting at outputs of 300,000 t/a of rolled products for construction applications. With higher production capacities, the economy of scale is improved and profit margins increase. Payback time is reduced from seven years to less than five years compared to standard minimills of the same capacity. For example, a WinLink70 plant variant with an annual production of 450,000 t allows a 25% internal rate of return (IRR) to be obtained, which is the same as a larger conventional minimill producing more than 700,000 t/a.

THE WINLINK CONCEPT

WinLink is based on the direct linking of a multi-strand billet caster and a rolling mill with high availability. Instead of a conventional billet reheating furnace, an advanced induction heating unit is employed. Liquid steel coming from an electric arc furnace or LD (BOF) converter is cast to billets and rolled into bars in a continuous, endless production line. While the typical application is for an output of between 300,000 t/a and 600,000 t/a of rebars, small flats and profiles may also be processed. Three different WinLink variants with different product dimensions and capacities have been developed: WinLink55, WinLink70 and WinLink85. Each of these variants can be augmented with the WinLinkFlex solution to enhance production capacities by an additional 30% (Table 1). In a WinLink line with a single high-speed billet caster, it is possible to produce from 45 t/h to up to 85 t/h. With the installation of an additional high-speed casting strand, the increased billet output can accommodate the production capacity of the meltshop. WinLink85 represents the most complete WinLink configuration. It includes a cantilever inline stand positioned between the continuous rolling

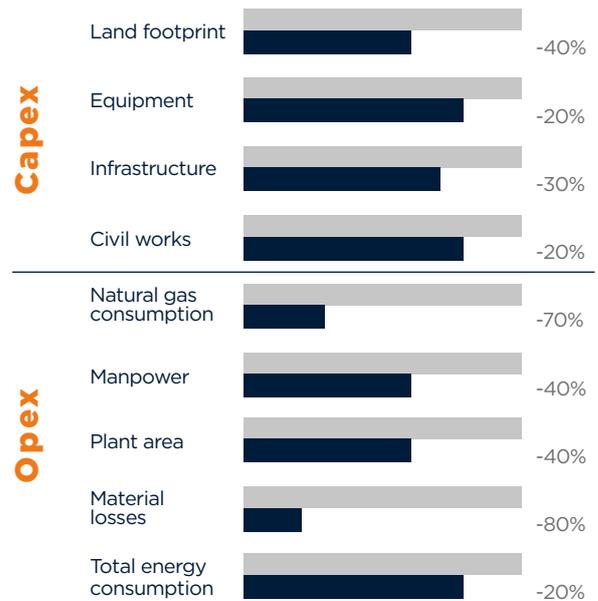


FIG. 2: Decisive capex and opex advantages offered by WinLink

mill and the hydraulic head-cropping shear (Figure 3). It reduces a rectangular 200 mm x 150 mm cast billet to a 160 mm x 160 mm billet, which is then fed to the continuous rolling mill. Line productivity can thus be increased by up to 600,000 t/a with this special mill stand. The WinLinkFlex minimill option represents a major step forward in the WinLink casting-rolling process. This variant allows a semi-endless production mode to be implemented for a productivity increase of 30% when compared to the endless production mode. Thanks to the high flexibility of the billet caster, billets can be cast in lengths between 18 m and 24 m. The billets are then hoisted from the line by means of a crane and quickly transferred to the rolling mill to increase total rolling productivity (Figure 4).

CONTINUOUS CASTING MACHINE

The WinLink caster is equipped with two or more high-speed strands in order to directly feed the rolling mill in endless mode, or in semi-endless mode by applying WinLinkFlex technology. A multi-strand configuration significantly improves the economy of scale of the meltshop and provides better flexibility when faced with

TABLE 1:

WINLINK MINIMILL VARIANTS

| WinLink variant | Billet size | Rebar capacity of a single rolling line |
|-----------------|-------------------------|---|
| WinLink55 | 130 mm or 140 mm square | Up to 380,000 t/a |
| WinLink70 | 150 mm or 160 mm square | 380,000 t/a to 500,000 t/a |
| WinLink85 | 200 mm x 150 mm | 500,000 t/a to 600,000 t/a |
| WinLinkFlex | All of the above | Up to 750,000 t/a |



FIG. 3:
WinLink configuration
with inline
cantilever stand

Cast rectangular billet
Cantilever rolling stand
Square billet heading
toward induction furnace



FIG. 4:
WinLinkFlex variant with
billet-transfer system

Quick-transfer crane
Cut billet being transferred
to rolling mill
High-capacity
induction furnace

unpredictable market changes. While the primary casting strand is dedicated to the endless feeding of the rolling mill, the additional strand(s) can be used for the production of flexible-size billets, which are both finished and saleable. These billets may be rolled in other mills, rolled in the semi-endless mode by applying WinLinkFlex technology, or sold on the market. The unique WinLink caster configuration enables rolling productivity to be increased by up to 30%. To obtain the casting speeds required for direct feeding to the rolling mill under stable casting conditions, a state-of-the-art billet caster is required. Implemented technologies to enable high-speed casting include tundish flow control, mold-level control, high-speed Diamold tubes, Dynaflex hydraulic oscillators, as well as technologies for enhanced secondary cooling and continuous straightening.

INDUCTION FURNACE

After cooling the cast strand to the temperature required to guarantee solidification of the core, the temperature of the strand is uniformly equalized for rolling in a compact induction furnace with a high

energy-transfer capacity. The IGBT (insulated-gate bipolar transistor)-controlled induction furnace is designed to provide up to 200°C of temperature increase. Its installed power ranges from about 2,000 kW to 4,000 kW with efficiency of more than 75%. The specific consumption of the IGBT induction furnace ranges from 15 kWh/t to 45 kWh/t, versus 180 kWh/t to 200 kWh/t for a gas-fired furnace with conventional hot charging. CO₂ emissions are thus significantly reduced.

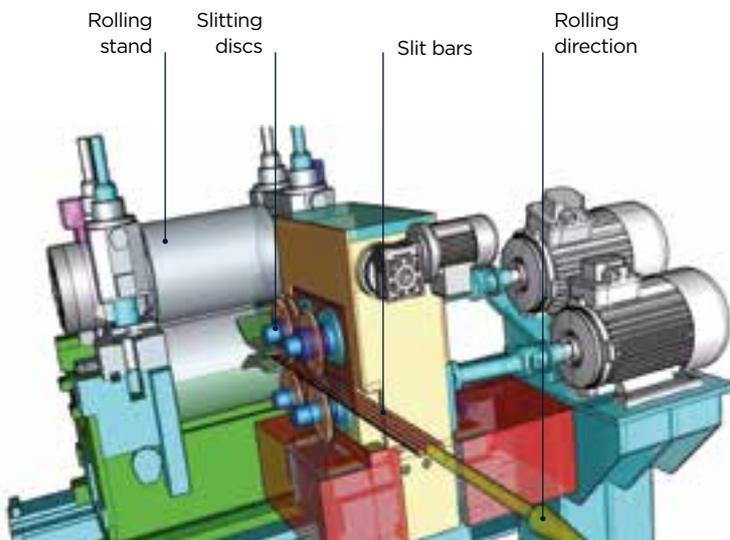
ROLLING STANDS

The housingless and double-support design of Red Ring stands has been implemented in more than 6,000 individual installations. This mill stand – currently in its fifth generation – is renowned for its high rigidity, durability and ease of maintenance (Figure 5). For a rebar mix with diameters ranging from 8 mm to 40 mm, the WinLink mill includes 18 to 20 Red Ring stands. Smaller dimensions are multi-slit (up to 4x) to increase their productivity with finishing speeds between a maximum of 22 m/s in a high-speed delivery system and 15 m/s in a setup with an apron delivery table. Intermediate and finishing stands



FIG. 5: Red Ring stands equipped with a quick-change system

FIG. 6: Power Slitter



are equipped with a quick-change system to minimize change time. To prolong production campaigns, the finishing stands are outfitted with carbide rolling rings mounted on shafts. Groove change is achieved by a fast guide-changing system that is integrated in a motorized rest bar. Stands and guides are completely preset and adjusted offline, while both stand and drive components use bearings with an extended lifetime.

POWER SLITTER

The Power Slitter (Figure 6) is equipped with slitting discs driven by motors with variable current control. It provides highly accurate and consistent slitting cuts of the preformed strand that promotes stable working conditions. The Power Slitter represents an important advantage over the traditional cutting operation, which is done by means of slitting guides that offer no control, require very precise alignment with the rolling stand, and have to be positioned as close to the rolling roll as possible. Besides offering higher speeds and better accuracy, slitting discs also have a lifetime up to ten times longer than slitting guides.

QUENCHING AND TEMPERING

The nozzles used in the quenching-tempering system are characterized by their high cooling capacity and efficiency. This contributes to a compact equipment arrangement; increased lifetime of pumps, valves and other critical components; and reduced water consumption. In comparison to other systems, the lower water flow reduces the tendency for cobbles, which improves the reliability, availability and output of the line. When required, water boxes can be easily removed from the line and replaced by means of a transverse exchange system – instead of having to be hoisted out with a crane. This minimizes exchange times.

FINISHING EQUIPMENT

Bar hot dividing is optimized so that only multiples of commercial product lengths are sent to the cooling bed, while shorter lengths are removed by a dedicated scrapping unit. Following cooling, cold commercial cutting is done by a static shear. Alternatively, hot commercial cutting may be considered. In this case, a high-speed, hot-cutting station is positioned at the entry section of a shorter cooling bed. A fully automated bar-counting station is installed between the cooling bed and the bundling station, which is designed for high production rates and boasts consistent accuracy exceeding 99.9%.

AUTOMATION AND CONDITION MONITORING

Advanced automation systems are applied to monitor and control the entire production process and to ensure that the required quality demands are met. Steel grades and products are carefully tracked throughout the entire line, all the way to final product dispatch. The latest condition-monitoring systems are also employed to allow real-time monitoring of the main equipment parameters so that symptoms of developing failures may be detected early on and corrective actions quickly implemented. Mill operators are assisted with predictive maintenance techniques to maximize equipment lifetime. Condition monitoring thus contributes to cost-efficient production, full utilization of wear parts and reduced plant downtime.

DECISIVE ECONOMICAL AND PRODUCTION BENEFITS

In conventional minimills, the production of smaller quantities of standard carbon-steel grades for the construction industry and infrastructure applications is not always attractive from a financial standpoint. In comparison, WinLink offers attractive process variants with decisive economical and production benefits for bar producers. These include the reduction of the total final product cost, low investment expenditures, decreased transformation costs, major energy savings, higher mill yield, smaller space requirements and lower CO₂ emissions. Furthermore, WinLink additionally offers the potential to exploit the capacity of a full-size meltshop by balancing production between rolled products and saleable billets. ●

Francesco Toschi, Principal Engineer Process & Technology
Primetals Technologies Italy

NOVEL DESIGNS, EXCEPTIONAL ACHIEVEMENTS

LAYING HEAD AND COIL REFORMING TECHNOLOGY ADVANCE HIGH-SPEED ROD MILL PERFORMANCE

Design changes in the laying head and laying pipe, along with the use of proprietary materials, have resulted in revolutionary performance levels at higher finishing speeds and with better mill utilization. Experience at several high-speed rod mills has demonstrated dramatic improvements in pipe life and resulting production increases. An improved coil pattern, coupled with a new reform tub design, can provide high-quality coils consistently.

One of the most important aspects of product quality in a long rolling mill that produces bar or rod in coil form is the quality of the finished coil. High-quality coils have orderly rings within the coil and uniformity of the inner and outer diameters for tangle-free payoff in downstream user operations, plus compactness of the coil package for efficient storage and shipment. The ability to obtain high-quality coil starts with the design and control of the equipment upstream of the coil reforming station and continues through to the coil-handling system.

In a high-speed rod rolling mill, effective operation of the laying head, a controlled cooling conveyor and a coil reforming tub are critical to achieving successful operations at speeds over 100 m/s. The laying head must form rings accurately and consistently so that they can be cooled

uniformly and form a good coil. Furthermore, a minimal degree of wear on the laying head pipe helps avoid downtime from frequent pipe changes, which lowers production. After proper cooling on the conveyor, the coil reform tub must transform the ring package from the conveyor into a well-ordered and dense coil, which can then be conveyed during further cooling, compacted and readied for shipment.

Recent design changes in the laying head and laying pipe, coupled with the use of proprietary materials, have resulted in revolutionary performance levels at higher finishing speeds and with better mill utilization. In addition, new designs of the reform tub system incorporate features for smooth coil handling over a range of coil sizes to enable dense coiling for all sizes and grades. From new mill instal-





FIG. 1: Morgan High Speed Laying Head in a rod mill

lations to mill modernizations, the design innovations from the laying head through to the reform station can significantly improve rod mill productivity and product quality.

CHALLENGES AT THE LAYING HEAD

The pinch roll and laying head determine the consistency of ring diameter and placement on the cooling conveyor. This can be especially difficult on small-diameter products rolled at speeds over 100 m/s. Closed-loop control of pinch force and speed, plus rapid and repeatable roll-close times, can be provided by the Morgan Intelligent Pinch Roll. In the laying, a good coil package depends on an efficient pipe path and tail-end control, stable pipe support and bearing design, plus good speed control with front-end positioning and coordination with the pinch roll operation (Figure 1).

The most common laying head problems faced by rolling mill managers are head- and tail-end formation, packaging and pattern-related issues, as well as excessive pipe wear. Poor head and tail ends and inconsistent ring patterns often cause delays at the reform station. High rates of pipe wear result in frequent pipe changes.

To tackle these industry-wide problems, engineers at Primetals Technologies in Worcester, Massachusetts, U.S.A., spent several years developing new laying head technology. Their goal was a design that could produce a consistent ring pattern at high speeds with significantly increased pipe life. One initial test site was at Sterling Steel in Sterling, Illinois, U.S.A. Sterling Steel's high-speed minimill – a mix of older and newer equipment – produced 450,000 t/a of rod, with about 80% of produc- »

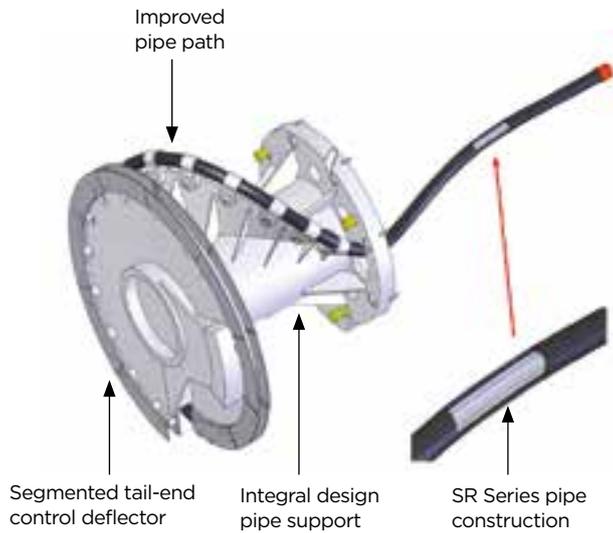


FIG. 2: New laying head design

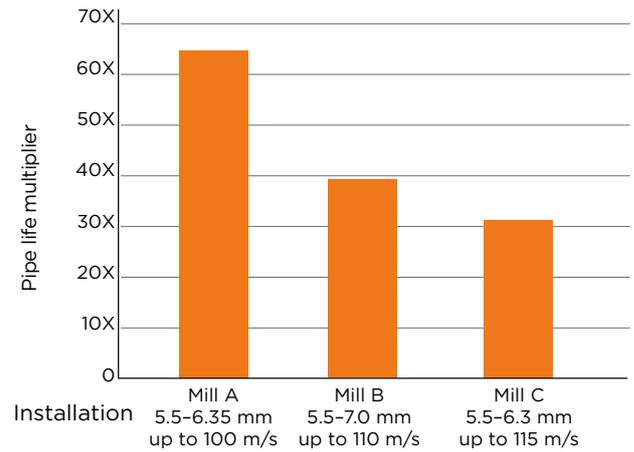


FIG. 3: Production results for the SR Series pipes



FIG. 4: Uniform and consistent high-speed SR Series ring pattern

FIG. 5: Coil height reduction due to SR Series pattern

tion in small-diameter rod, primarily 5.5 mm and 6.35 mm. Although rebuilt several times, the laying head was limiting mill performance. Laying head pipes wore out too often, and both the head ends and tail ends experienced problems, producing an inconsistent laying head pattern. Most months, Sterling Steel would roll less than 40,000 tons, changing pipe two to three times per week. Each pipe change shut down the line for close to 30 minutes. Poor ring patterns caused delays at the reform station, slowing production even further.

TRANSFORMATIONAL DESIGN

Primetals Technologies developed a number of improvements to the laying head system, including new pipe support, a modified pipe path and a revolutionary pipe design. The new laying head technology incorporates several patented innovations, with the greatest changes along the pipe path (Figure 2). In the SR Series pipe, new material replaces worn sections of laying head pipe

through a controlled “self-regenerating” process during rolling. The regeneration shifts the wear zone up to 150 mm without affecting the laying head dynamic balance. This shifting of the wear zone results in a dramatic improvement in pipe life, which can be further enhanced with proprietary pipe materials.

Initially used in production at four facilities – two in North America and two in Asia – the new SR Series technology has delivered record-breaking results (Figure 3). At Sterling Steel, the rolling mill ran 130,000 tons, mostly on 5.5 mm rod, through an SR Series pipe. In addition, the improved consistency of ring pattern (Figure 4) resulted in fewer delays at the reform station, leading to new production records. Unplanned downtime for pipe changes went from almost 2,500 minutes a year to less than 100 minutes. Three other test sites reported similarly dramatic results. The improved pattern from the SR Series pipe has been able to produce a coil with height

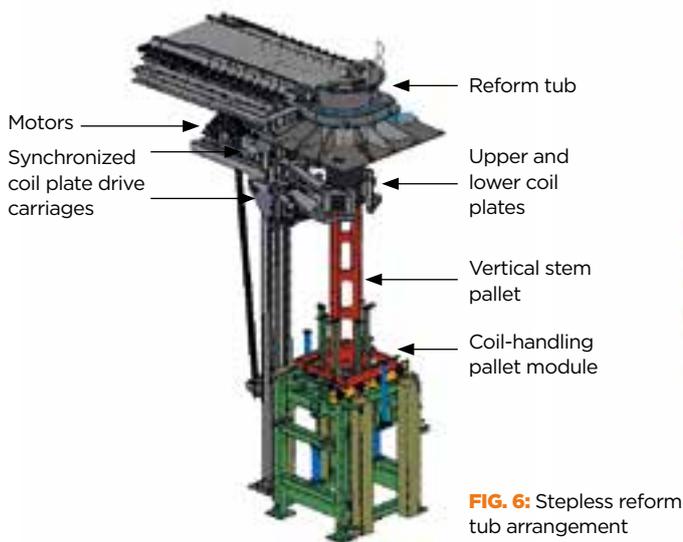


FIG. 6: Stepless reform tub arrangement

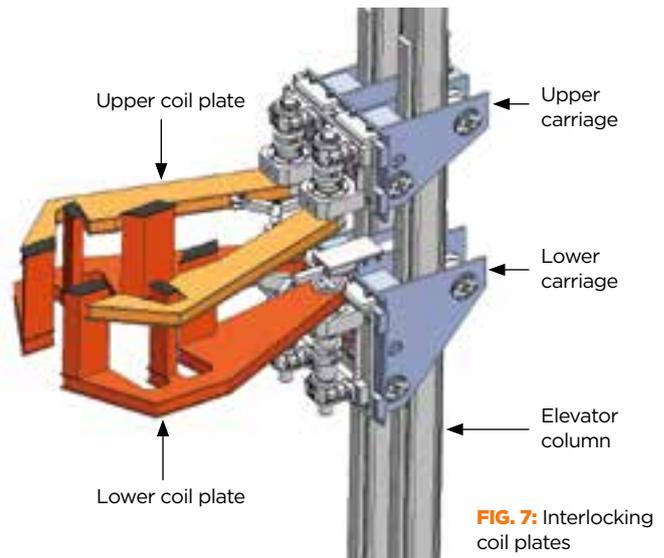


FIG. 7: Interlocking coil plates

reduced by approximately 15% to 20% – an important factor for compacted coil integrity, coil storage and shipping (Figure 5).

REFINEMENT TO CONVENTIONAL REFORMING TECHNOLOGY

Experience with many installations in mills around the world over the past 20 years has proven that the ring distributor forms the best-quality coils available in the industry today. However, older reform tubs and coil plate designs can form uneven or stepped coils as a result of drops within the system. Poorly formed coils are more likely to tangle during unspooling and can be difficult to pack for shipping due to the uneven shape, which can result in damage to protruding rings.

A new patented reform design eliminates all coil drops. The stepless reform tub is a complete system with two coil elevators on a shared column arrangement (Figure 6). Rings fall from the exit end of the cooling conveyor into the reform tub, are caught by an upper coil plate, and descend at a controlled rate. When the upper coil plate reaches the end of its travel limit, it nests into the lower coil plate. This interlocking design allows the upper coil plate to transfer the coil to the lower coil plate without any drop or step (Figure 7). After the handoff, the upper coil plate opens to allow the upper carriage to reset in anticipation of the next coil. When the coil is complete, the lower carriage accelerates to the base of the stem where the lower coil plate transfers the coil to the vertical stem or the two-armed mandrel. This system protects both human operators and critical components. Interlock gates prevent workers from entering these areas while the system is running.

IMPROVED PRODUCTION, QUALITY AND EQUIPMENT LIFESPAN

Technology developed for new laying heads responds to problems at many wire rod mills associated with lim-

In the SR Series pipe, new material replaces worn sections of laying head pipe through a controlled “self-regenerating” process during rolling.

ited mill speeds, low production rates and poor quality. Furthermore, upgrades dramatically extend pipe life through a patented self-regeneration process. As a result, wire rod mill operations have been able to improve production rates and achieve higher speeds with fewer pipe changes. The pattern and coil height of coil packages is greatly improved, with consistently high-quality rod meeting market demand.

The stepless reform tub system complements the laying head improvements by seamlessly transferring the well-formed rings from the conveyor, through the ring distributor to the coil plates. The results are a greatly improved coil package, and thus a more desirable final product for the downstream customer and less downtime for the mill. ●

Dr. Bruce V. Kiefer, Principal Engineer

Matthew Palfreman, Head of Technology
(both with Primetals Technologies)

MODERNIZED FOR MARKET DEMANDS

WIRE ROD MILL MODERNIZATION AT TŘINECKÉ ŽELEZÁRNY

A major modernization project was undertaken by Třinecké Železárny in 2013 on its 2-strand wire rod mill in Třinec, Czech Republic. With the addition of pre-finishing stands, water-cooling boxes, Morgan Reducing/Sizing Mills and Morgan High Speed Laying Heads, the mill has experienced significant improvements in productivity, product quality and processing capability.

The first wire rod mill for Třinecké Železárny was installed in 1912, modernized in 1922 and replaced in 1965 with a continuous rod mill. A new 4-strand mill commissioned in 1973 rolled 1 ton, 108-mm-square billets and finished at speeds up to 50 m/s from an 8-stand block. That mill was then rebuilt as a 2-strand mill in 1999, with a new furnace and roughing mill, a new controlled cooling conveyor, and new reform and coil-handling equipment. These improvements along with other mill updates brought the maximum speed up to 91 m/s on 5.5 mm rod. In subsequent years, Třinecké continued to improve different aspects of its operations, such as coil handling and compacting, logistics, surface quality control, dimensional controls and the water system.

REASONS FOR MODERNIZATION

In order to be positioned for future market demands, Třinecké started out by formulating anticipated product changes and targets for mill modernization. Through customer audits, it became apparent that significant disadvantages of Třinecké's products stemmed from obsolete equipment. Marketing studies also revealed potentially growing demand for thermo-mechanically (low temperature) rolled wire rod, which could reduce or entirely avoid annealing operations before drawing.

Given these study results, Třinecké set out to modernize its 2-strand rolling mill by focusing on:

- Increased quality in wire rod structure, strength and strength uniformity
- Reduced production costs
- Increased speed to exceed 110 m/s
- Greater mill flexibility and time utilization
- Improved product tolerances, including ovality
- Introduction of new grades with thermomechanical rolling
- Production of diameters below 5.5 mm
- Increased coil quality

KEY MODERNIZATION ELEMENTS

In order to achieve all of the production and quality goals of the mill modernization, Třinecké significantly altered the mill areas between Stand 15 of the intermediate train, where the strands split, and the cooling conveyor, and added new equipment. Figure 1 shows the finishing block area after modernization, for comparison with the previous arrangement shown in Figure 2. One goal of the modernization project was to reuse as much equipment as possible – particularly major elements like the existing finishing block. Key elements of the modernization included:

New pre-finishing mills, new process

A new roll-pass design accommodates the limited capacity of two existing pre-finishing stands, but to do so required an additional set of high-capacity stands. A new pre-finishing mill was added after the existing stands, consisting of a 2-stand, 230 mm horizontal/vertical (H/V) block, with ultra-heavy-duty (UHD) roll housings »



Marketing studies revealed a potentially growing demand for thermomechanically rolled wire rod, which could reduce or entirely avoid annealing operations before downstream forming.

FIG. 1:
Finishing block area
at Třinecké Železářny
after modernization



2.

One goal of the modernization project was to reuse as much equipment as possible – particularly major elements like the existing finishing block.

FIG. 2:

The finishing block area before the modernization

FIG. 3:

Morgan Reducing/Sizing Mill

FIG. 4:

Morgan High Speed Laying Heads



3.

provide the proper feed sections to finish roll all products in the RSM (Figure 3).

Morgan Water Boxes and equalization troughs for TMR

The length and placement of the water-cooling boxes was an important consideration, so detailed studies of expected temperature profiles were undertaken for the entire product size range and for all grades planned for the product mix. The additional rolling capacity in the pre-finishing stands and the configuration of those stands in a loop ahead of the finishing block makes it possible to add much more water cooling after Stand 15. New equalization troughs were provided in both rolling lines from the new water box after Stand 15 through to the laying head. A temperature-control system was installed for closed-loop control of each of the cooling zones to ensure the desired temperatures are maintained throughout the process.

for rolling at lower temperatures. The existing block was reconfigured to roll with six stands instead of ten.

Morgan Reducing/Sizing Mill installed

The Morgan Reducing/Sizing Mill (RSM), installed between the exiting finishing block and laying head, is responsible for much of the project's production and quality improvements. The RSM consists of a 2-stand reducing segment with 230 mm housings and a 2-stand sizing segment with close-centered rolls of 150 mm. The RSM design enables the use of single-family rolling throughout the mill, which simplifies the process and increases mill efficiency by reducing roll-change times. Instead of having to change grooves, upstream stands are dummied to

Pinch roll and laying head for consistent ring pattern

The modernization included the installation of new pinch rolls and the latest laying head design (Figure 4). A servo-motor-operated roll parting adjustment for accurate control of pinch force provides repeatable and high-speed pinch action for tail-end slowdown and speed-up functions. Morgan High Speed Laying Heads use a novel design of integral pipe support with the patented tail-end control deflector with segmented trough. Included as part of the new laying-head technology are SR Series laying head pipes, which produce consistent ring patterns at high speeds and extend life as a result of the patented self-regenerating pipe design.



4.

Cooling conveyor

Modifications to the cooling conveyor system included replacing seven fans and plenum chambers on each line with higher-capacity units, and installing the Optimesh air distribution system for cooling uniformity.

MILL UPGRADE IMPLEMENTATION

Třinecké and Primetals Technologies signed a contract to modernize the mill in February 2013. On-time equipment delivery meant that the mill was ready to roll its first billet in October 2014. The mill met its production target within the first full month of operation, as well as the guaranteed speed of 115 m/s for 5.5 mm and the ± 0.10 mm tolerance and 0.12 mm ovality target. The revamped mill is now well equipped for high utilization and productivity.

TECHNOLOGY AND QUALITY

Reaching production targets is only important if the rod quality meets customers' exacting standards. Early shipments of rod offered the same high level of quality as

before the modernization. Once rod quality met the standards for customers' existing orders, Třinecké could then utilize its modernized equipment to process to its fullest capacity. The capability to thermomechanically roll down to 750°C RSM entry temperature gives Třinecké the ability to operate in ways not possible before. Třinecké can now offer new products and possibly secure cost savings in expensive Cr and V alloying.

SUMMARY

The modernization undertaken by Třinecké in 2013 with Primetals Technologies has achieved a number of quality and production goals, from an improved and expanded product mix to faster speeds and greater mill utilization. The goals were met thanks to a carefully designed layout and equipment selection that fit Třinecké's specific needs. ●

Dr. Bruce V. Kiefer, Principal Engineer

Wade P. Krejdosky, Sales Manager

(both with Primetals Technologies)



Six 4,000 mm plates
leaving the cooling
bed, with no cold
leveling required

THE PROOF IS **IN THE PRODUCT**

PROCESS OPTIMIZATION TO ENHANCE PERFORMANCE AND CAPABILITIES OF PLATE AND ALUMINUM ROLLING MILLS

The quote “Nothing great is easy” has been used for many decades, and the ability to produce high-quality rolled products consistently and rapidly is no exception. Primetals Technologies offers a whole range of solutions to meet the challenges facing producers.

In striving to produce world-class material, Primetals Technologies has worked all over the world with steel and aluminum producers to create new products at higher and higher quality levels without reducing mill throughput or reliability. A number of process optimization examples for aluminum rolling mills and steel plate mills are described in the following:

SIGNIFICANT IMPROVEMENTS WITH SMALL CHANGES

Primetals Technologies was recently contracted to visit an existing aluminum foil mill in order to improve hydraulic automation gauge control (HAGC) and roll profile systems that have been operating for several years, but not at their highest potential. The changes included not only

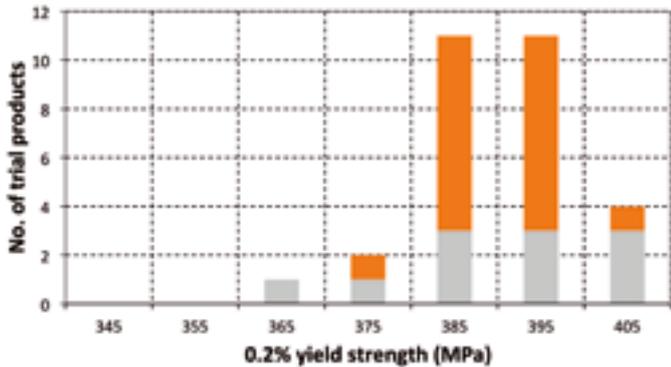


FIG. 1: Sample data from initial trials

■ Stock
■ Trial

tuning the system parameters such as system gains, but also rethinking various control logic settings. One outcome of this review led to moving the software filter from measurement feedback to the controller output. This relatively innocuous change created significantly faster response times and improved flatness.

OPTIMIZED SCHEDULE INCREASES QUANTITY AND QUALITY

Improvements in quantity as well as quality were made by one European aluminum producer through the optimization of a specific low-load rolling schedule. Engineers at Primetals Technologies studied the mill design and carried out a series of calculations using in-house models to ascertain what would be possible. The conclusion of the calculations was that a downward revision of the low load limit was technically feasible.

The desired change to the minimum load limit was successfully made and the control loops retuned. At very low speeds, the heat generated by deforming the material is small, and it is difficult to get the ideal temperature difference between work rolls and the coolant to ensure high-quality flatness performance. The increased rolling speeds resulted in greater heat generation rates in the mill bite. This, in turn, led to more stable flatness performance. Results from the initial trials for rolling speeds are impressive, with a near doubling of rolling speed to 700 meters per minute (mpm).

COMPREHENSIVE PROCESS KNOW-HOW FOR OPTIMIZED THROUGHPUT AND LOWER COSTS

In cooperation with a major European steel producer, Primetals Technologies established a reliable route for the production of normalized steel plates. The benefits

included reduced processing costs for these particular plates, and consequently a lower load on the existing heat-treatment line that allowed throughput to be optimized in this area.

The aim of the work was to develop and expand the normalized rolling production range for structural steel grade S355J2+N. Primetals Technologies provided process know-how for the whole process and production route in the areas of material chemistry, reheating furnace practice, rolling schedules, cooling bed and hot stacking. Results for samples taken from both the end and body sections of a selection of the trial products manufactured with two slab compositions were compared to EN Standard 10025-2. The requirements for this thickness are 0.2% offset yield strength of 345 MPa, and an impact toughness of 27 J at -20°C for the normalized rolled delivery condition.

All products passed the EN Standard 10025-2 requirements for yield strength and exhibited only a small spread in the data set (Figure 1). As a result of these trials, up to 72% of the customer's product mix for normalized plates could be produced by normalized rolling, thus dramatically increasing the capacity for normalized products. In addition, the costs of the offline heat treatment could be saved; the environmental impact of the process was lower because fuel did not have to be burned for the heat-treatment process; and alloying costs were reduced through the use of specific material chemistries prescribed by Primetals Technologies.

EXCELLENT COOPERATION, EXCELLENT RESULTS

Primetals Technologies was asked to work with a well-established plate manufacturer to help produce very wide (>4 m) plates at 6 mm and 7 mm thicknesses with low levels of cold leveling. The customer was very familiar with the plate rolling process and had been rolling many difficult grades for the international market with success, but at higher thicknesses and lower aspect ratios. Site visits along with preliminary trials identified what could be achieved, which practices were used as standard and what, if any, mechanical changes would be required. A full mill survey was then conducted by Primetals Technologies using the latest laser survey equipment, and the necessary changes were implemented by the customer.

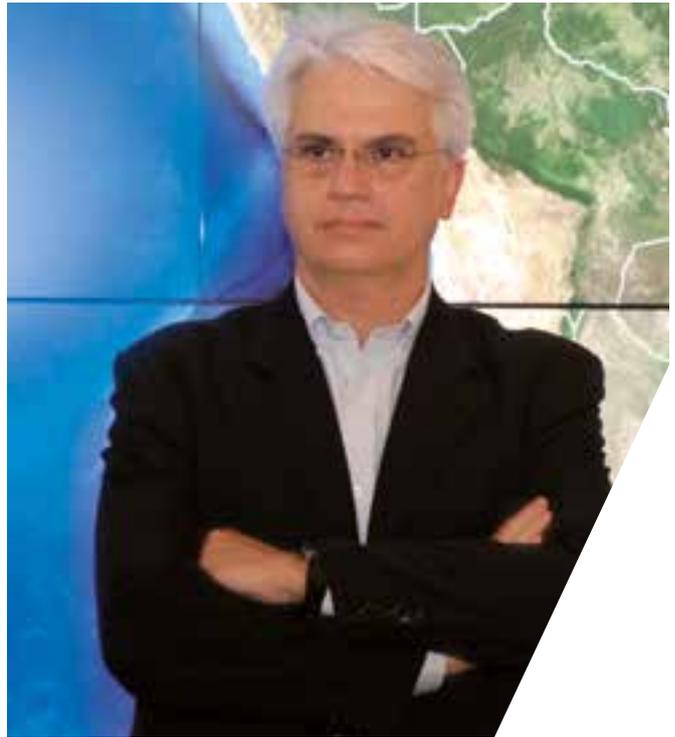
To achieve consistency, the rolling schedules for all grades and sizes were studied in depth, which resulted in the model controlling the mill being tuned to ensure that the predicted load and torque accuracy was within +/-10% of the actual values. As a result of the excellent cooperation between the plate producer and Primetals Technologies, the final trial resulted in direct shipping values of 90% compared to the original value of less than 30%. The main photo for this article shows the high degree of final product flatness on the cooling bed. ●

Andrew Harvey, Process Manager - Plate and Aluminum Rolling

INTERVIEW

WITH HERMENIO PINTO GONÇALVES

Industrial, Engineering and EHS* Corporate Director, Gerdau, Porto Alegre, Brazil



What are the main challenges that your company is currently facing?

Hermenio Pinto Gonçalves: The global steel market is going through a challenging moment that is marked by excess installed capacity and by stiff competition among industry players. In this scenario, Gerdau's challenge is to increase productivity while improving the quality of its products and by reducing its production costs. These initiatives will make it more competitive to take on the challenges faced by the steel sector.

How do you see the future of the steel industry in your market area, and what factors need to be taken into consideration?

Gonçalves: Our markets are in the United States, Brazil and the rest of South America. Each of these regions has a different situation. In the United States steel demand is currently growing and prices are improving. In Brazil there are problems related to the economy. Maybe in two years or so we will see some improvements here. South America is generally open for imports because most of the countries don't have a large local steel industry, so we have to compete here with other steel suppliers.

What major activities, efforts or investments are planned by the Gerdau Group to meet the challenges that lie ahead?

Gonçalves: We want to increase the mechanization of our plants to reduce manpower requirements followed by more automation and process control. In particular, it will be important to increase the degree of automation and robotic solutions in dangerous areas to improve safety.

What do you see as the main areas for further research and development to improve production operations, costs and market opportunities at Gerdau?

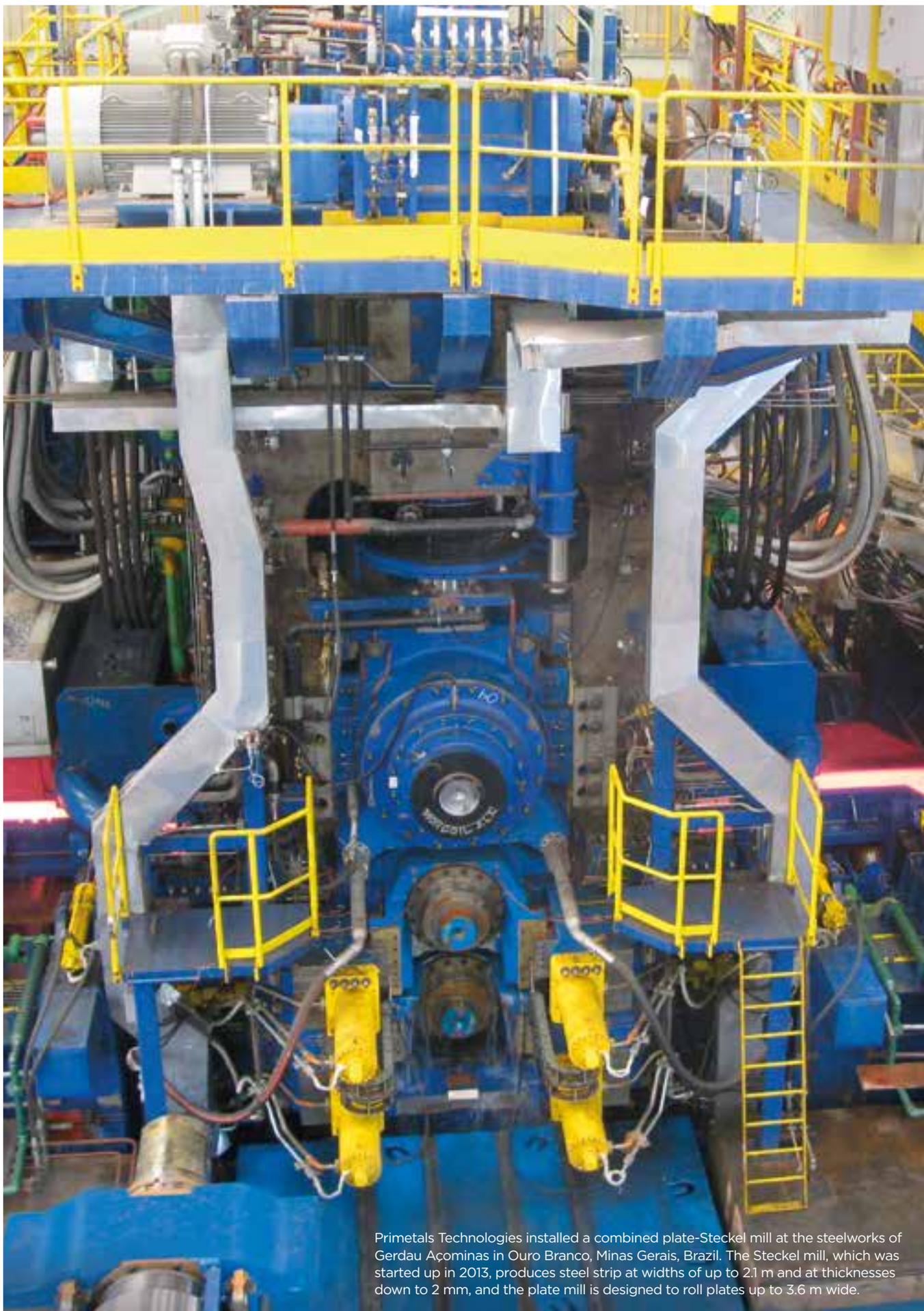
“For us it is important to maximize the total lifetime of a plant investment. Committed lifecycle support from a supplier is therefore a key factor.”

Gonçalves: Solutions for improving overall efficiency and process control would be important. We ourselves don't have the capacity to do major R&D work in these areas, so a partner is required to develop new technologies and to improve existing ones.

What are the main criteria that you consider when selecting a technology supplier, and which factors do you value most when dealing with business partners?

Gonçalves: For us it is important to maximize the total lifetime of a plant investment. Committed lifecycle support from a supplier is therefore a key factor. Construction costs are high where we are located, which means that simple and reliable facilities generally offer us the best cost-investment option. A supplier's reputation and know-how are very important for us. ●

*EHS stands for environment, health and safety



Primetals Technologies installed a combined plate-Steckel mill at the steelworks of Gerdau Açominas in Ouro Branco, Minas Gerais, Brazil. The Steckel mill, which was started up in 2013, produces steel strip at widths of up to 2.1 m and at thicknesses down to 2 mm, and the plate mill is designed to roll plates up to 3.6 m wide.

SUPERIOR MILL PERFORMANCE

PRIMETALS TECHNOLOGIES INSTALLS ADVANCED HOT-STRIP MILL EQUIPPED WITH WORLD-CLASS TECHNOLOGY AT USIMINAS

Primetals Technologies supplied a hot-strip mill to Usinas Siderúrgicas de Minas Gerais S.A. (Usiminas) at Cubatão in the Brazilian state of São Paulo. Started up in 2012, the mill incorporates advanced technologies that include third-generation Pair Cross actuators equipped with Mill Stabilizing Devices to reduce vibration. The new rolling facility fully meets the demands for the production of a broad range of steel grades at varying strip thicknesses and with excellent strip crown and shape results.



FINISHING MILL STANDS
of Hot-strip Mill No. 2,
Usiminas, Brazil

Over the years, rolling speeds have been continually increasing in order to raise productivity. At the same time, high-reduction rolling of high-strength steels requires larger rolling forces. This combination amplifies mill vibration, which adversely affects the life of mechanical parts, operational stability and thus mill productivity.

Compared to the rolling of conventional steel grades, special products such as line pipe, dual-phase (DP), transformation-induced plasticity (TRIP), high-strength, low-alloy (HSLA), interstitial-free (IF) and electrical steels call for a mill capable of producing a wider strip-crown range. The requirements placed on new hot-rolling mills to enable enhanced strip-crown control are therefore continually growing. In response to these challenges, Primetals Technologies has combined the well-established Pair Cross mill with the new Mill Stabilizing Device (MSD) to meet today's demands for hot rolling.

SUPPLY SCOPE AND MILL SPECIFICATIONS

The No. 2 Hot Strip Mill at Usiminas is one of the most modern rolling facilities of its type anywhere in the world. It is equipped with Pair Cross rolling technology and the MSD solution. Primetals Technologies supplied the complete rolling line, which included the foundation design and auxiliary equipment that comprised roll-shop equip-

ment, the water-treatment system, the compressed-air plant, cranes, ventilation and air-conditioning, as well as the fire-detection and extinguishing facilities. Table 1 summarizes the main mill and product specifications, and Figure 1 shows the general line layout.

MILL EQUIPMENT

The line consists of a 4-high reversing roughing mill (R2) equipped with hydraulic gap control and a vertical edger at the entry side (Figure 2). Long-stroke, hydraulic automatic width control (HAWC) is applied to ensure high width accuracy and simple maintenance. A differential-speed rotary crop shear is installed in front of the finishing mill to square the transfer bar (Figure 3).

The finishing mill consists of six 4-high mill stands, F1 to F6, in tandem arrangement. Hydraulic Automatic Gauge Control (HAGC) is provided on all finishing stands for work-roll gap adjustments. Pair Cross rolls equipped with MSDs are installed in stands F1 to F4. Stands F5 and F6 are equipped with work-roll shifting to enable an extension of the rolling campaign at the same strip width. Cyclic shifting of the work rolls prevents both stepped and local wear. Positive and negative work-roll bending is employed on stands F5 and F6 for fine flatness control. Stands F5 and F6 are also outfitted with MSDs. »

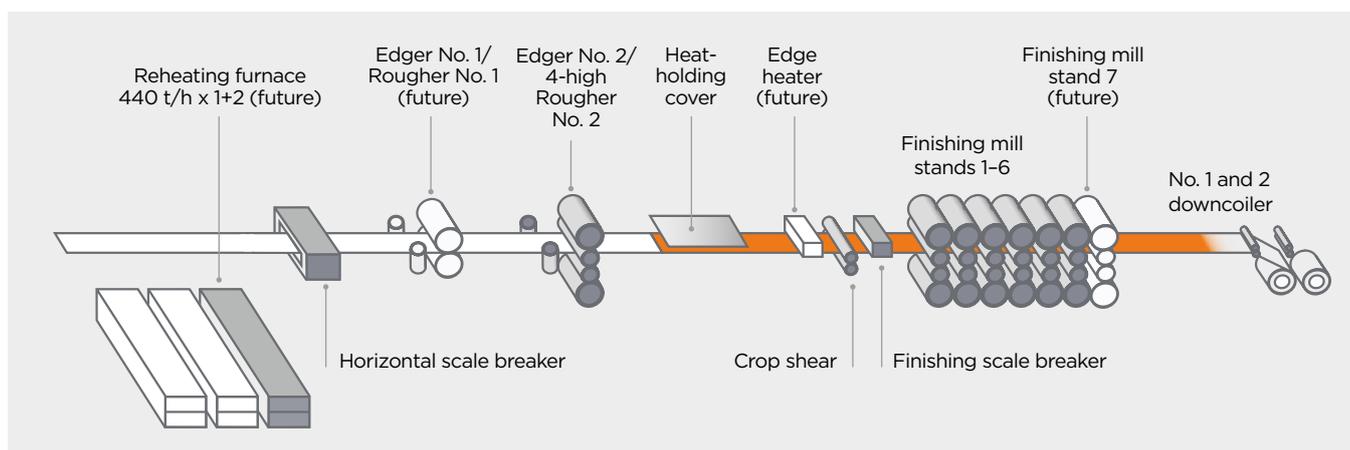
TABLE 1:

HOT-STRIP MILL SPECIFICATIONS

| | |
|---------------------|---|
| Hot-run start | March 2012 |
| Production capacity | 2.3 million t/a (4.8 million t/a in the future) |
| Steel grades | Carbon, pipe, HSLA, DP, TRIP and electrical steels |
| Strip thickness | 1.5 mm–20 mm (1.2 mm–20 mm in the future) |
| Strip width | 750 mm–2,050 mm |

The No. 2 Hot-Strip Mill at Usiminas is one of the most modern rolling facilities of its type anywhere in the world.

FIG. 1: Layout of the No. 2 Hot-Strip Mill of Usiminas at start-up



The demand for a high-reduction mill capable of rolling advanced steel grades at thinner gauges and with improved strip crown and shape control was fully met.

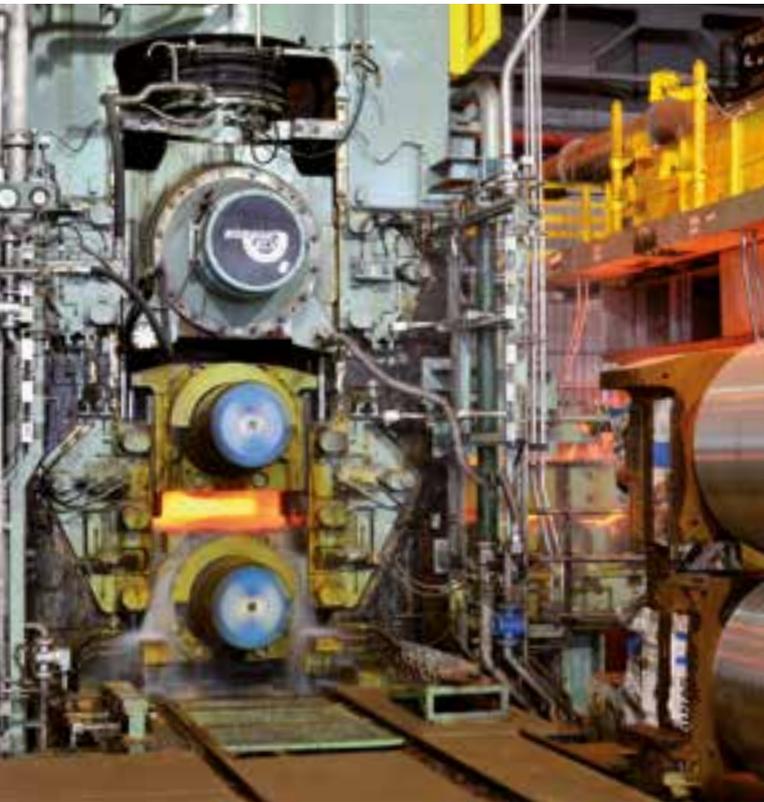


FIG. 2: Roughing stand of Hot-strip Mill No. 2 with an attached vertical edger



FIG. 3: Differential-speed rotary crop shear

Hydraulic cylinder-operated loopers are located at each interstand area for mass-flow control and improved speed regulation. Interstand strip tension is calculated from hydraulic pressure and/or the load cell as the basis for feedback control of each looper. A rolling oil dispenser at the entry side of each stand further reduces roll wear and strip-surface defects. Furthermore, the oil dispenser decreases electrical power consumption.

Laminar-flow water cooling is applied on both the top and bottom surfaces of the strip after the finishing stands. Altogether, there are 15 separate cooling banks installed. These comprise intensive flow banks for fast cooling, normal cooling banks for regular cooling, and fine cooling banks for temperature control before coiling (Figure 4). The length of the cooling zone and water-flow rates are designed for the production of DP and TRIP steels as well as for conventional carbon steel grades.

Two downcoilers were installed. Three sets of wrapper rolls with quick-opening control (QOC) technology

support smooth and quality coiling. QOC technology allows each wrapper roll to jump the step created by the head end of the strip, which reduces top-end marks that appear on the inner wraps. The mandrel has the capability to coil thicker strip of high-strength steel, and it also exhibits a unique feature called stepless expansion that improves the quality of coiling. The mandrel is able to expand in diameter in stepless increments while the strip is being coiled. While waiting for the strip, the mandrel is set to a smaller diameter than normal. Once the second wrap is wound, the mandrel begins to expand, which helps the strip to wrap tightly. With this feature, coiling tension is established very early during the coiling process without strip slippage.

PAIR CROSS MILL WITH MILL STABILIZING DEVICE

Crown on rolled strip is primarily caused by elastic deformation of the rolls. Because this is unavoidable during the rolling process, an additional actuator is needed to achieve strong and high-precision rolling of



FIG 4: Laminar-flow strip cooling

strip with the correct amount of crown. This is especially true under the changing conditions resulting from variations in the rolling schedule, as well as other causes.

The Pair Cross mill controls crown by crossing the rolls to achieve a changing gap between the top and bottom work rolls (Figure 5). Each work roll is narrower in the center and gradually becomes wider toward both ends. The name Pair Cross comes from the fact that not only the work rolls but also the backup rolls are crossed. By keeping the corresponding contacting work roll and backup roll parallel to each other, development of thrust force and wear between both rolls is minimized.

The Pair Cross mill was first developed in the 1980s and the design has been continually enhanced since then. The Usiminas mill is equipped with the third-generation Pair Cross system, which offers the following advantages compared to previous systems:

The Pair Cross mill controls crown by crossing the rolls to achieve a changing gap between the top and bottom work rolls.

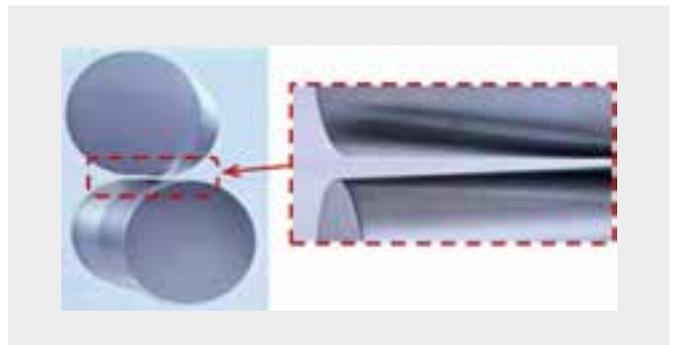


FIG 5: Varying gap achieved by crossing work rolls

- Greater strip crown and flatness control is possible using just the Pair Cross mill by itself
- Improved operational stability using the MSD under demanding rolling conditions
- 75% reduction in the required number of components leads to simpler maintenance

FULLY MEETING THE REQUIREMENTS

Primetals Technologies installed and equipped the No. 2 Hot Strip Mill at Usiminas with some of the world's most advanced hot-rolling technologies. The demand for a high-reduction mill capable of rolling advanced steel grades at thinner gauges and with improved strip crown and shape control was fully met. The mill is characterized by its high productivity, stable operation and reduced maintenance requirements. ●

Taroh Satoh, Engineer, Hot Rolling Project Division¹⁾

Jiro Hasai, General Manager, Hot Rolling Project Division¹⁾

Frank Beddings, Vice President of Sales²⁾

¹⁾ Primetals Technologies Japan ²⁾ Primetals Technologies U.S.A.

MILL STABILIZING DEVICE

REDUCTION OF MILL VIBRATION IN HOT-STRIP MILLS

By equipping conventional roll chocks with the hydraulic Mill Stabilizing Device from Primetals Technologies, impact forces during strip threading into the finishing stands of a hot-strip mill are reduced by approximately one half and the amplitude of mill vibrations is substantially lowered.



Today's market demands for superior strip quality and high-strength steels rolled to thinner gauges require higher rolling forces. Strip moves faster through the mill and greater rolling forces are exerted. This results in larger impact forces during threading, and leads to vibrations of enormous amplitude. The larger impact force or mill vibration not only shortens the life of mechanical parts, but also reduces operational stability and rolling efficiency.

The behavior of work-roll chocks was investigated and it was found that these units moved during rolling and were not stable. The reason for a larger impact force is as follows: As the inertia of the backup roll is greater than that of the work roll, the relative speed of the work roll is less than the speed of the backup roll during strip threading. This generates a horizontal force in the direction of the entry housing that causes the work roll to move significantly in the direction of the entry housing when there is clearance between the work-roll chock and the mill housing. When the work-roll chock strikes the entry side of the housing, it reverses direction and moves back toward the delivery side of the housing, causing a large impact force. Mill vibration in hot rolling can be explained by the follow-

ing phenomenon: The upper and lower work rolls vibrate in opposite directions to each other, and predominantly in the rolling direction. When there is clearance between the work-roll chocks and the mill housing, the mill stand is prone to start vibrating under high-reduction conditions. As mentioned above, it is understood that the larger clearance between the work-roll chock and housing is the main cause of instability.

AN ELEGANT SOLUTION

To solve these issues, Primetals Technologies developed the Mill Stabilizing Device (MSD), which eliminates the clearance between the roll chocks and housing. The MSD, which is installed between the roll chocks and the mill housing, consists of a hydraulic cylinder designed with orifices that provide a damping effect. In this way, the force of impact is reduced (Figure 1).

This elegant approach was first investigated in a test mill equipped with load cells. Strip-threading impact forces were compared with the MSD off and on in *impact force vs. time* graphs. When off, the impact force was 13.2 ton-force (tf) per roll, but with the MSD on, the force fell to 7.45 tf per roll (Figure 2).

MILL STABILIZING DEVICES

are installed in the finishing stands of a hot-strip mill supplied by Primetals Technologies at Dragon Steel Corporation, Taiwan



The Mill Stabilizing Device eliminates the clearance between the roll chocks and the mill housing.

RESULTS OF MSD IN A PRODUCTION MILL

At Posco's Gwangyang Steel Works, impact accelerations in the rolling direction were measured by accelerometers attached to the post of the entry and delivery housings of a hot-strip finishing mill. With the MSD off, large impact accelerations are generated during strip threading into the stand. When the MSD is on, the accelerations are greatly reduced (Figure 3). This significantly minimizes wear of the mechanical parts surrounding the work-roll chock during threading, and consequently lower maintenance costs are incurred.

STABILIZATION OF MILL VIBRATION DURING ROLLING

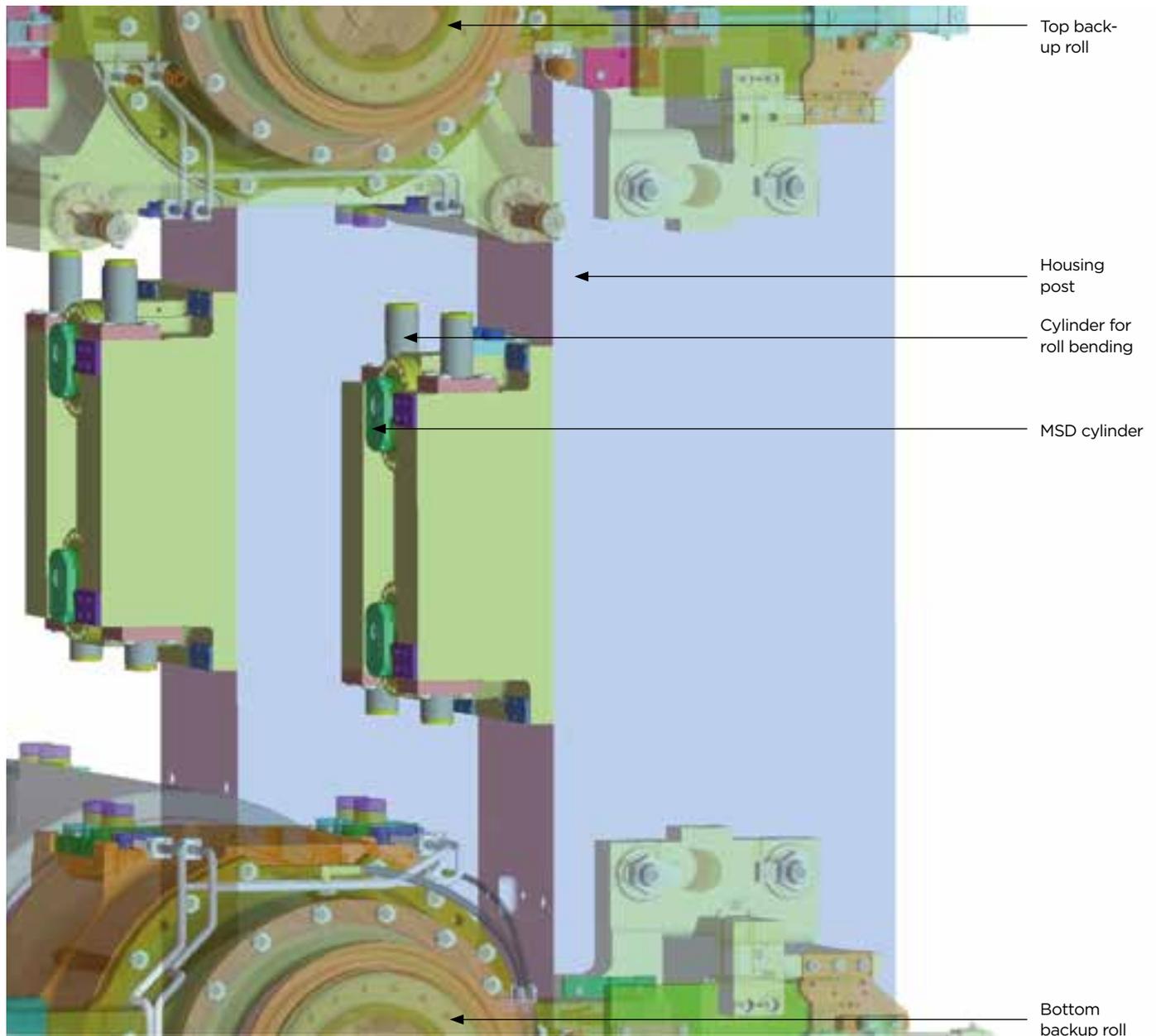
When strip moves faster with increasing thickness reductions, the mill stand is prone to suddenly start vibrating with a large amplitude. This is because the upper and »

APPLICATION OF THE MSD LEADS TO THE FOLLOWING BENEFITS:

- Lower impact forces during threading of the strip front end into the mill stands and thus reduced wear and maintenance costs
- Stabilized mill vibrations, which allow greater strip reduction during rolling
- Increased operating stability of the mill during rolling
- Stabilized strip steering during threading and tail out
- Easily installed in various mill types, also as a retrofit in existing mills

Since 2000, nearly 160 Mill Stabilizing Devices have been installed in the work and backup rolls of Pair Cross mill stands and other types of mill stands.

FIG 1: Illustrated 3D CAD view of the Mill Stabilizing Device



lower work rolls vibrate in opposite directions (predominantly horizontally). This vibration is a self-exciting type, mainly in the frequency range of 60 Hz to 90 Hz. Mill vibration occurs above a criteria curve line governed by the rolling speed and the parameter *rolling force per unit width x reduction in thickness*.

The criteria curve is influenced by the dynamic rigidity in the horizontal direction. Because the MSD eliminates the clearance between the roll chocks and the mill housing, dynamic rigidity is increased. Much of the damping effect is achieved by the viscosity of the hydraulic oil expelled through the orifice.

Thus, the damping effect increases as vibrations become larger. The dynamic rigidity when the MSD is on is about twice that when it is off. Accelerations of mill vibration were measured by accelerometers attached to work-roll chocks of a hot-strip finishing mill at Posco's Gwangyang Steel Works. Mill vibration can be reduced with the MSD turned on (Figure 4). This means that harder and thinner materials can be rolled.

INSTALLATION IN PAIR CROSS MILLS

The well-known Pair Cross mill has evolved since the 1980s to enable better strip crown and shape control. Now in its third generation, the mill is equipped with hydraulic cylinders that replace the mechanical roll-crossing mechanism on the entry side. The hydraulic cylinders, which are part of the MSD system, force the work rolls to move toward the delivery side of the housing. This eliminates the clearance between the work-roll chock and housing.

A WELL-PROVEN SOLUTION WITH AN ADDED BENEFIT

Since 2000, nearly 160 MSDs have been installed in the work and backup rolls of Pair Cross mill stands and other types of mill stands (Figure 5). When backup rolls are also equipped with MSDs, clearance between the backup roll chocks and housing is eliminated, which maintains better alignment between the backup and work rolls. Thus, the thrust force in the axial roll direction is reduced, which decreases the differential rolling force between the drive side and work side. As a result, an improvement of strip steering stability can also be achieved. The MSD can easily be installed as a retrofit as well as in new mills. ●

Hideaki Furumoto, General Manager, Research and Developing, Technical Developing Department¹⁾

Kanji Hayashi, Fellow, Research and Developing Office, Technical Developing Department¹⁾

Takao Owada, Senior Engineer, Plant Engineering & Planning Expedition Department¹⁾

Frank Beddings, Vice President of Sales²⁾

Shinya Kanemori, Team Manager of Control Systems, System Technology Development Department³⁾

¹⁾Primetals Technologies Japan

²⁾Primetals Technologies U.S.A.

³⁾Mitsubishi Heavy Industries

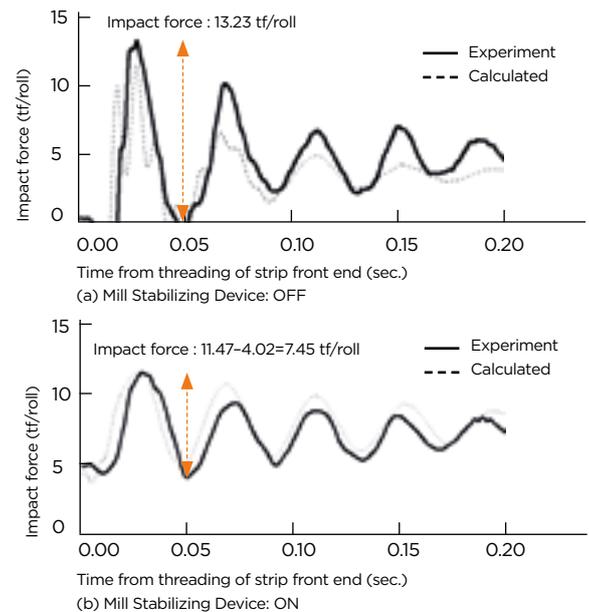


FIG. 2: Relationship between impact force from threading and time with the MSD off and on

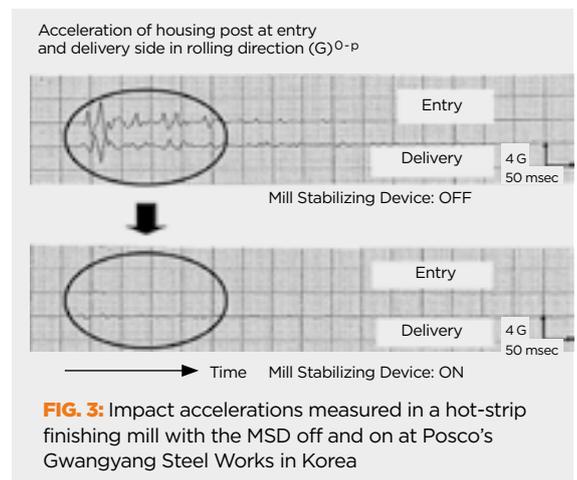


FIG. 3: Impact accelerations measured in a hot-strip finishing mill with the MSD off and on at Posco's Gwangyang Steel Works in Korea

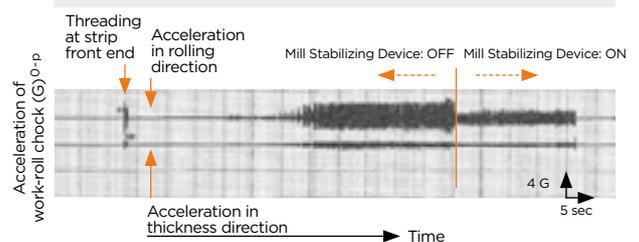


FIG. 4: Accelerations of work-roll chock measured in a hot-strip finishing mill with the MSD off and on at Posco's Gwangyang Steel Works in Korea

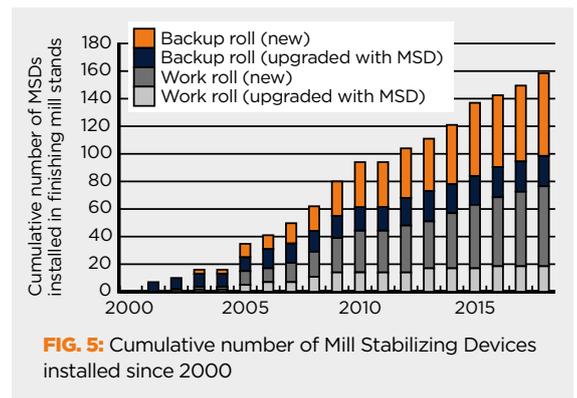


FIG. 5: Cumulative number of Mill Stabilizing Devices installed since 2000



FIG. 1: Looper Shape Meter in operation on the upstream side of the final finishing stand

KEEP YOUR STRIP IN SHAPE

IMPROVED STRIP-SHAPE CONTROL ACCURACY WITH THE LOOPER SHAPE METER

Market demand for high-tensile-strength steels is steadily increasing, which means hot-strip mills have to roll harder and thinner products. Exact inline strip shape measurements are required as the basis for a reliable strip-shape-control system. Conventional optical devices used for this purpose, however, have a major drawback: a large part of the strip length where tension acts and affects the strip shape is hidden, making visual measurements extremely difficult. Primetals Technologies has therefore developed an alternative measurement system known as the Looper Shape Meter, which has proven its effectiveness in the arduous mill environment since 2006 (Figure 1).

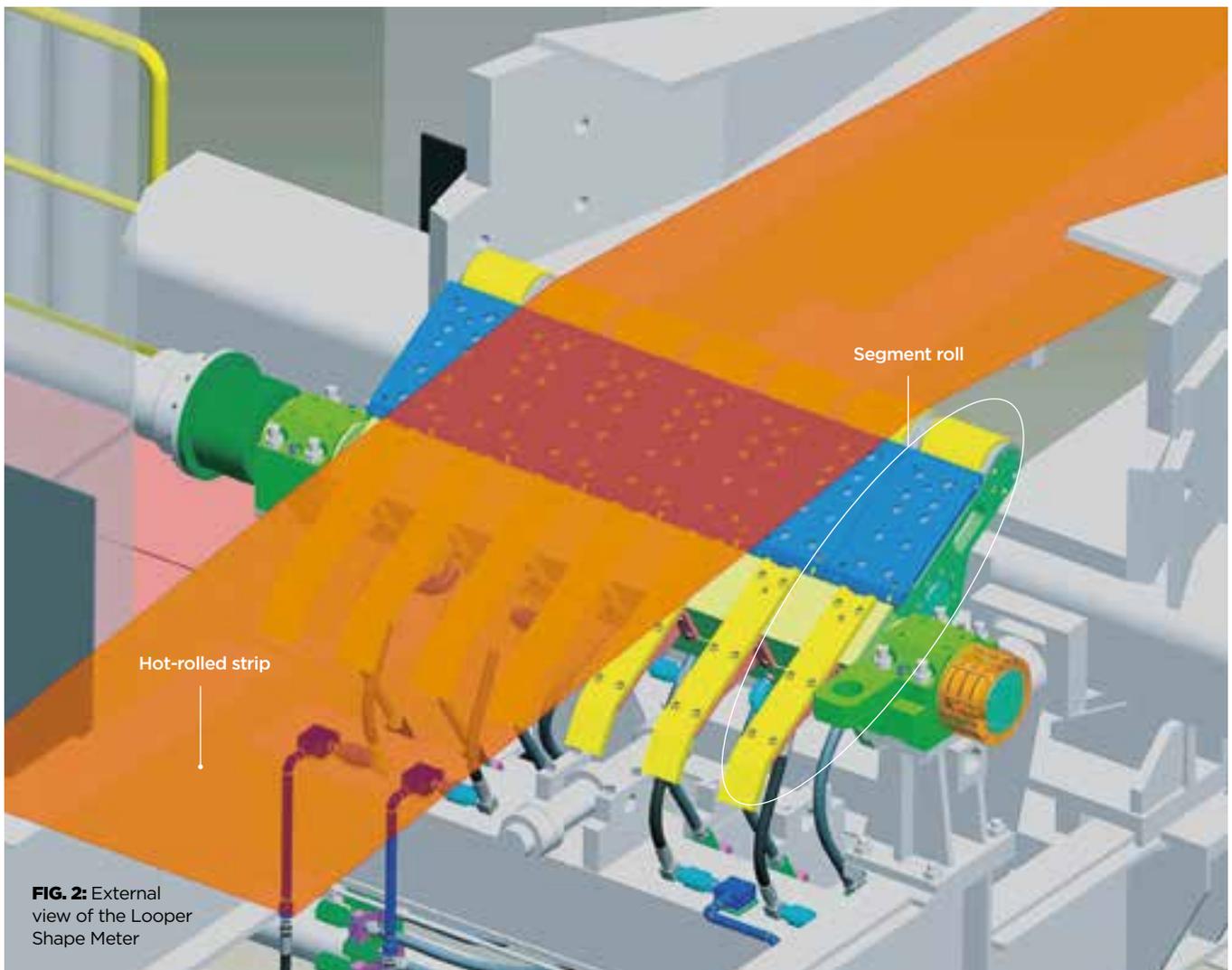


FIG. 2: External view of the Looper Shape Meter

The Looper Shape Meter has excellent robustness, even under the harsh conditions of hot rolling.

The Looper Shape Meter (LSM) is a strip-shape-measurement system that is based on the use of torque meters to accurately measure tension distribution across the strip width. It could be shown that torque measurements correspond to a high degree to the actual strip shape. The LSM substitutes the existing looper of the finishing mill. It consists of seven roll segments evenly spaced across the strip width with torque meters installed on both sides of the center block of each segment (Figures 2 and 3). The tensile force measured at each segment is directly received by the torque meters through the arm. The torque that corresponds to the tension distribution in the segment roll is then measured.

The individual torque meters are covered by a shield and air-purged to prevent the intrusion of water and dust. To

protect these units against heat radiating from hot-rolled strip, internal water cooling is employed in the center block and in the apron above the center block.

For accurate measurements, it is important to reduce the hysteresis caused by sliding parts. Because the LSM measures tension distribution directly with the torque meter and therefore has few sliding parts, hysteresis-related disturbance is minimized in the measured results. Furthermore, in comparison to the optical devices generally used to measure strip shape, the LSM delivers much more precise information because the sensors acquire a complete picture of the strip shape.

The data from the LSM is sent from the 14 torque meters to the shape-calculating device. At the same time, the »

The first LSM has been operating in a hot-strip mill since 2006 where the solution was thoroughly tested.

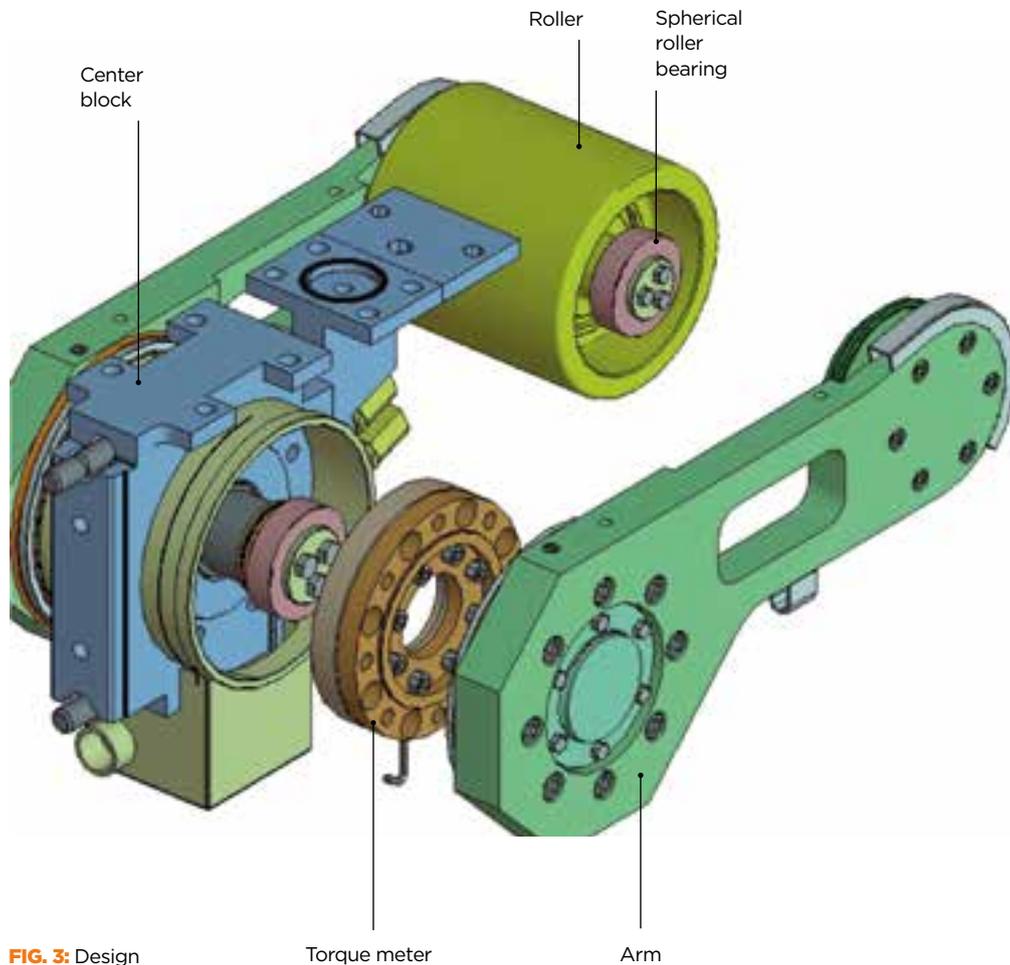


FIG. 3: Design of the segment roll

looper angle, strip speed, strip thickness, strip width and other data are sent from the Level 1 and Level 2 controllers to the shape arithmetic unit. The calculated strip shape is transmitted to the control pulpit where it is displayed on the operator screen. These results are useful to control stand leveling and roll-bending-force adjustments by the operator, and therefore contribute to stable strip threading-out, prevention of defective strip shape, and tail pinching.

A PROVEN SOLUTION

The first LSM has been operating in a hot-strip mill since 2006 where the solution was thoroughly tested. Results show that the LSM has excellent robustness, even under the harsh conditions of hot rolling. For example, in a test to examine temperature, the torque meter remained at

LOOPER SHAPE METER REFERENCE EXAMPLES IN HOT-STRIP MILLS

| Reference plant | Type of project |
|---------------------------------------|------------------|
| Tata Steel, IJmuiden, the Netherlands | Revamp project |
| Hyundai Steel, South Korea | Revamp project |
| Tata Steel, India | New rolling mill |

TESTING RESULTS

The LSM demonstrated the following measurement results during testing: The final strip thickness was 2.44 mm and the width 1,513 mm. The torque was highest near the strip edges and center, and lower at the quarter point (a). The resulting strip shape

calculated shows a smaller elongation on the work side, center buckling and quarter buckling (b). This could be separated into primary, secondary and quaternary components as in (c), (d) and (e), respectively.

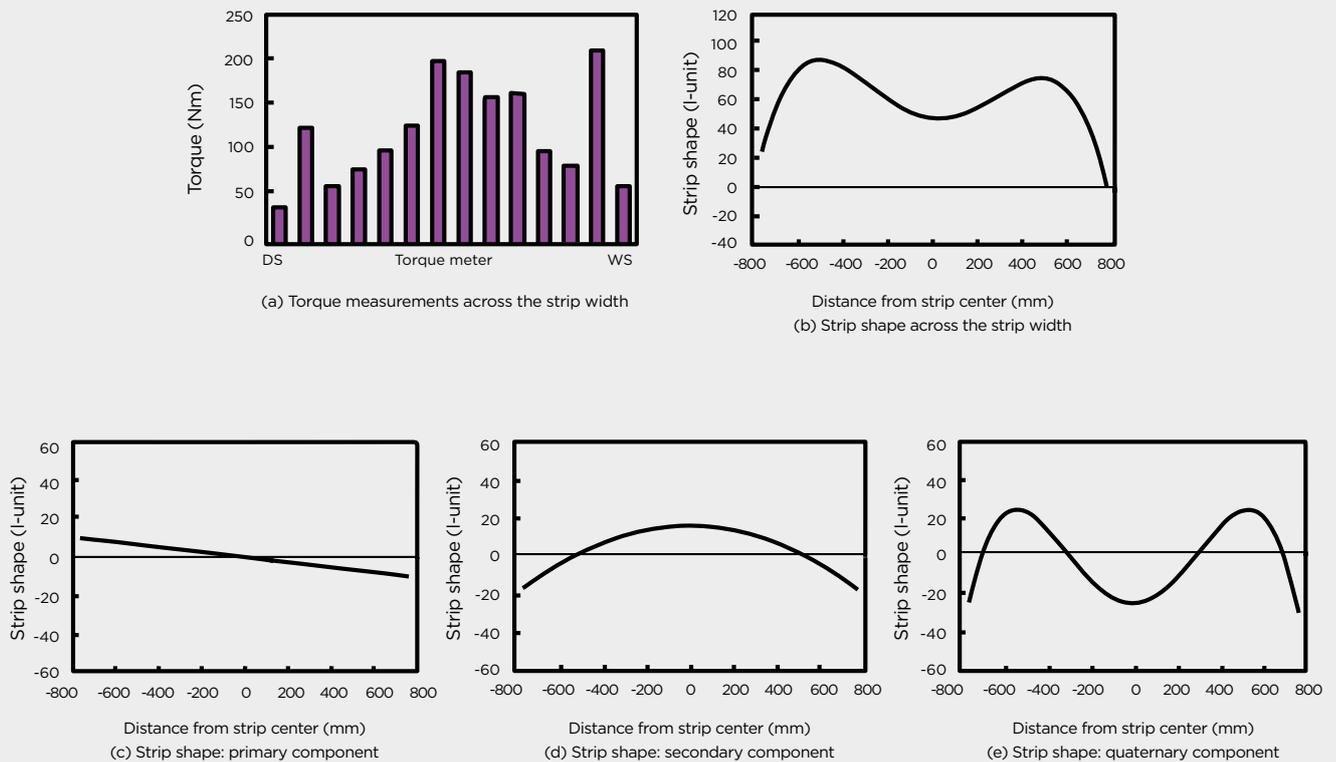


FIG. 4: Looper Shape Meter testing results

around 25°C during approximately ten minutes of continuous rolling – despite a strip temperature close to 900°C. After rolling, there were no signs of water or dust intrusion and the LSM remained in good condition.

As the market demand for hot-rolled strip continues to rise, particularly for high-tensile-strength steels, LSM technology could become a solution for enhanced strip-shape-control accuracy, more stable strip-rolling and threading-out conditions, and therefore productivity improvements. ●

Hideaki Furumoto, General Manager, Research and Developing, Technical Developing Department¹⁾

Kanji Hayashi, Fellow, Research and Developing Office, Technical Developing Department¹⁾

Ryohei Kinose, General Manager, Technical Developing Department¹⁾

Naoto Migakida, Engineer, Project Management Department, Hot Rolling Project Division¹⁾

Takao Owada, Senior Engineer, Plant Engineering & Planning Expedition Department¹⁾

Shuji Maniwa, Integration Manager, Electrics/Automation²⁾

Shinya Kanemori, Team Manager of Control Systems Team, System Technology Development Department³⁾

Shigeki Sueda, Deputy Manager, No. 2 Laboratory Materials Research Department³⁾

¹⁾Primetals Technologies Japan

²⁾Primetals Technologies Germany

³⁾Mitsubishi Heavy Industries

BLUEPRINT FOR EXCELLENCE

COUPLED PICKLING AND TANDEM COLD-ROLLING LINE AT TERNIUM MEXICO

In August 2013, a coupled pickling line and tandem cold-rolling mill (PLTCM) supplied by Primetals Technologies commenced operation at Ternium Mexico S.A. de C.V. (Ternium Mexico) in Monterrey. The facility, which has an annual rolling capacity of 1.5 million tons, is part of a major investment by Ternium to increase its production of advanced steel grades for the growing automotive market. Features of the different plant sections, products and benefits are described below.



The new PLTCM at Ternium Mexico has performed brilliantly since its start-up more than two years ago – which took place only 26 months after the contract signing. The advanced facility is designed to produce a wide range of rolled products that comprises thin-gauge strip with thicknesses down to 0.18 mm, high-tensile-strength automotive steels up to 980 MPa, exposed automotive steel grades and electrical steel (Table). The installed technologies from Primetals Technologies include jet-pickling tanks, Flying Width Change (FWC) side trimmer, and a 6-high Universal Crown Control Mill with work-roll shifting (UCMW). In combination with a sophisticated electrical control system supplied by Hitachi, the high-performance line produces strip that features extremely accurate thickness and flatness values as well as an excellent edge profile.

Coupling the pickling and cold-rolling steps results in a number of benefits for Ternium with regard to productivity, strip quality, yield and production costs. The elimination of strip threading and tailing out means a major increase in throughput capacity, a longer work-roll lifetime and fewer work-roll changes. Continuous operation minimizes strip head and tail ends and thus the frequency of off-gauge strip. These features result in a notable reduction in required maintenance and manpower costs.

SPECIFICATIONS OF THE TERNIUM MEXICO PLTCM

| | |
|----------------------|---|
| Rolled steel grades | Commercial quality (CQ), drawing quality (DQ), deep-drawing quality (DDQ), extra-deep-drawing quality (EDDQ), interstitial-free (IF), advanced high-strength steel (AHSS), structural and electrical steels |
| Entry thickness | 1.5 mm–6.5 mm |
| Delivery thickness | 0.18 mm–3.5 mm |
| Strip width | 700 mm–1,850 mm |
| Coil weight | 35,000 kg |
| Pickling speed | Max. 210 m/min |
| Rolling speed | Max. 1,250 m/min |
| Strip-dividing speed | Max. 300 m/min |
| Welder type | Built-in laser welder |
| Pickling system | Jet bath |
| Mill type | 5-stand, 6-high UCMW (short-stroke shift) |



Main control pulpit of the coupled pickling line and tandem cold-rolling mill at Ternium Mexico

PICKLING SECTION

The entry section for handling and feeding hot coils to the PLTCM is fully automated. This section includes dual payoff reels, a crop shear, a weighing scale, a laser beam welder and an entry looper. The laser welder in particular was selected for its ability to weld a wide range of steel grades, such as interstitial-free (IF) steel, high-tensile-strength steel and electrical steel. Surface quality monitoring takes place prior to pickling to detect any strip defects and thus avoid problems during line operation.

A tension-leveler-type scale breaker was installed for pre-descaling. Cassette-type roll changing was adopted to enable rapid roll change – even during strip threading. The patented jet-pickling process developed by Primetals Technologies was chosen for its high pickling performance and superior pickling results. Submerged jet nozzles are installed in each of the polypropylene pickling tanks, which are covered with a water-tight lid. This minimizes acid exposure to the atmosphere, evaporation and energy loss. Furthermore, automated acid concentration control with the use of a process model improves pickled strip quality and reduces excess acid consumption.

The strip is side-trimmed after pickling. Loopers are installed on both the entry and delivery sides of the side trimmer. Dual Center Position Control (CPC) in operation

at the entry sides of both the side trimmer and tandem cold mill (TCM) ensures an accurate center positioning of incoming strip. Furthermore, immediately prior to the No. 1 mill stand, a three-roll bridle roll restrains the strip and feeds it securely into the roll bite.

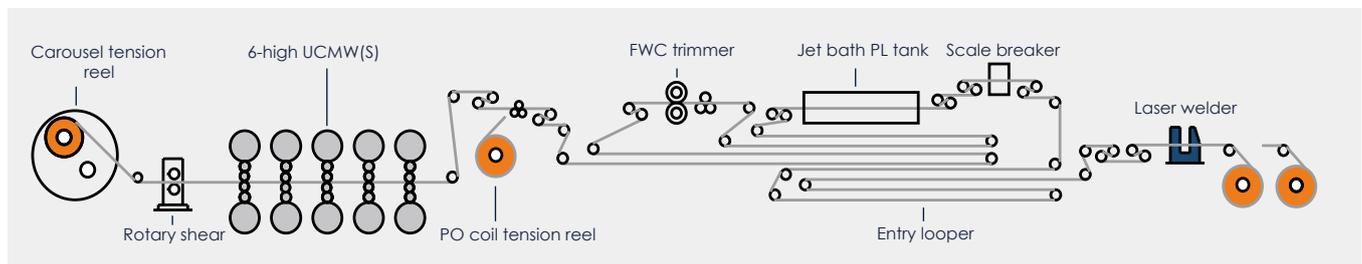
COLD-ROLLING MILL

The 5-stand 6-high UCMW is equipped with work-roll shifting to compensate for edge drop. The UCMW mill concept for shape control also includes work-roll and intermediate-roll bending, as well as intermediate roll shifting. Parallel ground crownless rolls are used for work, intermediate and backup rolls during most rolling operations, including the rolling of high-strength steels. Work rolls with a modified shape at the strip edges are used to roll electrical steels. Normally, electrical steels require a very flat strip shape profile, as they are used in laminated blocks and clearance between each layer should be as small as possible to ensure good magnetic characteristics. The amount of edge drop in cold rolling can be reduced by dynamically shifting the roll position during rolling and by adjusting the gap between the work rolls. This leads to an improved yield.

Primetals Technologies offers two types of UCMW mills: one with short stroke [UCMW(S)] and the other with long stroke [UCMW(L)]. The actual application depends on »

The new PLTCM at Ternium Mexico has performed brilliantly since its start-up more than two years ago – which took place only 26 months after the contract signing.

FIG. 1: General layout of the pickling line and tandem cold-rolling mill



the product mix. At Ternium Mexico, the UCMW(S) – with a shifting stroke of around 150 mm – was installed with consideration to the low volume of electrical steels produced and the need to roll wider materials such as automotive steel. At the mill exit, the section of strip that contains the weld made at the entry side of the pickling line is cut out by a rotary shear.

A carousel-type reel is used for the tension reel. Since the position to start winding is always the same near the TCM, the carousel reel has the advantage of reducing strip defects and strip walking compared to using two tension reels. Coils are automatically weighed, banded and labeled during the coil cycle. The coil is inspected on an offline inspection table connected to the line by means of an inspection coil car and inspection payoff reel. Figure 1 shows a general layout of the coupled pickling line and tandem cold-rolling mill.

MILL CONTROL

Automatic gauge control (AGC) of strip consists of conventional feed forward AGC (FF-AGC), roll position control AGC (BISRA-AGC) based on a gauge meter formula, and also monitor-AGC. In addition to these, mass flow AGC and an AGC system based on decoupling control are included. Mass flow AGC measures the actual running speed of the strip with laser speed meters installed at the exit of stands No. 1 through No. 5 and feeds back the measured data



Jet-bath pickling tanks

Overview of the pickling line entry section of the PLTCM at Ternium Mexico

for gauge control. This method helps increase accuracy of gauge control, particularly in the acceleration and deceleration phases. Decoupling control is a method to suppress interference between inter-stand tension variations resulting from strip gauge and rolling-force variations. This control improves the strip gauge accuracy in the normal rolling phase. Furthermore, unlike the conventional control process that employs an initial setup using the data obtained from previously rolled strip, the Hitachi system applies a dynamic schedule change using data obtained from current rolling. This control can dynamically adjust the setting of thickness for each stand delivery. As a result, load balance between each stand is optimized. This greatly contributes to the improvement of operating stability and high efficiency of the facilities.

Flying gauge change (FGC) must be performed accurately and quickly. This is especially true for materials rolled at low speeds where it is hard to get precise gauge control and for which gauge precision is considered indispensable to obtain a high yield. Variation in rolling force following a flying gauge change considerably affects the control of strip shape. The UCM mill addresses this problem with high lateral rigidity compared to a 4-high mill or other types of 6-high mills. Strip-crown deformation caused by fluctuations in rolling force due to flying gauge change is thus minimized. A new automatic response adjustment system for the hydraulic roll gap controller was included. It consists of an automatic monitoring function that performs measurements for a number of preset control gains, and an automatic tuning function that searches for applicable control gain. Because this system is connected to the mill controller, it can start measuring at a specific time and obtain actual rolling data.

CUSTOMER FEEDBACK

Following more than two years of operational experience with the PLTCM, Ternium Mexico has particularly praised the robustness of the line to meet changing market requirements. This robustness can be attributed to several factors. For one, the highly automated production line minimizes manual intervention. Another key factor is the server in charge of calculating the setup processes and its ability to rapidly process a great amount of information in a very short time by using predefined values, mathematical modeling, statistical analyses and coil information provided by Ternium. The interface between Ternium tracking and Hitachi tracking is also successful due to the clear communication structure and traceability. Finally, the communication protocol inside the Hitachi system network is very stable and reliably delivers each preset value in time for all equipment in the PLTCM. In the end, all of these factors lead to high-quality products with precise thickness and flatness, excellent edge profiles and high productivity. ●

Motoyuki Fujii, Ichiro Maeno, Yoichi Kai

(all with Primetals Technologies)

21 MONTHS FROM CONTRACT TO COIL

THE NEW COUPLED PICKLING LINE AND TANDEM COLD-ROLLING MILL AT TANGSHAN STEEL

In April 2013, a contract for the supply of a cold-mill complex in Tangshan was signed between Primetals Technologies Austria and Tangshan Iron and Steel Group Co., Ltd. (Tangshan Steel) – a member of the HBIS Group, China’s largest steel producer. The clear target for the new mill was to produce highest-quality cold-rolled coils for the automotive industry in the shortest time possible. This ambitious undertaking was met with flying colors: the first coil was produced on January 15, 2015 (Figure 1), just 21 months after contract signing.

FIG. 1: First cold-rolled coil produced at Tangshan Steel on January 15, 2015





CONTRACT SIGNATURE

APRIL 14, 2013

**CONSTRUCTION**

NOVEMBER 2013

**SHOP TESTING**

MARCH 2014

INSTALLATION

SEPTEMBER 2014



FIG. 2: Project timeline from contract signature to preliminary acceptance certificate. Photographs from left to right: construction activities in the cold mill complex area; side trimmer workshop testing; installation of the cold-rolling tandem mill; the completed cold mill; outstanding cold-rolled coil ready for the market

Highest-quality steel coils are increasingly in demand by China's automotive industry. To meet this trend, Tangshan Steel launched a project to extend its existing cold-rolling and strip-processing facilities with the new Cold-rolling Complex No. 2. The project comprised a coupled pickling line and tandem cold-rolling mill (PLTCM) with a rated capacity of 1.6 million t/a, a continuous galvanizing line capable of processing 440,000 t/a, and a continuous annealing line for the treatment of 750,000 t/a of steel. The cold mill complex also includes a new roll shop and an acid-recovery plant for the pickling of more than 2 million tons of steel strip per year.

Hot coils at the entry of the PLTCM range in width from 700 mm to 1,620 mm with a thickness of 1.5 mm to 6.0 mm. The galvanizing and annealing lines accept strip with widths from 700 mm to 1,600 mm and thicknesses from 0.2 mm to 2.5 mm. The cold-rolling mill was designed and built in a 5-stand, 6-high configuration and features the SmartCrown intermediate roll-shifting

system for flatness control. Work-roll and intermediate-roll bending complement the flatness actuator systems on all mill stands. Stand No. 5 is additionally equipped with a multi-zone cooling system. In order to cope with the upper level of advanced high-strength steels, each mill stand is capable of exerting a total rolling force of 35,000 kN. The total installed mill stand power is 32,000 kW. At the mill exit a carousel tension reel is mounted below the strip passline. With this arrangement, finished strip can be inspected in the inline inspection station on the basis of inspection samples cut by a rotary shear downstream of Stand No. 5.

FAST DELIVERY, PLANT START-UP, COMMISSIONING AND RAMP-UP

A remarkable aspect of this project was the extremely short execution period of only 21 months from the contract signing to the first coil (Figure 2). A smooth transition from the pre-project to the project phase and a strong focus on an optimized supply and engineering

Product mix

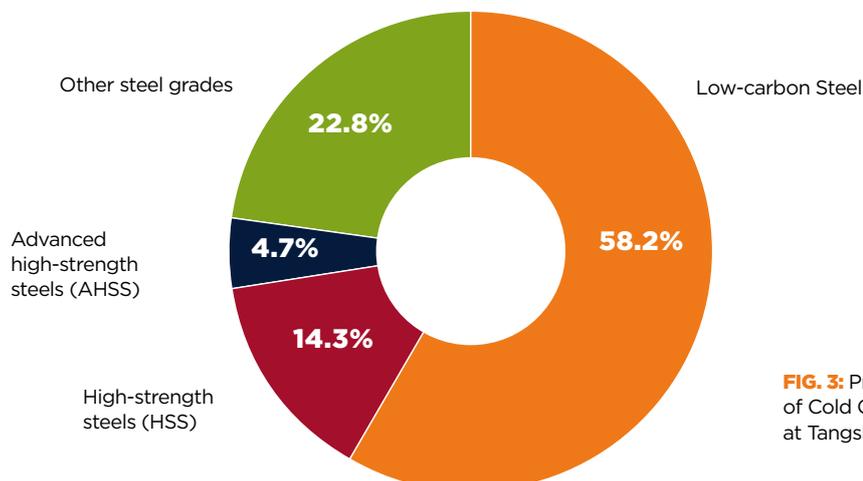
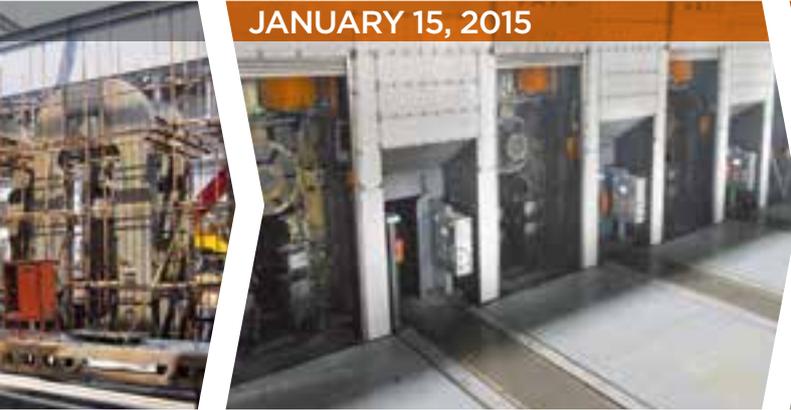


FIG. 3: Product mix of Cold Complex No. 2 at Tangshan Steel

FIRST COIL**JANUARY 15, 2015****COLD MILL RAMP-UP****PRELIMINARY ACCEPTANCE CERTIFICATE****SEPTEMBER 2015**

concept with a large share of local manufacturing were decisive for this achievement. Primetals Technologies China held sole responsibility for Chinese equipment supply, which further expedited project progress. Minimum transportation times were achieved, which was crucial for starting construction activities on schedule. Moreover, thanks to intensive design discussions with the customer right from the beginning of the project, key topics could be thoroughly addressed at an early stage. An additional success factor was that the Primetals Technologies China office was deeply involved in all phases of the project - from engineering and manufacturing up to plant start-up and commissioning. The close cooperation between engineers from Tangshan Steel and Primetals Technologies also ensured that Chinese manufacturing standards were implemented from the beginning, so no drawings had to be converted.

In order to guarantee high equipment manufacturing quality, supervision was jointly performed by the Chinese and European teams of Primetals Technologies with customer participation during final inspection. To fulfill the high demands with respect to the automation system, the advanced electrics and automation solution was comprehensively pretested during integration tests at the Primetals Technologies office in Erlangen, Germany, again with participation of the Tangshan Steel project team. Supervision of the erection companies was carried out by Tangshan Steel to ensure strict adherence to the challenging time schedule.

The well-coordinated final erection stage enabled an efficient transition to the cold commissioning phase. All of the above factors were decisive for the rolling of the first coil on January 15, 2015, which was of sellable quality. After production of the first coil, commissioning was carried out at a high pace by Tangshan Steel and Primetals Technologies. Production ramp-up of the mill to nominal capacity quickly followed. Output rates of 300 t/h and higher were achieved as early as 14 days

after the first coil was rolled. Just six months later, more than 13,000 coils were sold on the market. Following the successful completion of the performance tests, the preliminary acceptance certificate (PAC) was signed in September 2015.

OUTSTANDING PRODUCTS

Ever since the start-up of the new Cold-rolling Complex No. 2, a strong focus has been placed on extending the product mix in order to meet market demands. Besides high-quality commercial grades, soft interstitial-free (IF) grades and advanced high-strength steels (AHSS) are included in the weekly production schedules. In this context, the continuous optimization of product-quality parameters is a key focus of Tangshan Steel's engineers and operators together with Primetals Technologies. Specific attention is also placed on rolling thin-gauge material. So far, products with an exit thickness of 0.2 mm have been rolled successfully. However, the declared goal is to roll product gauges of 0.18 mm, which is below the designed minimum strip thickness for the cold-rolling mill.

WITH AN EYE TO THE FUTURE

Completion of the Tangshan Steel cold mill complex has set a company milestone for the production of automotive steel grades. With an eye to the future, Tangshan Steel intends to further extend and diversify its product range in order to enter additional markets for special steel grades (Figure 3). Technicians from Primetals Technologies therefore investigated and implemented the required upstream plant solutions to enable this product mix extension. Currently, an extended know-how package is being provided to Tangshan Steel, which will allow the company to expand its scope of products and to optimize overall production. ●

Roland Kellermayr, Sales Manager, Cold Rolling

Dr. Christian Westermayer, Technology and Innovation, Hot & Cold Rolling

(both with Primetals Technologies Austria)

READY FOR TOMORROW'S MARKET

THE NEW PICKLING LINE TANDEM COLD MILL FOR AUTOMOTIVE STEEL PRODUCTION AT VAMA

In 2014, Primetals Technologies supplied a coupled pickling line and tandem cold-rolling mill (PLTCM) facility to automotive steel producer Valin ArcelorMittal Automotive Steel Co., Ltd. (VAMA) in China. The mill is part of a new cold-rolling complex erected in the city of Loudi in the Chinese province of Hunan. Primetals Technologies was responsible for equipment supply, supervision of erection and start-up activities. Today, the mill is operating according to design specifications and a wide range of advanced steel grades are produced within the required gauge and flatness tolerances.



The complete mechanical and electrical equipment for the PLTCM was engineered and supplied by Primetals Technologies, including auxiliary equipment such as the hydraulic, pneumatic and safety systems. The line features an advanced automation system comprising basic (Level 1) automation, process optimization (Level 2) as well as special process and technology models. These systems serve as the basis for stable production operations, maximum plant availability, high product yield and excellent product quality across the entire product mix. A notable aspect of the project is that the cold and hot test runs could be performed after a project time of only 21 months, which was followed by the successful rolling of the first coil on June 3, 2014, only 24 months after the contract was signed.

FEATURES OF THE PICKLING LINE

For the initial project stage, the new PLTCM was designed for an annual production capacity of 1.5 million tons of steel strip. The line receives incoming hot-rolled strip with widths from 900 mm to 1,890 mm at thicknesses from 1.8 mm to 6.0 mm. The strip is continuously fed from a single payoff reel in the entry section to the pickling line that comprises a scale breaker and three catenary-type pickling tanks (Figure 1) where the acid and iron concentrations are automatically controlled by the Faplac pickling process model. After pickling, the strip edges are trimmed in a turret-type side trimmer.



4-stand, 6-high tandem cold-rolling mill, VAMA, China

Today, the mill is operating according to design specifications and a wide range of advanced steel grades are produced within the required gauge and flatness tolerances.

FEATURES OF THE TANDEM COLD-ROLLING MILL

The cold mill currently has four 6-high mill stands. Two independent circuits supply rolling emulsion, with one dedicated to Mill Stands Nos. 1 to 3, and the other to Mill Stand No. 4. Stands Nos. 1 and 2 are additionally equipped with a direct-application system to enable flexible lubrication (depending on the steel grade) with a higher concentrated emulsion for the rolling of challenging products such as advanced high-strength steels (AHSS). The strip is then coiled on one of the two reels of a carousel coiler. For surface-quality examination, both an inline inspection station and an offline inspection line are available. The mill was designed so that it can be extended in a second phase to enable the production of 2 million t/a by adding a second payoff reel, a fourth pickling tank and a fifth mill stand. »



FIG. 1: Overview of the pickling line

The mill stands have an installed power of 7,000 kW each and an installed maximum roll force of 35,000 kN to roll high-strength steels within narrow thickness tolerances. The flatness-control system, consisting of SmartCrown rolls, special actuators and control features, provides highest accuracy to meet the guaranteed flatness tolerances of the final products.

SMARTCROWN ACTUATOR

The excellent flatness results can be attributed to the patented SmartCrown flatness-control system that is highlighted by a special roll contour geometry for the intermediate and backup rolls. The system offers significant advantages in terms of profile and higher-order shape control. The roll-contour coefficients are chosen in such a way that for any roll-shifting position, the resulting unloaded roll-gap profile is always cosine-shaped. Lateral shifting of the bottle-shaped intermediate rolls allows a continuous, gradual adjustment of the roll-gap profile to be achieved. In addition to roll shifting

The excellent flatness results can be attributed to the patented SmartCrown flatness-control system that is highlighted by a special roll contour geometry for the intermediate and backup rolls.

With its new PLTCM, VAMA is well prepared to thrive and profit in a challenging market environment.

VAMA AT A GLANCE

Valin ArcelorMittal Automotive Co., Ltd. (VAMA), founded in September 2010, is a joint venture company of ArcelorMittal, the Chinese Valin Iron & Steel Group Co., Ltd. and the automotive industry in the Chinese province of Hunan. The new complex in Loudi, Hunan province, is dedicated to serving the growing demand for high-strength steel from Chinese automotive suppliers, in particular for local car-manufacturing projects.

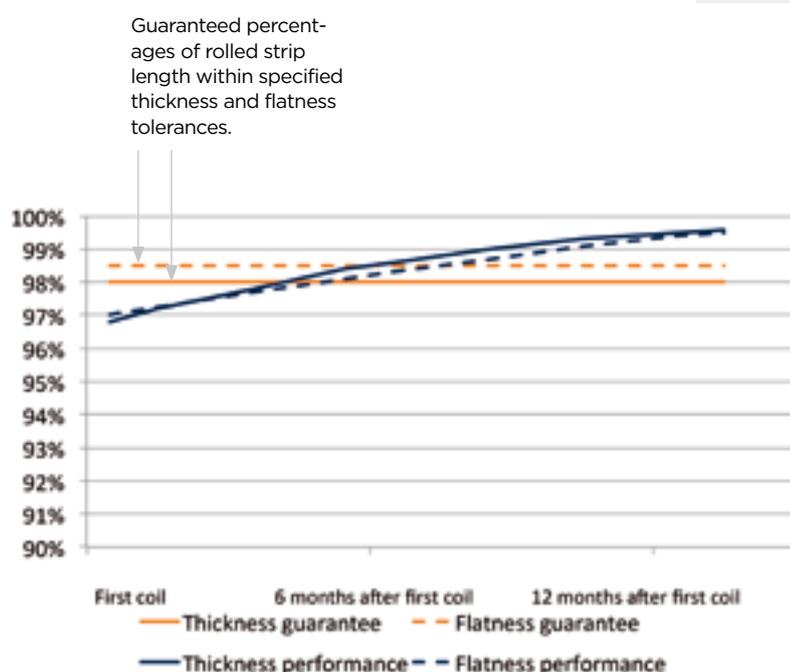


FIG. 2: Strip thickness and flatness performance following mill start-up

and bending, multi-zone cooling in the final mill stand serves as an additional powerful actuator to correct any remaining shape defects of all orders.

PRODUCTION TARGETS MET

A wide range of steels can be processed in the line to satisfy changing market demands. These include mild, high-strength (tensile strengths of up to 1,200 N/mm²), low-alloyed, interstitial-free (IF), dual-phase (DP), transformation-induced plasticity (TRIP) and bake-hardening (BH) grades. All of the originally foreseen steel products, including high-strength steels, have already been rolled within the required gauge and flatness tolerances. Currently, the VAMA rolling facility is in the qualifying phase to allow the company to supply these products to the local automotive industry.

In the early stages of the PLTCM start-up, it was already possible to attain excellent thickness and flatness performance results. Since the first coil was rolled, more than

99% of the total rolled strip length was produced within the contractual thickness tolerance of 0.5% of the nominal exit gauge. The flatness tolerance of 5 I-units was reached for over 99% of the total rolled length. Both parameters refer to the coil body length, for which an average total off-gauge length of only 3 m were achieved for each coil (Figure 2).

READY FOR TOMORROW'S MARKET

The demand for new steel grades with excellent forming properties in conjunction with the production of high-strength steels for automotive applications has significantly grown during the past years. This trend is expected to continue, which means that these steel grades will command an ever-increasing portion of a typical cold mill product mix. With its new PLTCM, VAMA is ready for tomorrow's market. ●

Dr. Martin Bergmann, Technology and Innovation, Hot & Cold Rolling (Primetals Technologies Austria)

REMARKABLE TECHNOLOGY

REMARKABLE RESULTS

THE WORLD'S FIRST 6-STAND TANDEM COLD-ROLLING MILL SUCCESSFULLY COMMISSIONED AT HYUNDAI STEEL

The need to roll increasingly high-strength steel strip with ever-increasing tensile and yield strengths has led to the world's first 6-stand 6-high tandem cold-rolling mill at Hyundai Steel in South Korea. Completed within only 23 months, the project features an advanced Universal Crown Control Mill that is linked to an innovative pickling line for outstanding product results.

Hyundai Steel operates an advanced continuous pickling line and linked tandem cold-rolling mill (PLTCM) that was supplied by Primetals Technologies to process high-strength automotive steels. Features of this line include iBox (immersed box) pickling tanks and a tandem cold mill with six 6-high Universal Crown Control Mill (UCM) mill stands (Figure 1). Starting with a strip entry thickness of 1.5 mm to 5.0 mm at strip widths between 800 mm and 1,650 mm, the 6-stand mill is designed to roll high-strength automotive and other steel grades to finishing gauges between 0.30 mm and 2.3 mm. During commissioning, automotive steels with strengths of 1,180 MPa were successfully rolled to a thickness of 0.8 mm. UCM mill technology, combined with high-response hydraulic gauge control (HYROP-F), is applied to ensure precise strip gauge and flatness control.

The new line is the third PLTCM installed at Hyundai Steel (Primetals Technologies installed two of the three existing lines). It is capable of producing 1.8 million tons of high-quality cold-rolled strip for the automotive and construction industries. Figure 2 depicts the layout of the PLTCM.

iBOX PICKLING TANK

The mill entry side is linked to a pickle line that employs iBox tanks from Primetals Technologies. iBox pickling technology is characterized by its superb descaling efficiency with acid turbulence, energy savings and low maintenance requirements. This unique pickling solution does not require continuous acid circulation using pumps – as is the case with other circulation-type tanks – and steam consumption is decreased thanks to specially designed tank covers (Figure 3).

Hyundai Steel produces mostly high-strength steels with high silicon contents. iBox pickling tanks were supplied to avoid the problems that arise in connection with silicon sludge clogging in conventional tanks. Normally, since the external heat exchangers of conventional circulation-type pickling tanks have small holes on the process side, they tend to get clogged with silicon sludge, which disturbs pickling operations. With iBox technology, the heat exchangers are installed along the sidewalls of the pickling tanks, which considerably facilitates tank access and maintenance (Figure 4). The accumulation of silicon



FIG. 1: Hyundai Steel's new 6-stand tandem cold-rolling mill with Universal Crown Control on all mill stands

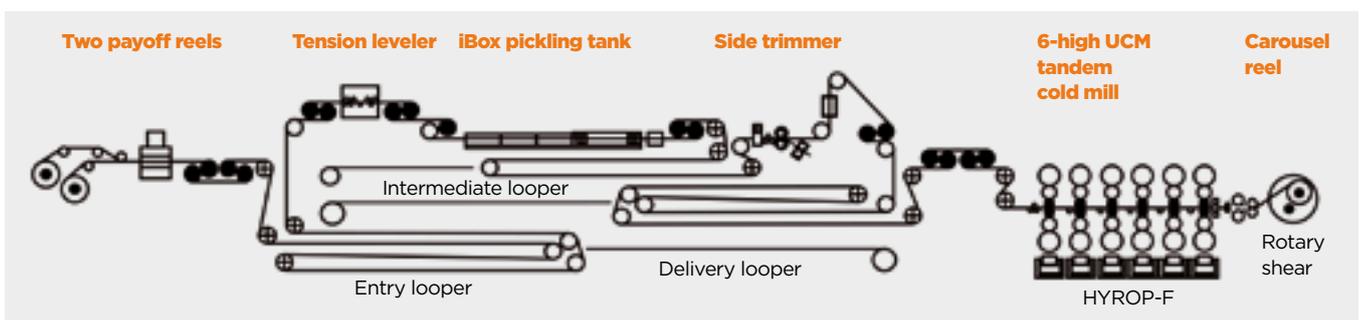


FIG. 2: Configuration of the most recently installed PLTCM at Hyundai Steel

sludge in the pickling tank does not affect line production, and the heat exchangers can be removed for easy maintenance and cleanup work.

UNIVERSAL CROWN CONTROL MILL

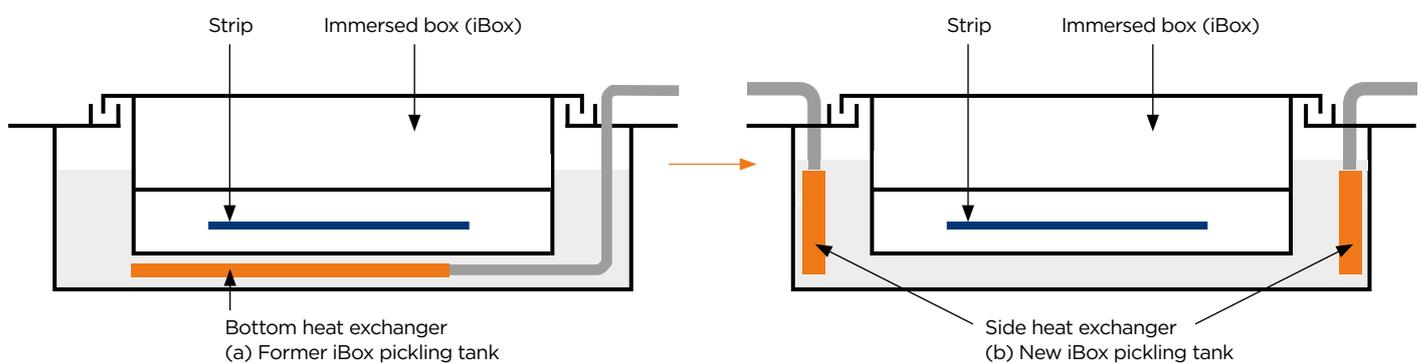
To meet the expected market trend calling for harder high-strength steels, Hyundai Steel decided to build the new PLTCM with six 6-high mill stands. UCM mill technology

was selected because of its proven benefits and superiority in rolling advanced steel grades. Depending on the strip width, the intermediate roll is shifted axially in the roll direction to prevent undesirable contact between the work and backup rolls. The UCM mill solution results in a major improvement in strip-shape-control performance and self-stabilization of the strip shape. The mill stand is also equipped with work-roll and »



FIG 3: iBox pickling tank

FIG. 4: Improved iBox design with side-mounted heat exchangers



intermediate-roll bending functions to further enhance strip-shape control during flying gauge changes or width changes. Another decisive benefit that results from the novel roll arrangement of a UCM mill is that it is possible to use smaller-diameter and straight work rolls (without an initial crown) for the rolling of all steel grades. Improved strip flatness during strip-shape changes employing a UCM mill with straight work rolls minimizes cobbles, associated roll damage and strip breakage. Strip passing to the tension reel after the shear cut is also stabilized. The use of smaller-diameter work rolls means that greater strip-thickness reductions can be achieved during each mill-stand pass. Depending on the product mix and targeted finished-strip dimensions, in some cases it is even possible to reduce the number of required mill stands by one for significant investment cost savings. Changing the work and intermediate rolls is possible without removing the strip from the mill. This feature plays an

important part toward enhancing production efficiency. The roll-change system is fully automated to decrease roll-change downtime.

The function principle of a UCM mill is depicted in Figure 5. Additional features and advantages of UCM mills and the latest mill development – the Hyper UCM – are described in the next article.

HYDRAULIC ROLL POSITIONING DEVICE

Gauge accuracy depends largely on the performance of the roll-positioning device. The Hydraulic Roll Positioning Device (HYROP-F) was first introduced by Primetals Technologies and has been installed in more than 600 stands throughout the world. It consists of hydraulic cylinders, a force motor valve (FMV), a high-response, directly operated servo valve and a position detector that is accurate to one micron. The accuracy of automatic

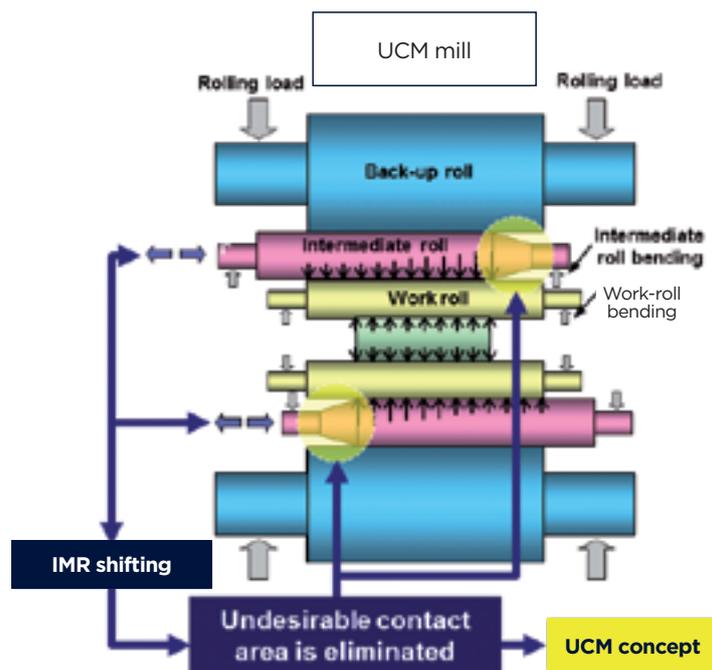


FIG. 5: Function principle of a UCM mill stand

ADVANTAGES OF THE UCM MILL ROLL ARRANGEMENT

- Work-roll deflection is reduced
- Straight work rolls can be applied
- Strip crown and edge profile is reduced
- Work-roll inventory can be greatly reduced
- Use of smaller-diameter work rolls is possible
- Work- and intermediate-roll bending is effective

Within a period of just over 6 months, productivity of the new PLTCM already exceeded 100% with good strip shape and gauge results.

gauge control has dramatically improved using HYROP-F. The length of off-gauge strip is notably reduced and overall yield is increased.

MILL EXIT AREA, COIL-HANDLING SYSTEM AND INSPECTION AREA

At the mill exit, a drum-type high-speed rotary shear, a belt wrapper and a carousel-type tension reel are installed. Compared to a two-tension reel arrangement, the carousel-type reel has only one winding position close to the last stand, which allows high-speed and safe winding on the reel. Cold-rolled strip can be wound continuously without any stoppage for coil switchover. The coil-handling system is comprised of a delivery coil car and a walking beam that is complemented with a shuttle car to reduce transport time to the inspection station. The newly designed inspection station facilitates careful inspection of both sides of the strip.

IMPRESSIVE PROJECT COMMISSIONING

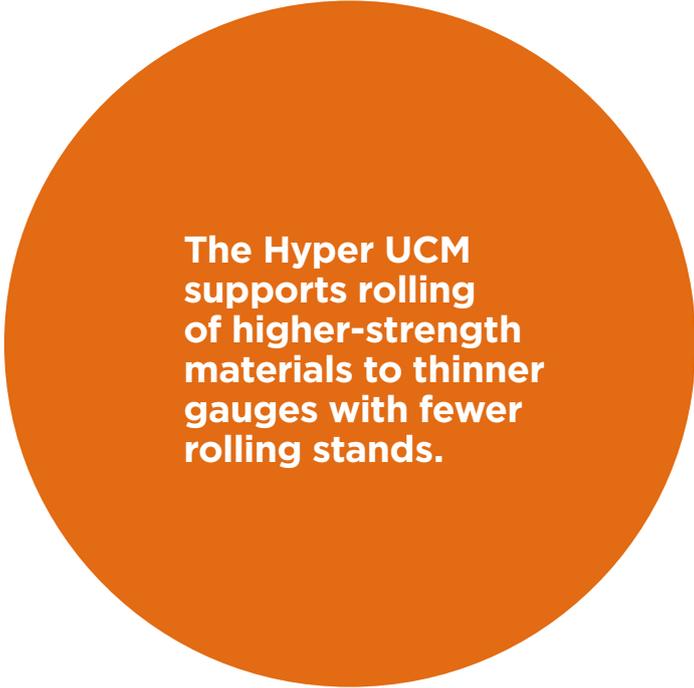
The time from order placement in June 2011 to the scheduled mill start-up (hot run) in 2013 was only 23 months. Within a period of just over 6 months, productivity of the new PLTCM already exceeded 100% with good strip shape and gauge results. This success can be attributed to the use of advanced yet proven technology, dedication to rolling excellence, and the outstanding cooperation between the project teams of Hyundai Steel and Primetals Technologies. ●

Akihiro Yamamoto, Senior Engineer, Cold Rolling Project Division, Project Management Department

Kosei Tsuji, Senior Engineer, Process Line Project Division, Project Management Department (both with Primetals Technologies Japan)

NEXT-GENERATION ROLLING MILL STAND

FEATURES AND BENEFITS OF THE NEW HYPER UNIVERSAL CROWN-CONTROL MILL FOR HIGHER REDUCTIONS IN COLD ROLLING



**The Hyper UCM
supports rolling
of higher-strength
materials to thinner
gauges with fewer
rolling stands.**

Primetals Technologies has developed a new Universal Crown-Control Mill (Hyper UCM) that features work rolls with diameters that are 20% to 40% smaller than those used in conventional UCM mills. This allows greater thickness reductions to be achieved in the cold-rolling process, which is particularly important for the rolling of advanced high-strength steels. The applicability of smaller-diameter work rolls was made possible by the development of spindles with smaller diameters and higher torque to drive the work rolls. As a result, it has become possible to achieve targeted strip gauges with one less mill stand in a tandem cold mill, which means investment and maintenance cost savings.



First installed Hyper UCM in operation in a reversing cold mill at Maanshan Steel, China

Demand for high-strength steels (HSS) is continually growing in the automotive industry.

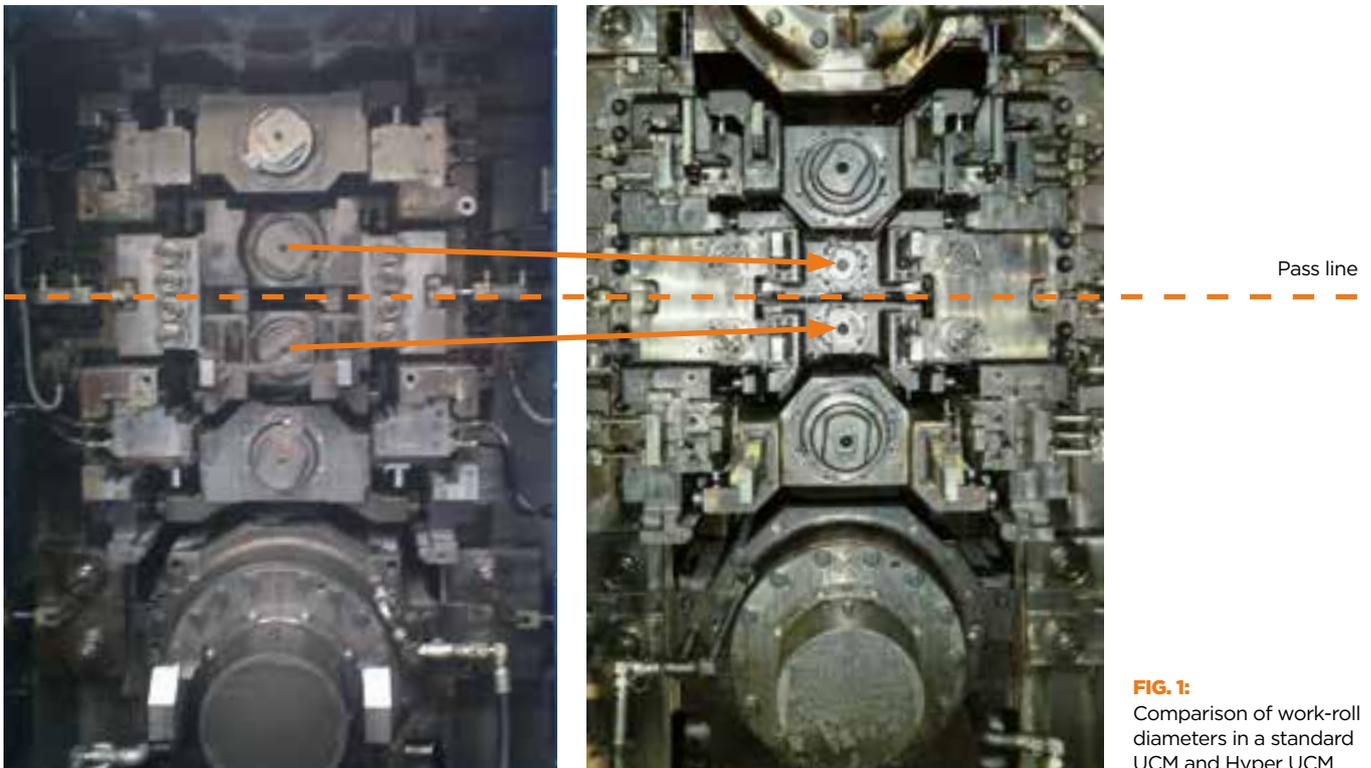


FIG. 1: Comparison of work-roll diameters in a standard UCM and Hyper UCM

Demand for high-strength steels (HSS) is continually growing in the automotive industry. Fuel economy is improved using thinner-gauge material, and vehicle crashworthiness and passenger safety can be increased. At the same time, orders are on the rise for high-quality electrical steel sheets needed for highly efficient motors to meet ever-stricter emission regulations.

HSS is normally rolled in tandem cold mills (TCMs) that employ 4-high or 6-high rolling stands with work-roll diameters ranging from 630 mm to 420 mm. HSS exceeding 980 MPa has been manufactured by extending TCMs with the installation of an additional mill stand. However, the demand for steels with up to 1,500 MPa makes it almost impossible to produce advanced high-strength steels (AHSS) simply by increasing the number

of stands. Smaller-diameter work rolls that reduce the rolling load are required to solve the problem.

High-quality electrical steel sheet is usually manufactured in reversing cluster mills (ZR mills). However, trials are being conducted to roll electrical steels in the TCM for higher productivity. In order to enable the use of smaller-diameter work rolls in a TCM, Primetals Technologies carried out a study that compared reduction ratio with work-roll diameter, shape-control capability and hertz stress between the rolls in a tandem mill.

CONVENTIONAL UCM

Small-diameter work rolls deflect primarily as a result of the contact with the backup rolls in the roll portion outside the width of the strip. This causes work-roll

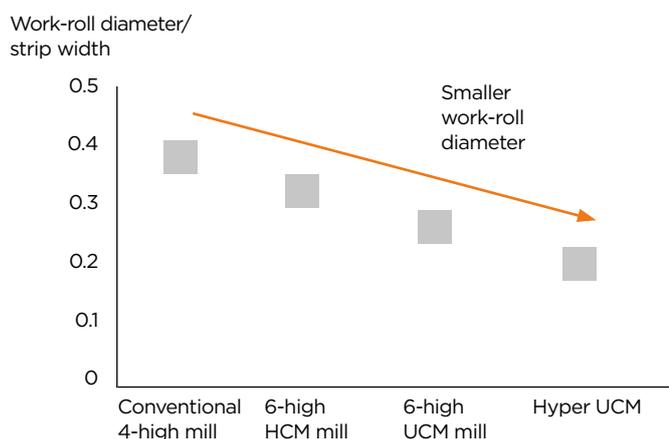


FIG. 2: Comparison of work-roll diameters in a conventional 4-high mill, High Crown Control Mill (HCM), Universal Crown Control Mill (UCM) and Hyper UCM



FIG. 3: New high-torque spindle for Hyper UCM

deflection that makes it difficult to roll strip with the necessary flatness. In a conventional 1,828-mm-wide (72 inch) 4-high mill, the ratio of the work-roll diameter to the maximum strip width has remained at around 0.33. In the 6-high UCM, this ratio has been reduced to around 0.25 by adding shifting intermediate rolls that are moved in the direction of the roll axis in accordance with the strip width. This suppresses work-roll deflection beyond the strip, and also makes it possible to maximize the effect of work-roll and intermediate-roll bending (see Figure 5 of the previous topic).

KEY FEATURES OF THE UCM MILL INCLUDE:

- All work rolls have the same straight crown, which reduces roll inventory
- A higher reduction ratio can be obtained using smaller-diameter work rolls
- A stable strip shape can be maintained under varying rolling loads
- Higher strip-shape control capability can be achieved
- Material yield can be improved as a result of reduced edge drop

HYPER UCM

If the ratio of the work-roll diameter to the maximum strip width is reduced to below 0.25 by using even smaller-diameter work rolls, a driven intermediate roll is necessary in a conventional UCM due to the insufficient strength of the smaller-diameter spindle that is required to drive the thinner work roll. An intermediate roll drive has two major disadvantages, namely 1) slip occurs between the work roll and intermediate roll, and 2) strip flatness deteriorates as a result of the horizontal deflection of the work rolls caused by the tangential driving force acting on them.

An investigation of the best combination of roll diameters revealed that the highest strip reduction can be achieved with work-roll diameters varying between 300 mm and 400 mm for UCM mills with a maximum strip width between approximately 1,500 mm and 1,900 mm. Thus, the work-roll diameter/max. strip-width ratio for a 1,828-mm-wide (72 inch) UCM mill is in the range of 0.16 to 0.21,

which means a 20% to 40% decrease in the work-roll diameter (Figures 1 and 2).

A higher-strength spindle is therefore required due to its smaller diameter. The structure and material of the spindle was improved by optimizing the design to greatly amplify the spindle strength to allow up to 2.7 times more torque to be transmitted compared to the conventional universal joint-type spindle (Figure 3).

This new generation of UCMs is called the Hyper UCM. The work-roll diameter is 340 mm compared to 475 mm in a conventional UCM. When the standard UCM mill with five stands is considered, and if the rolling load is limited to the allowable values from the No. 1 stand onwards, the rolling load at the No. 5 stand will eventually exceed the maximum limit value. This leads to unsuccessful strip rolling to the desired thickness and necessitates the installation of a sixth mill stand to keep the rolling load within limit values. In comparison, the Hyper UCM enables rolling to the desired thickness values using five stands while remaining within the limit rolling load.

A BRIGHT FUTURE AHEAD

In summary, the Hyper UCM supports the rolling of higher-strength materials to thinner gauges with fewer rolling stands. This means reduced investment and maintenance costs for tandem cold mills. In reversing mills, productivity can be improved by reducing the number of necessary rolling passes to achieve the desired final strip thickness.

The first Hyper UCM was successfully installed and started up in a single-stand reversing cold mill at Maanshan Iron and Steel Co. Ltd. (Maanshan Steel) in 2013. Silicon steel grades are rolled to product thicknesses between 0.35 mm and 0.65 mm at strip widths between 800 mm and 1,280 mm. ●

Hajime Higuchi, Manager, Primetals Technologies Japan

Shinichi Yasunari, General Manager, Primetals Technologies Japan

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



CROSS SEAM WELDER (CSW)

The CSW pilot plant is installed in a continuous cold-rolling verification facility of Primetals Technologies, Hiroshima, Japan

HIGHER YIELD **HIGHER PROFIT**

INTRODUCTION OF THE CROSS SEAM WELDER AND AN INNOVATIVE COLD-ROLLING TECHNIQUE

Each year, thousands of tons of perfectly good steel are scrapped at reversing cold-rolling mills. A new welding solution, referred to as the Cross Seam Welder (CSW), together with an innovative rolling technique, reduces scrap and can increase mill yield by more than 6%. The first orders for the CSW were received from JFE Steel Corporation in Japan.

The Cross Seam Welder (CSW), together with an innovative rolling technique, reduces scrap and can increase mill yield by more than 6%.

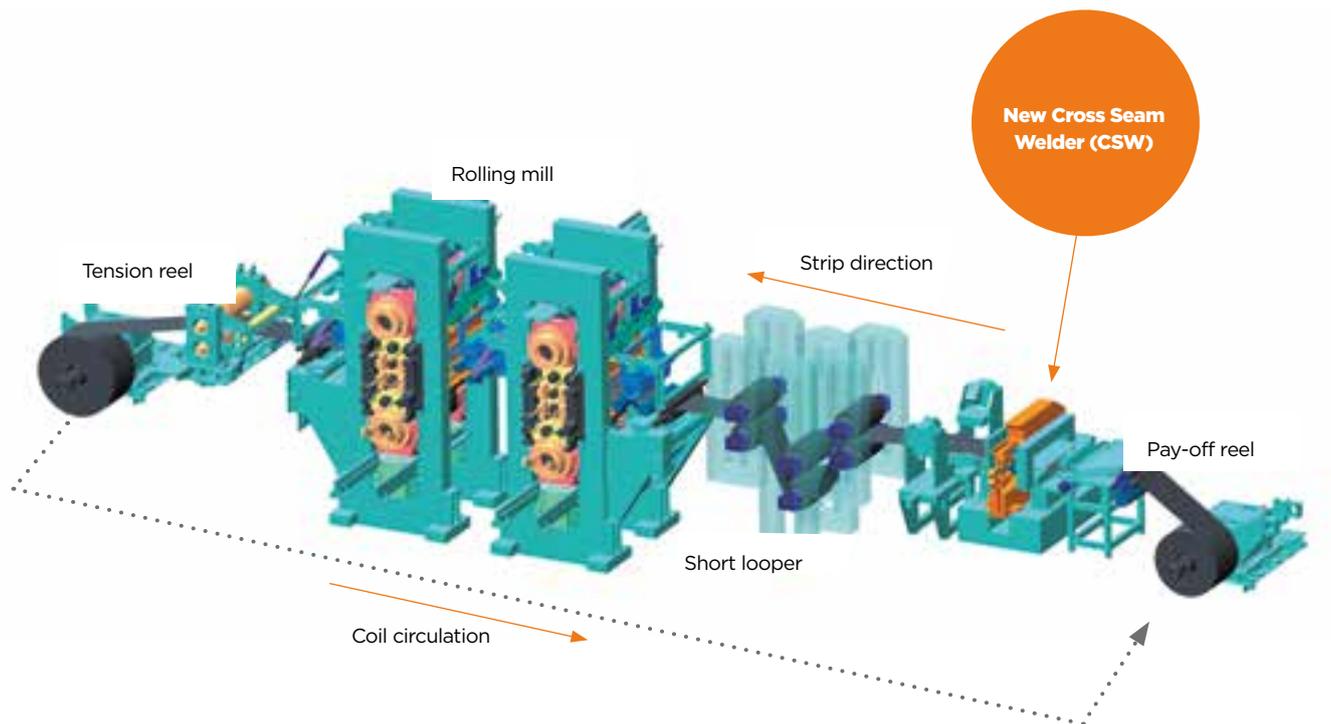


FIG. 1: Principle of continuous one-way rolling

Cold-rolling mills for the steel industry with production capacities of 600,000 t/a to 800,000 t/a typically employ a 2-stand reversing cold mill (2RCM) or two single-stand reversing cold mills (RCMs). Mills of this type continue rolling until the final pass with the leading and tail ends of the strip coiled on reels. Unrolled strip portions at both strip ends are scrapped. The quantity of scrap generated in a 2RCM typically accounts for about 6.5% of the overall production volume, and in a twin-stand RCM the scrap rate is around 2.5%.

To improve the overall strip-rolling yield in cold-reversing mills, engineers at Primetals Technologies have developed a new cold-rolling system in which continuous one-way rolling is performed. After each pass, the rolled coil is returned to the payoff position for the next pass until the prescribed strip thickness is obtained (Figure 1). This

system can reduce the scrap amount to just 0.3%, which means a yield increase of more than 6% in a 2RCM. The main features of continuous one-way rolling are coil circulation, coil build-up, super-low-speed rolling and the new Cross Seam Welder (CSW) that is capable of joining strip up to 6.5 mm thick.

CSW WELDER DESCRIPTION

The CSW welder is similar to a conventional mash seam welder (MSW), namely that it also employs electric resistance welding. Figure 2 illustrates the CSW welding principle. With this welding method, the tail edge of the preceding coil and the leading edge of the following coil – both held by clamps – are simultaneously cut by a double-cut shear (not shown) and the cut ends are overlapped (View A of Figure 2). The lap is pressed and energized by the electrode wheel, and the heat gener- ➤

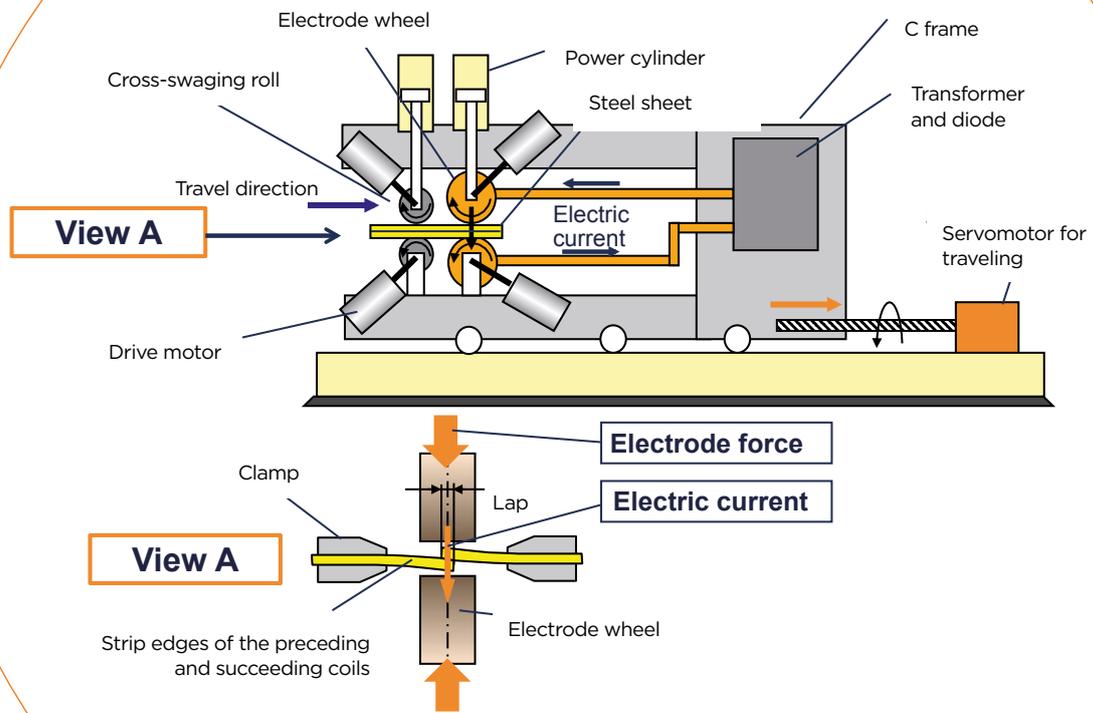
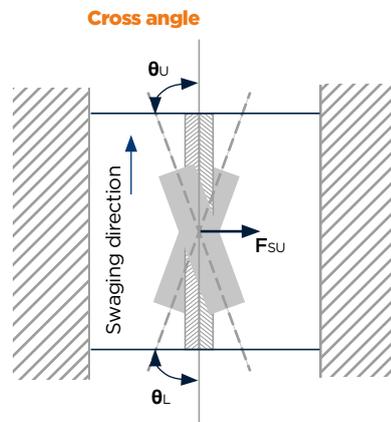
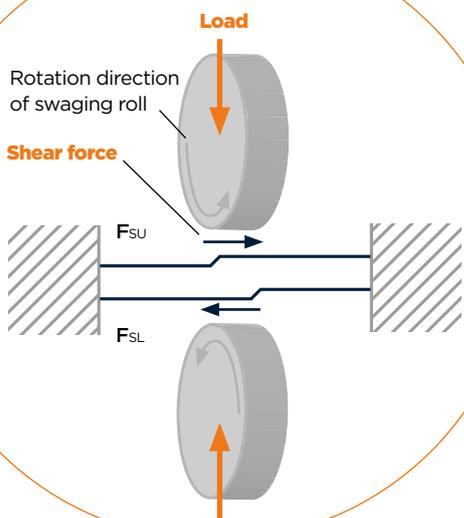


FIG. 2: Principle of the Cross Seam Welder



FIGS. 3A AND 3B: Principle of cross swaging of strip weld

ated by electrical resistance welds the lap together. The welder moves across the strip width and performs welding as it travels.

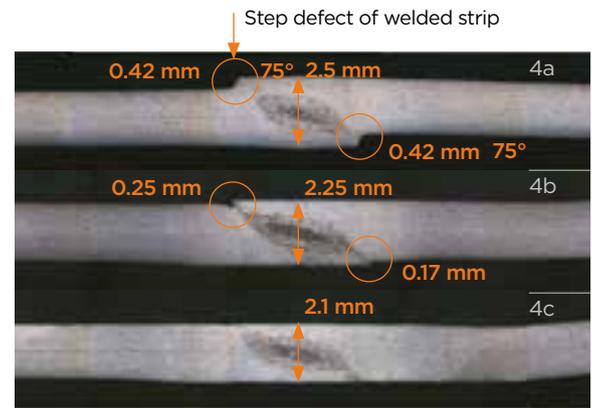
Compared to the CSW, the conventional mash seam welder has two principle weaknesses: one is a limited welding thickness of up to 4.5 mm, and the other is the step of the welded joint following welding. CSW has solved these problems by means of a so-called cross-swaging technique in addition to the application of a welding method that exerts a larger electrical current (Figures 3a and 3b). The latter softens the welded joint and makes it easier to deform the thicker part of the weld at high temperatures. Consequently, CSW is capable of welding strip with no step at all and is suitable for cold-rolling applications (Figures 4a to 4c). Thanks to the application of a larger electrical current, strip with thicknesses of up to approximately 6.5 mm can be welded (Figures 5a to 5c). Furthermore, because the CSW design is based to a large extent on the MSW, it additionally offers the benefits of low cost and compactness.

OTHER CSW APPLICATION POSSIBILITIES

In addition to its suitability for reversing cold-rolling mills, the CSW can also be used in pickling lines. Engineers at Primetals Technologies are further expanding the application possibilities of CSWs for welding applications in tandem cold-rolling mills. In conventional setups, the coils wound in the hot-rolling process are sent to the pickling line where scale is removed before cold rolling. The coils are joined by welders prior to the pickling process to enable continuous pickling. At many plants, flash butt welders are used and have often been in operation for decades. However, these welder systems are generally large and expensive, and are thus generally unsuitable for use in small and medium-sized mills. Another disadvantage is that a flash butt welder cannot weld high-tensile-strength steels (HSS) and other advanced steel grades – for which market demand is steadily increasing. Therefore, it is only a matter of time before flash butt welders will have to be replaced in existing pickling and cold-rolling lines. If ongoing tests at Primetals Technologies to weld HSS and special steel grades turn out to be successful, the new CSW may indeed prove to be a future-oriented welder alternative for steel producers.

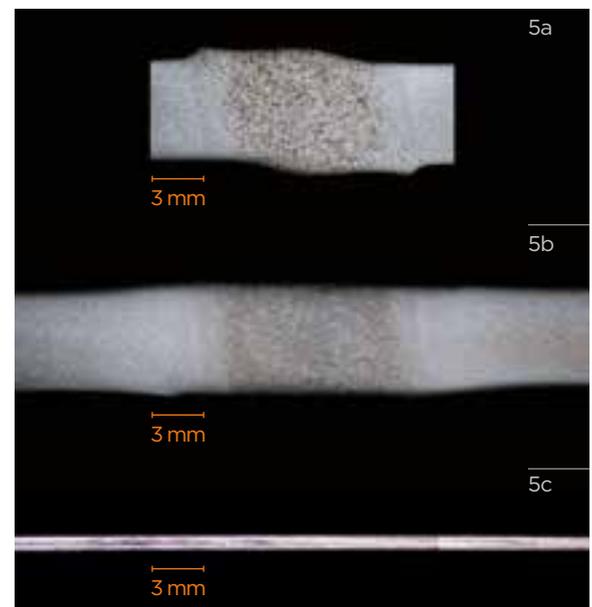
CSW ADVANTAGES AND FIRST INDUSTRIAL INSTALLATION

The new Cross Seam Welder from Primetals Technologies offers producers the possibility to replace flash butt welders and laser beam welders used in pickling lines and tandem cold mills with substantial investment cost savings. In addition to its capability to weld thicker strip (up to 6.5 mm), the CSW also has the potential to weld a broad range of steel grades. In reversing cold-rolling mills, the combination of a newly developed continuous rolling process and the CSW will allow plant owners to profit from the thousands of tons of steel that don't have to be scrapped.



FIGS. 4A TO 4C: Effects of cross swaging on a 2-mm-thick strip weld

4a: Macrostructure of cross section of as-welded strip
 4b: Results of 0-degree axial rotation of swaging rolls in relationship to each other immediately after the weld
 4c: Results of 3-degree axial rotation of swaging rolls in relationship to each other immediately after the weld



FIGS. 5A TO 5C: Results of rolling 6.0-mm-thick strip with cross-swaged weld to final strip thickness of 1.0 mm

5a: Macrostructure of cross section of as-welded strip
 5b: Macrostructure of strip cross section with cross-swaged weld
 5c: Welded and cross-swaged strip rolled to thickness of 1.0 mm

The first order for the CSW was received from West Japan Works Kurashiki of JFE Steel Corporation, where it was installed in the No. 1 Continuous Pickling Line. Commercial operation commenced in April 2015. The second CSW order was from East Japan Works Chiba of JFE Steel where it will be used in the No. 5 Continuous Pickling Line following the scheduled start-up in April 2016. ●

Noriaki Tominaga, General Manager, Technical Development Department
Hisayoshi Ishii, Manager, Equipment Design Department
 (both with Primetals Technologies Japan)

IS THIS YOUR PRODUCT?

SOLUTIONS FOR IMPROVED SURFACES IN ALUMINUM HOT-ROLLING MILLS

Demands placed on aluminum plate and strip are continually increasing, particularly for product surfaces free of scratches and stains. Primetals Technologies offers practical and innovative solutions to deal with typical problems arising in aluminum hot-rolling mills that can lead to less-than-ideal surfaces.

Starting with a thick-cast and scalped slab, aluminum is hot rolled at temperatures between 550°C and 300°C on a single-stand hot-roughing mill or plate mill to produce long transfer bars that are subsequently processed to coil products and cut plates. Roller tables on either side of the hot mill are used to support the product, ideally without damaging, scratching or staining its bottom surface at any time during the hot-rolling process. Generally, the aluminum slabs are supported at the edges only by solid table rolls with double or compound tapers, or tubular rolls with double tapers or inclined cylindrical rolls. Figure 1 illustrates the principle behind this approach. The taper angle is normally between 1.30° and 3.60°, depending on the final product thickness, width and strength at elevated temperatures. For plate products, smaller angles have historically been used to minimize the difference in the peripheral speed along the roll barrel of the solid rolls, as the thinnest or widest plates rolled could not support their own weight anyway. For strip products, any bottom surface markings result in the material being scrapped, and for that reason larger angles are typically used. However, the minimum transfer bar gauge is also limited – depending on its width – to ensure the product does not sag to such an extent that it makes contact with the roll surface either in the center or in-board of the edges (Figure 2).

REDUCING ROLL CONTACT BY APPLYING MODELING TECHNIQUES

In the framework of new installations and revamps, Primetals Technologies calculates the optimum taper angle for the product range to be rolled. However, the products rolled change during the lifetime of a rolling mill, and the original angle may not be sufficient for future product

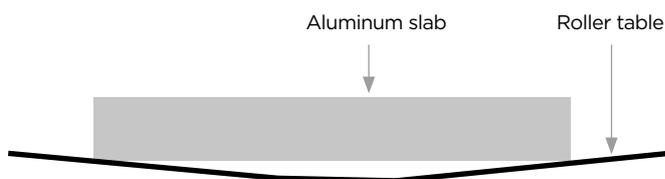


Fig. 1: Aluminum slabs are supported only at the edges to prevent surface damage, scratching or staining

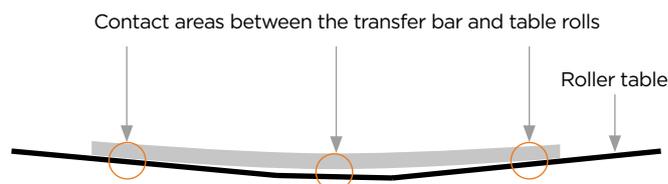


Fig. 2: Contact with the roll surface as a result of transfer bar sagging leads to surface markings

portfolios. The centering guide force also increases deflection, and the effect is also calculated on the basis of the set force and guide head length. The impact of the product head end on the roller table rolls also increases the risk that the bottom surface of the product might touch the rolls. Primetals Technologies applies finite element modeling to determine the effect of this impact, which of course is dependent on the turndown and incorporates a factor of safety (1.5 to 2) into the calculation, depending on speed. Also, due to the high temperatures relative to the melting temperature, material creep increases product sagging, especially at the end of long transfer bars. Further work is required on this creep effect, as currently only the factor of safety is used to reduce contact with rolls.



Close-up view of a scratched and stained aluminum surface

SOLUTIONS FOR AN OPTIMIZED ROLL-ASSEMBLY DESIGN

With consideration to the slab thickness, large-diameter solid rolls must be used close to the roughing or plate mill. These rolls have historically been manufactured from a single piece of forged metal, and for this reason large taper angles result in large differences in the roll peripheral speed. Further away from the roughing or plate mill, the product is thinner, and hence half-width inclined tubular rolls can be used with large taper angles with no difference in the roll peripheral speed.

Half-width cylindrical solid rolls for heavy-duty applications or tubular rolls for light-duty applications are clearly the best technical solution due to the constant peripheral speed at the roll surface. However, because of reliability issues, individually driven rolls are preferred over group-driven rolls powered by roller chains, toothed belts or gears. Primetals Technologies has developed a cost-effective solution where the half-width rolls are connected with a proprietary coupling that can accommodate the large taper angles and has only one drive motor unit per full-width roll assembly.

IMPLEMENTED SOLUTIONS FOR IMPROVED SURFACE QUALITY IN A CUSTOMER PLATE MILL

A recent plate mill reference from Primetals Technologies has solid, one-piece table rolls with low taper angles of 1 in 44 (1.30°), a minimum thickness of 6 mm and a maximum plate width of 3,800 mm. Plates that are around 10 mm thick and have a width of 1,700 mm or more will sag considerably, even at low temperatures of around 300°C. This results in undesirable contact with the roll surface.

Scratches from the variation in roll peripheral speed are minimized by using roll coolant lubrication sprays on all table rolls. However, the water in the residual coolant on the roll surface evaporates, leaving an oily residue on the roll surface that can cause black stains on the bottom surface, which is unacceptable for the end customer. To remove these black stains, the rolls are cleaned with hot (60°C) coolant, which dissolves the oily residue prior to the product passing over the table rolls. Primetals Technologies therefore made some detail changes to the table roll lubrication system:

1. Dedicated pumps with a continuous-loop supply line with lagging along the entire table length ensure that the coolant is hot, even at the ends of the tables.
2. Spray header pipes with no downward loops and automatic drain valves safeguard that hot coolant is sprayed out of the nozzles immediately.
3. Additional nozzles provide full coverage/cleaning of the whole roll barrel length and larger nozzles to avoid blockages.
4. Software changes to the control system ensure that the spray headers are drained and then activated prior to the plate passing over each table section.

INCREASED YIELD, ENHANCED QUALITY AND CUSTOMER SATISFACTION

The solutions described above contribute not only to improving the surface quality of aluminum plate and strip products, but also to increasing product yield. Producers benefit from scratch- and stain-free products that satisfy the strictest surface-criteria demands and that can command premium prices in the market. ●

Stuart Leflay, Technical Manager, Aluminum Rolling

FOR UNSURPASSED QUALITY

KALEIDOSCOPE OF SOLUTIONS FOR STRIP-PROCESSING LINES

Primetals Technologies has an outstanding reputation for high-performance and cost-efficient strip-processing lines that support operators to fully meet market demands for high-end products as required by the automotive industry, the construction sector and for white goods. The company's processing solutions include continuous or push-pull pickling lines, continuous galvanizing and other metallic coating lines, organic coating lines, continuous annealing lines, stainless steel lines, finishing lines as well as expert systems for quality monitoring. Additionally, customers profit from metallurgical expertise and know-how offered by Primetals Technologies to keep up with the latest production trends and market requirements.



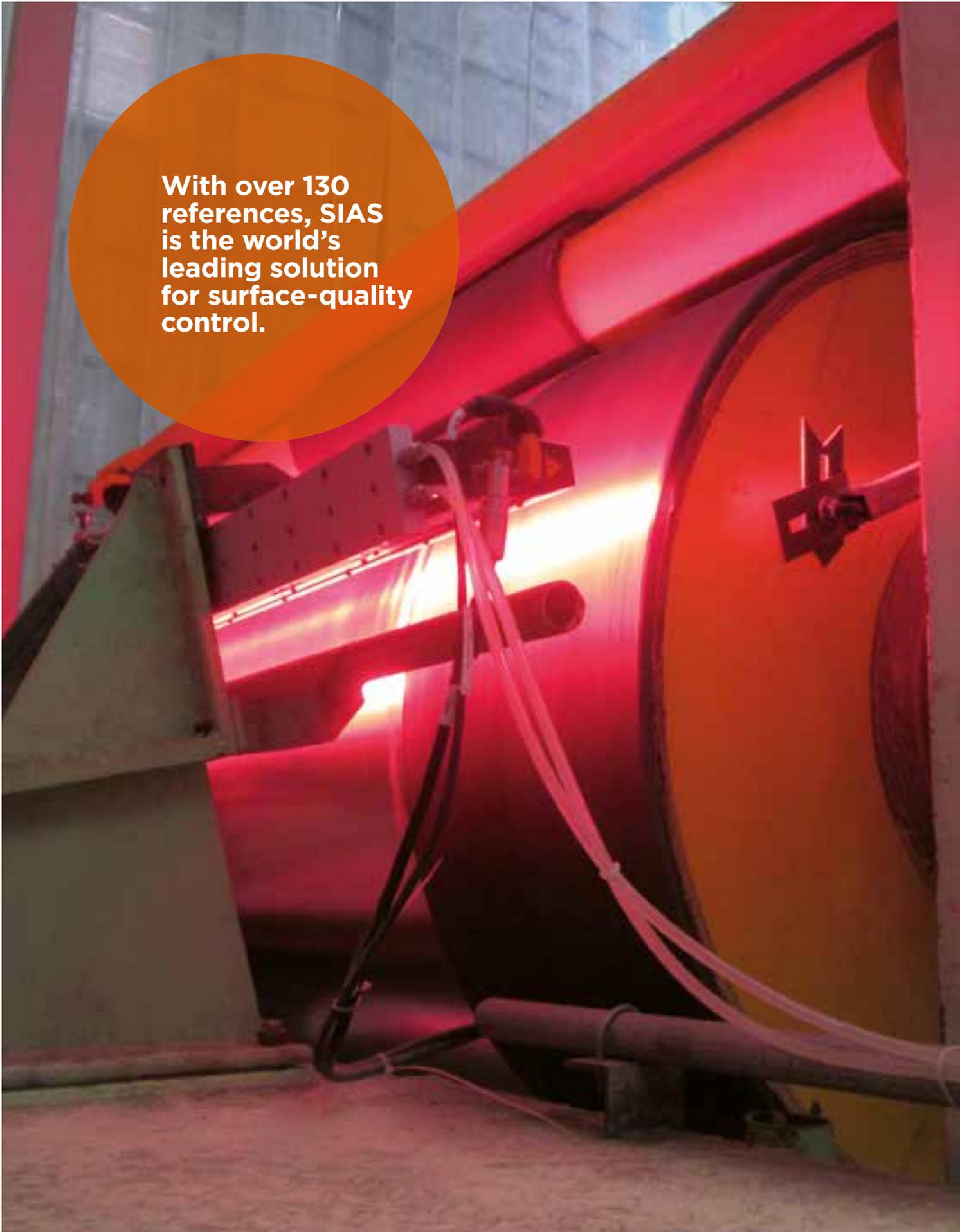
FIG. 1: The iBox pickling tank in a coupled pickling line and tandem cold-rolling mill (PLTCM), AK Steel Corporation, Dearborn, Michigan, U.S.A.

FIG. 2: Continuous galvanizing line installed at Tangshan Steel for the processing of AHSS grades for automotive applications



Producers of flat-rolled products are increasingly being required to conform to the trend toward zero-defect tolerances regarding surface quality.

With over 130 references, SIAS is the world's leading solution for surface-quality control.



Primetals Technologies offers integrated and comprehensive solutions to meet the ever-increasing requirements placed on quality, productivity and cost efficiency.

FIG. 3: Example of a SIAS surface-inspection system installed in a coupled pickling line and tandem cold-rolling mill

Companies are increasingly calling for higher-quality products and production lines that require a lower energy consumption and reduced maintenance. To satisfy the market demands for top quality, plant operators need to produce strip with perfect surfaces, excellent flatness, tight dimensional tolerances, uniform mechanical properties and reliable coating adhesion properties.

Primetals Technologies offers integrated and comprehensive solutions to meet the ever-increasing requirements placed on quality, productivity and cost efficiency. These solutions are the result of years of operational and design experience as well as the close collaboration with leading steel manufacturers worldwide. Furthermore, continued emphasis placed on research and development has led to the application of new solutions, such as the highly efficient iBox pickling process (Figure 1), compact and cost-optimized hot- and cold-strip galvanizing and annealing lines (Figure 2), air knives with an integrated strip stabilizer, light- and heavy-gauge laser welders, the galvannealing line section for automotive strip qualities and SIAS automatic

surface-inspection systems (Figure 3). An overview of the solutions offered for strip-processing lines from Primetals Technologies is presented in the following:

PICKLING LINES

Continuous and push-pull pickling lines from Primetals Technologies feature modular design, high pickling efficiency, economical operation and the application of advanced technologies for high-speed pickling. Continuous pickling lines are supplied with compact scale breakers, advanced heavy laser welders, heavy side trimmers outfitted with a scrap chopper, and a flat-tank design. Pickling line speeds of up to 400 m/min are possible with the iBox tank system, which does not require a complex acid-recirculation system, or with the tunnel-tank type equipped with side jets. The pickling process section is automatically regulated by an acid concentration control system, which offers significant benefits in terms of productivity, quality, operation management and operational costs. The latest pickling line references and projects are shown in Table 1. »

TABLE 1: Overview of recent pickling line references and projects (new plants)

(VAMA = Valin ArcelorMittal Automotive Steel Co., Ltd.; PLTCM = pickling line tandem cold mill, CPL = continuous pickling line)

| Customer | Country | Project | Production start | Production capacity (t/a) | Max. process speed (m/min) | Thickness (mm) | Max. width (mm) | Pickling type |
|-------------------------|---------|---------|------------------|---------------------------|----------------------------|----------------|-----------------|---------------|
| Tosyali-Toyo | Turkey | PLTCM | 2017 | 670,000 | 180 | 1.6–4.0 | 1,270 | iBox |
| Rizhao Steel | China | CPL | 2015 | 2,000,000 | 400 | 0.8–4.0 | 1,600 | Jet tunnel |
| Guangxi Iron & Steel | China | PLTCM | 2015 | 2,270,000 | 250 | 1.8–6.0 | 1,880 | iBox |
| Baotou Rare Earth Steel | China | PLTCM | 2015 | 2,000,000 | 270 | 2–6.0 | 1,880 | iBox |
| Tangshan Iron & Steel | China | PLTCM | 2014 | 1,345,000 | 280 | 1.5–4.0 | 1,600 | Jet tunnel |
| VAMA | China | PLTCM | 2014 | 1,500,000 | 300 | 1.8–6.0 | 1,890 | Shallow |
| Zaporizhstal | Ukraine | CPL | 2014 | 1,350,000 | 240 | 1.5–6.0 | 1,580 | Catenary-type |

For the pickling of up to approximately 1 million tons of strip per year, push-pull pickling lines offer significant advantages with respect to investment costs and operational flexibility. This is particularly the case with frequently changing strip dimensions and steel grades. Primetals Technologies offers a uniquely designed V-shape flat pickling tank, which improves strip stability during its passage through the tank.

ANNEALING AND GALVANIZING LINES

Primetals Technologies supplies both batch-type and continuous annealing lines. The latter is highlighted by a flexible, multi-zone furnace design for the production of a broad range of steel grades and dimensions. Continuous annealing lines are available for both carbon steel and tinplate sheet applications. The lines integrate key technologies that include the furnace, mash-lap or laser welders, cleaning sections, air knives, temper mill and

tension levelers, side trimmers with a scrap chopper, rotary shears, roll coaters, electrostatic oilers and SIAS automatic surface-inspection systems. Continuous lines are required for high throughput rates, high yields, significant energy savings and the production of high-quality products for high-end applications.

Customized solutions are offered for hot-dip galvanizing of both hot- and cold-rolled strip (Figure 4). The most stringent market demands are met for the production of first-class materials for automotive grades, exposed surfaces, white goods and construction applications. All types of coatings can be applied to meet the wide range of strip-protection needs. Examples include pure zinc, galvannealing (ZnFe), galfan (Zn95 Al), zinc aluminum (Al55Zn) and aluminum (AlSi or Al), to name just a few. Examples of the latest annealing and galvanizing line references and projects are listed in Table 2. »

The most stringent market demands are met for the production of first-class materials for automotive grades, exposed surfaces, white goods and construction applications.

FIG. 4: No. 3 Continuous Galvanizing Line at Nippon Steel & Sumitomo Metal Corporation (former Sumitomo Metal Ind.), Japan

| Customer | Country | Project | Production start | Production capacity (t/a) | Max. process speed (m/min) | Thickness (mm) | Width range |
|-----------------------|-----------|-----------|------------------|---------------------------|----------------------------|----------------|-------------|
| Erdemir | Turkey | CGL No. 2 | 2018 | 350,000 | 150 | 0.4-2.0 | 700-1,900 |
| Tangshan Iron & Steel | China | CGL No. 5 | 2017 | 250,000 | 180 | 0.18-1.5 | 850-1,300 |
| | | CGL No. 6 | 2017 | 400,000 | | 0.5-3.0 | 850-1,600 |
| Tosyali-Toyo | Turkey | CAL | 2017 | 240,000 | 500 | 0.16-0.8 | 1,270 |
| JFE Steel | Indonesia | CGL | 2015 | 460,000 | 180 | 0.4-2.3 | 1,880 |
| Pangang Steel | China | CGL | 2015 | 450,000 | 160 | 0.5-3.0 | 1,650 |
| Tangshan Iron & Steel | China | CGL No. 4 | 2015 | 420,000 | 180 | 0.2-2.5 | 1,600 |
| Tangshan Iron & Steel | China | CAL | 2014 | 976,000 | 420 | 0.2-2.5 | 1,600 |

TABLE 2: Overview of recent galvanizing and annealing line references and projects (new plants) (CGL = continuous galvanizing line, CAL = continuous annealing line)





ROLLING, ANNEALING AND PICKLING LINES FOR STAINLESS STEEL

Stainless steel lines from Primetals Technologies combine the traditionally separate processes of rolling, cleaning, annealing, pickling, skin passing and leveling into an integrated processing line. Following hot rolling, the stainless steel hot-rolled strip is annealed and pickled before it is cold rolled on either a 20-high reversing mill, or on a 6-high or 18-high continuous tandem cold mill. The cold-rolled strip is then processed back into the annealing and pickling sections and skin-passed. For the thinnest gauges, a rerolling operation is necessary. Table 3 shows the possible downstream line combinations offered by Primetals Technologies, and Table 4 shows the latest combined processing line references for stainless steel.

Furthermore, the lines can be supplied with all of the necessary equipment required for continuous processing such as laser welders, horizontal loopers, side trimmers with an integrated scrap chopper, rotary shears and the SIAS automatic surface-inspection systems.

Cold-rolling section: The 18-roll stand concept, recently redeveloped by Primetals Technologies and marketed as the Power X-HI Mill, includes a number of unique features. As a result of the high work-hardening charac-

teristics of stainless steel, small work rolls are required to achieve the necessary reduction. The technology uses additional lateral support rolls to ensure stable and controllable rolling. Lateral shifting of the intermediate rolls as well as positive and negative bending of the intermediate rolls enable a precise strip shape control to be achieved. The mill is equipped with an automatic roll-change car for work rolls and intermediate rolls, thus enabling roll replacement while the process section is being operated.

Cleaning section: Strip surface quality is an essential property of stainless flat products. Strip cleanliness prior to the annealing furnace or after the mill is therefore paramount in importance. Reliable inline degreasing sections provide the required strip cleanliness for assuring highest product quality.

Annealing and pickling section: The work-hardened strip requires annealing and surface-scale removal. This is carried out in a tunnel furnace and acid pickling section. For hot-rolled strip, Primetals Technologies also supplies shot-blast and scale-breaker equipment that is installed between the furnace and pickle sections to remove scale. Figure 5 shows a combined stainless steel annealing and pickling line supplied by Primetals Technologies. »

FIG. 5: Example of a Primetals Technologies-supplied annealing and pickling line for stainless steel, Tiancheng Stainless Steel Products Co., Ltd., Guanghan, Sichuan Province, China

| Plant type | Cold mill | Cleaning | Annealing | Pickling | Skin passing | Tension leveling |
|--|-----------|----------|-----------|----------|--------------|------------------|
| Hot annealing and pickling line (HAPL) | | ✓ | ✓ | ✓ | | |
| Direct rolling, annealing and pickling line (DRAP) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Continuous tandem cold mill (CTCM) | ✓ | ✓ | | | | |
| Cold annealing and pickling line (CAPL) | | ✓ | ✓ | ✓ | ✓ | ✓ |

TABLE 3: Possible downstream line combinations offered by Primetals Technologies for stainless steel

TABLE 4: Overview of recent combined processing line references for stainless steel (TCSS = Tiancheng Stainless Steel Products Co., Ltd., JISCO = Jiuquan Iron & Steel (Group) Co. Ltd.)

| Customer | Country | Project | Production start | Production capacity (t/a) | Max. process speed (m/min) | Thickness (mm) | Max. width (mm) |
|------------------------------------|---------|---------|------------------|---------------------------|----------------------------|----------------|-----------------|
| Beihai Chengde Stainless Steel Co. | China | CTCM | 2015 | 600,000 | 400 | 1-5 | 1,250 |
| Baosteel Fujian Desheng Nickel Co. | China | DRAP | 2014 | 372,000 | 125 | 2-5 | 1,250 |
| TCSS | China | CAPL | 2013 | 250,000 | 100 | 0.3-3 | 1,300 |
| JISCO | China | CAPL | 2012 | 500,000 | 160 | 0.3-4 | 1,600 |



FIG. 6: SIAS installation on a continuous pickling line

Inline determination of the mechanical properties of strip in galvanizing lines and continuous annealing lines is now possible with the PropertyMon system.

PROCESS EXPERTS SYSTEMS, METALLURGICAL EXPERTISE AND KNOW-HOW

As a market leader in the field of strip-processing lines, Primetals Technologies is not only a plant builder and equipment manufacturer, but also widely recognized as a key partner for plant quality monitoring and production development. The company's solutions incorporate various expert systems for continuous tracking of both the equipment operating conditions and product quality.

PROCESS QUALITY CONTROL

The steel industry has made tremendous progress in improving product quality through process control. Processing lines are equipped with an increasing number of sensors and gauges that generate an abundance of data to be analyzed by plant personnel. To assist with daily plant operation and process know-how management, Primetals Technologies developed advanced software such as TCOptimizer and TPQC (Through Process Quality Control).

These tools collect data and signals from all parts of the line and upstream processes, as well as from the external laboratory when required. Through multi-source data correlation models and business management rules, all associated gigabytes of data are transformed into comprehensive production events and just-in-time alarms.

This allows immediate and focused corrections by the line manager or operators. The systems also incorporate a sustainable knowledge-management function that effectively documents best practices and solutions for solving problems. All data can be easily exported for further use in material development or for direct assistance from metallurgical experts at Primetals Technologies. Table 5 shows TCOptimizer references installed by Primetals Technologies.

SIAS AUTOMATIC SURFACE-INSPECTION SYSTEMS

Producers of flat-rolled products are increasingly being required to conform to the trend toward zero-defect tolerances regarding surface quality (Figure 6). With single-camera inspection and a powerful third-generation LED illumination system, the SIAS on-line surface-quality control system detects and automatically classifies all surface defects visible on the strip for all flat-product rolling and processing plants.

Surface inspection on processing lines detects both upstream (incoming material) defects and those that are a result of the process itself. It performs final product quality control and allows the optimization of process parameters and production practices to reduce defect occurrence. With over 130 references, SIAS is the world's leading solution for surface-quality control.

| Plant | Country | Production start | Plant type | Technical data |
|--|---------|------------------|---|---|
| Tangshan Iron & Steel | China | 2015 | Continuous galvanizing line | Production capacity: 420,000 t/a Process speed: 180 m/min Steel grades: CQ, DQ, DDQ, EDDQ, SEDDQ, BH, HSS, DP, TRIP |
| | | | Continuous annealing line | Production capacity: 750,000 t/a Process speed: 420 m/min Steel grades: CQ, DQ, DDQ, EDDQ, SEDDQ, BH, HSS, DP, TRIP, MS |
| Baosteel Desheng, Luoyuan | China | 2015 | Direct rolling, annealing and pickling line | Production capacity: 372,000 t/a Process speed: 125 m/min Steel grades: hot-rolled annealed and pickled stainless steel |
| Xinyu Iron & Steel Co. Ltd | China | 2011 | Continuous annealing line | Production capacity: 735,000 t/a Process speed: 420 m/min Steel grades: CQ, DQ, DDQ, EDDQ, SEDDQ, HSS, DP, TRIP |
| Tianjin Tiantie Metallurgical Group (TTMG) | China | 2010 | Continuous annealing line | Production capacity: 730,000 t/a Process speed: 420 m/min Steel grades: CQ, DQ, DDQ, EDDQ, SEDDQ, HSS, DP, TRIP |

TABLE 5: References of the TCOptimizer system installed by Primetals Technologies (CQ = commercial quality, DQ = drawing quality, DDQ = deep-drawing quality, EDDQ = extra-deep-drawing quality, SEDDQ = super extra-deep-drawing quality, BH = bake hardening, HSS = high-strength steel, DP = dual-phase, TRIP = transformation-induced plasticity, MS = martensitic steels)

CONDITION MONITORING

Condition monitoring is the process of constantly checking the health of a set of machines. The condition monitoring system (CMS) from Primetals Technologies significantly improves the monitoring, optimization and management of equipment and plants. Since 2012, company-supplied laser welders and side trimmers have been equipped with a CMS for optimal plant operation, accurate maintenance scheduling and the prevention of downtimes. A CMS can also be integrated in the framework of a retrofit.

INLINE MEASUREMENT OF THE MECHANICAL PROPERTIES OF STRIP

Inline determination of the mechanical properties of strip in galvanizing lines and continuous annealing lines is now possible with the PropertyMon system. On the basis of contactless and non-destructive measurements of electromagnetic parameters, it is possible to calculate the magnetic properties, tensile strength and yield strength of steel along the entire strip length.

METALLURGICAL SUPPORT

The manufacture of advanced steel grades, such as advanced high-strength steel (AHSS), generally requires a modification of the production steps along the entire value chain. As an example, recent processing lines built by Primetals Technologies are designed to process grades up to DP1200. Besides the necessity to define

specific plant parameters and machine sizing, this new generation of materials involves other matters that need to be addressed, for example, precisely monitored upstream processes, furnace control with pre-oxidation stages, and a rapid cooling system. All of these factors have a major impact on end-product quality.

Solutions and services are offered to assist customers in the development of advanced or new steel grades. This includes metallurgical know-how support; a mobile surface inspection system for specific test campaigns; physical simulators for rolling, leveling, annealing and galvanizing process development; and metallurgical simulation tools and models. In-house company experts provide these services.

PLANT MODERNIZATION

Primetals Technologies has a wealth of experience in upgrading and modernizing processing lines. The targets may include:

- Decrease of operational costs (energy, maintenance, consumables, personnel)
- Improvement product quality (thickness, flatness, surface) or production capacity
- Extension of the product mix in terms of steel grades and dimensional ranges
- Enhancement of operations and maintenance with a focus on user-friendliness and safety. »



Pickling line speeds of up to 400 m/min are possible with the *i*Box tank system.

FIG. 7: Upgraded pickling line, Tata Steel IJmuiden, the Netherlands (courtesy of Tata Steel IJmuiden)

Primetals Technologies, together with customers and partners, therefore continues to focus on developing the solutions of tomorrow.

TABLE 6: Overview of recent pickling line modernization references and projects (CPL = continuous pickling line; PLTCM = pickling line tandem cold mill)

| Customer | Country | Project | Production restart | Max process speed (m/min) | Thickness (mm) | Max. width (mm) | Modernization |
|---------------|---------|--------------|--------------------|---------------------------|----------------|-----------------|---|
| JFE Steel | Japan | CPL revamp | 2016 | 200 | 1.2–5.5 | 1,765 | Pickling tank replaced with shallow polypropylene tank |
| ArcelorMittal | Spain | CPL revamp | 2015 | – | – | – | Production capacity increase, entry and looper section upgrades |
| U.S. Steel | U.S. | CPL revamp | 2015 | 250 | 1.52–6.35 | 1,880 | Replaced pickling tank with iBox technology |
| Nippon Steel | Japan | CPL revamp | 2014 | 220 | – | 1,450 | – |
| Nisshin Steel | Japan | PLTCM revamp | 2014 | 360 | 1.8–6.0 | 1,320 | Replaced pickling tank with iBox technology |

The improvement of pickling lines serves as an example of the upgrading capability of Primetals Technologies. Almost all pickling lines experience a deterioration of the pickling tanks when high-tensile-strength steels are produced. Silicon (Si) sludge typically clogs nozzles, piping and heat exchangers in silicon steel production, and working conditions often need to be improved. iBox pickling technology from Primetals Technologies addresses these issues. Developed in 1990, it has helped to improve pickling productivity, suppress Si-sludge clogging, and reduce energy, acid and steam requirements. The solution has also simplified maintenance work. More information about iBox pickling technology is outlined in a separate article in this issue.

With a systematic approach, Primetals Technologies works closely with its customers to develop a tailored modernization concept based on individual needs. All prevailing conditions are taken into account. Furthermore, the company's upgrading experience assures fast production ramp-up to the targeted product quality with minimum plant downtime. Figure 7 shows the upgraded pickling line at Tata Steel IJmuiden and Table 6 lists recent pickling line modernization projects of Primetals Technologies.

COMMITMENT TO QUALITY

Strip-processing lines play a decisive role in meeting the strictest quality specifications as required by high-end steel applications. Existing processing solutions, however, will not be sufficient to satisfy tomorrow's demands placed on product properties, certification, costs and plant reliability. Primetals Technologies, together with customers and partners, therefore continues to focus on developing the solutions of tomorrow to support producers to meet their future production and marketing targets. ●

Alain Challaye, Technical Director¹⁾

Gaël Imbert, Head of Technical Sales Department¹⁾

Yoichi Kai, Expert, Portfolio Management, Processing Line²⁾

Masao Tambara, General Manager, Processing Line Project Division³⁾

¹⁾Primetals Technologies France, ²⁾Primetals Technologies UK,

³⁾Primetals Technologies Japan



TRENDSETTER FOR STEEL QUALITY

PROCESSING LINES FOR HIGH-END AUTOMOTIVE STEEL PRODUCTION

In a technology-driven steel market for automotive products, Primetals Technologies stands out as a leading supplier of new and modernized strip-processing lines. These lines are designed for a wide range of applications and feature the use of state-of-the-art technologies and systems. A number of future-oriented solutions for strip-processing lines are highlighted in this article.

FIG. 1: Schematic view of a state-of-the-art galvanizing line for the production of advanced high-strength steels (AHSS) for automotive applications



FIG. 2 AND 3: Skin-pass mill and tension leveler built and ready for dispatch at the Montbrison workshop of Primetals Technologies France



Product quality is a fundamental performance factor of new plants that serve the market for high-end automotive steels, in particular for exposed automotive panels. To supply the best strip quality, process new steel grades and cut operational costs, Primetals Technologies offers a wide spectrum of advanced solutions for strip-processing lines (Figure 1). This includes the use of solid-state laser welders, pickling tunnel tanks, skin-pass mills and tension levelers, side trimmers, and a new generation of surface-inspection systems. All of these solutions are linked through global quality and process monitoring software to provide just-in-time warnings and root-cause analyses.

FOR PERFECT STRIP FLATNESS, ROUGHNESS AND ELONGATION

Automated elongation machines not only provide the right flatness at the end of strip processing, but also at intermediate stages. For example, scale breakers are used to remove scale from the strip surface and to improve strip shape prior to pickling. Strip flatness is finally mastered in the exit areas of processing lines where the latest skin-pass mill and tension levelers are applied (Figures 2 and 3).

Beside their classical function of managing both roughness and yield point elongation (YPE), skin-pass mills are essential for assuring highest strip surface quality for automotive applications. These mills are therefore usually designed as wet-type processes for lower rolling friction and to reduce so-called pick-ups. A high-pressure cleaning system is generally installed for the work rolls and backup rolls in addition to a mill exit rinse and strip dryer to achieve the best-possible surface quality.

The tension leveler from Primetals Technologies is precisely controlled so that strip surface roughness imparted by the skin-pass mill is not affected. A new generation of tension levelers is now available to address the upper ranges of advanced high-strength steel (AHSS) grades. The levelers are characterized by high tensions and loads as well as by a roll configuration designed to minimize residual stress.

FOR OUTSTANDING PICKLED SURFACES

To meet today's most stringent surface requirements, including those for exposed panels, Primetals Technologies has recently developed a high-speed pickling process »

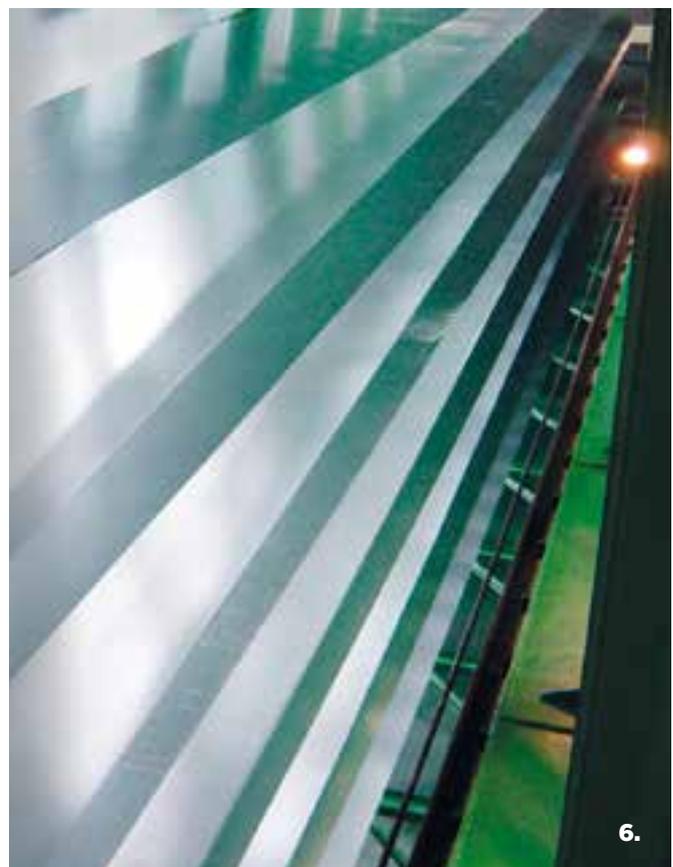


FIG. 4: Solid-state laser welding



FIG. 5: Side trimmer built and ready for dispatch at the Montbrison workshop of Primetals Technologies France

FIG. 6: Continuous galvanizing line for the processing of AHSS grades for automotive applications



The latest fiber-based, solid-state laser technology makes welding possible for every grade of automotive steel.

that ensures the production of the cleanest strip surfaces without scratches or stains. Scale breakers initially remove coarse scale from the strip surface, which allows a homogeneous acid attack along the entire strip length. This step also minimizes the risk of surface scratches that may occur during the pickling process. The strip then passes through a series of pickling tanks that are designed for precise strip guidance. The tanks include entry/exit spray headers and lateral injectors for high-quality pickled edges. The entire process is controlled automatically to provide the right acid level at very low line speeds without over-pickling. This capability to operate at lower line speeds while upholding high surface quality is particularly important in a coupled pickling line and tandem cold-rolling

mill (PLTCM) configuration, as this accommodates longer rolling mill downtimes without the need to stop the pickling process. Cascade-type rinsing units feature a high-pressure final rinsing ramp for maximum strip cleanliness at relatively low water-consumption rates.

STRIP SURFACE CLEANLINESS IN ANNEALING AND GALVANIZING LINES

In order to deliver the surface quality and strip cleanliness required by the automotive market, vertical-type accumulators, furnaces and electrolytic cleaning systems are commonly installed. A pre-oxidizing section in the furnace along with atmospheric control is required for higher steel grades with higher silicon and manganese contents in

Product quality is a fundamental performance factor of new plants that serve the market for high-end automotive steels.

order to have the proper surface preparation for good zinc adhesion. The galvanizing pot area, which primarily determines the planned line stoppages and resulting production bottleneck, is carefully designed to minimize operational disruptions and to safeguard the production of uniform, consistent and defect-free coatings. This is made possible by precisely maintaining the targeted temperature of the coating metal melt, its chemical composition, and the metal bath level in the galvanizing pot to reduce or eliminate dross generation. Automatic or semi-automatic dross removal devices can be installed to substitute both demanding and hazardous manual work.

ADVANCED PROCESS-MONITORING SYSTEMS

Attaining the required steel quality for automotive applications is the result of a series of successive steps along the metallurgical route, from meltshop to the processing line. Each step can have a major impact on final product quality. Focusing on downstream processes is not sufficient to guarantee complete fulfillment of quality specifications. Sophisticated monitoring systems from Primetals Technologies are therefore offered for various process stages, as follows:

- SIAS automatic surface-inspection system
- PropertyMon for non-destructive, real-time, inline measurements of the mechanical properties of strip material
- Other closed-loop, process-optimization systems and product-quality tracking gauges or sensors

Drawing on the experience acquired in dealing with massive volumes of data and to assist producers in the daily operation of a processing line, Primetals Technologies has developed advanced software tools. These include TCOptimizer (Total Condition Optimizer) and TPQC (Through-Process Quality Control) that provide just-in-time warnings and root-cause analyses. These tools collect data and signals from all parts of the production chain. This information is embedded in a business rule management system (BRMS) that is based on simple logical expressions and decision trees to allow non-IT specialists to handle the incoming signals, as well as to manage the generated relevant-only manufacturing events and just-in-time warnings.

OTHER KEY PROCESS EQUIPMENT ITEMS

Sustaining high strip quality levels requires carefully managed, stable and reliable processes. This is supported by a variety of additional solutions from Primetals Technologies, such as:

- Strip welding, which allows a continuous production mode to be applied. The latest fiber-based, solid-state laser technology (Figure 4) makes welding possible for every grade of automotive steel. A recent highlight was achieved with a full laser cut and weld solution. Already fully proven on continuous annealing lines and continuous galvanizing lines, this technology is now available for PLTCM and other continuous processing lines with strip thicknesses up to 6.5 mm. Preheating, post-annealing and weld quality are integrated to achieve the near-zero weld breakage ratio required by a modern production line.
- Side trimmer with dynamic width adjustment, which no longer stops at strip transitions. This eliminates the risk of mill roll marking and thus contributes to productivity gains through the avoidance of notching (Figure 5).

LIFECYCLE PARTNERSHIPS FOR NEXT-GENERATION STEEL GRADES

The automotive market remains a clear trendsetter in the development of new steel grades. Primetals Technologies offers a complete spectrum of solutions and services for this market, including metallurgical know-how support and steel grade development assistance. Additional services offered in this regard comprise the use of a mobile surface-inspection system for specific test campaigns; physical simulators for the development and optimization of rolling, leveling, annealing and galvanizing processes; and metallurgical simulation tools and models – all backed by services from in-house experts. Processing lines from Primetals Technologies are distinguished by their state-of-the-art technologies and systems that address the latest market requirements, and which support producers to quickly respond to tomorrow's challenges (Figure 6). ●

Gaël Imbert, Head of Technical Sales Department

Sébastien Maillard, Head of Technology and Innovation

Dr. François Mignard, CEO

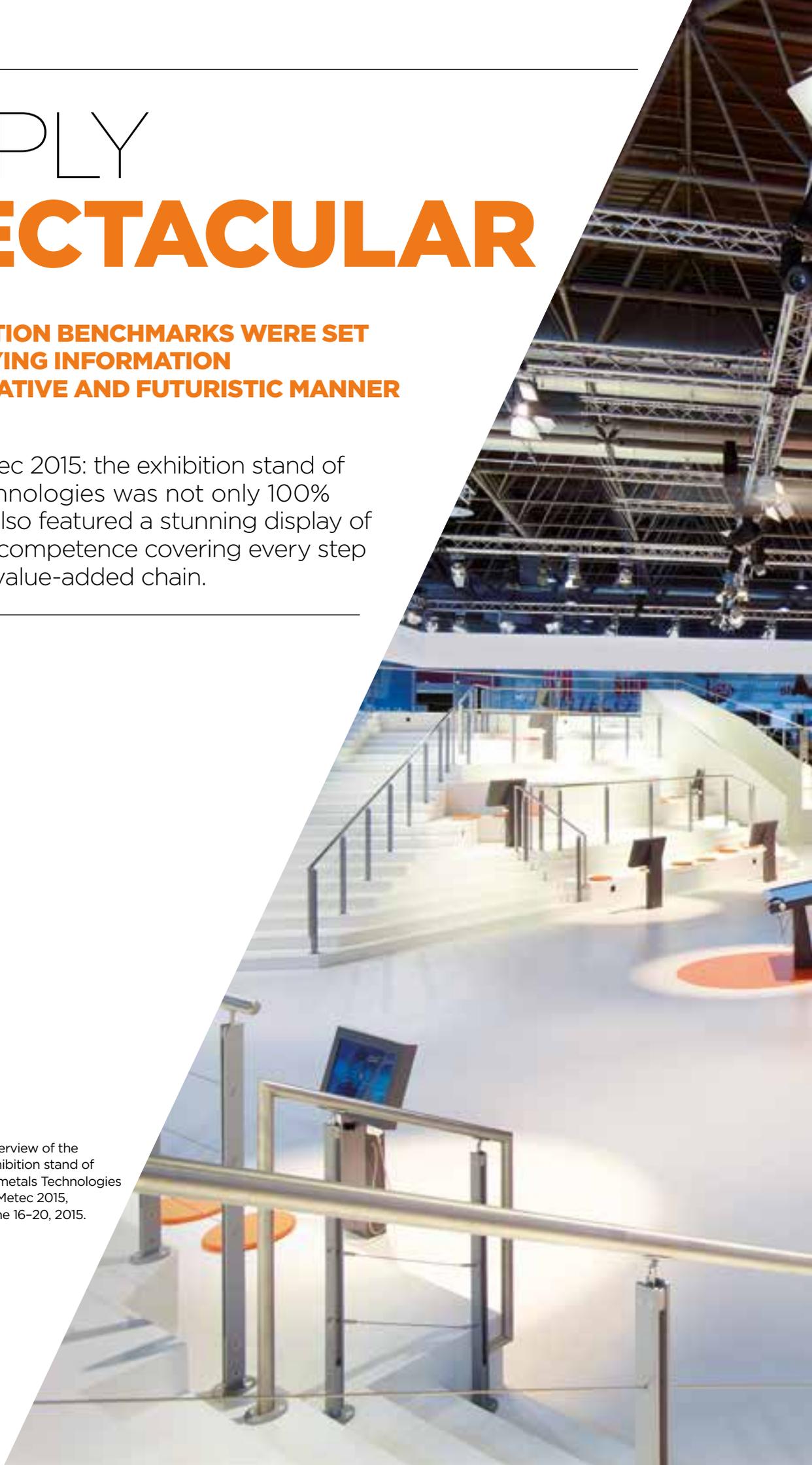
(all with Primetals Technologies France)

SIMPLY SPECTACULAR

**NEW EXHIBITION BENCHMARKS WERE SET
FOR CONVEYING INFORMATION
IN AN INNOVATIVE AND FUTURISTIC MANNER**

Unique at Metec 2015: the exhibition stand of Primetals Technologies was not only 100% interactive, it also featured a stunning display of technological competence covering every step of the metals value-added chain.

Overview of the
exhibition stand of
Primetals Technologies
at Metec 2015,
June 16–20, 2015.



The exhibition stand featured a stunning display of technological competence covering every step of the metals value-added chain.

CREATING THE FUTURE OF METALS AS OF



ATTENTION

This article was neither reviewed nor approved by the Chief Editor of Metals Magazine.

**DR. LAWRENCE
"LARRY" GOULD,**
Chief Editor of Metals Magazine,
at home in the Mühlviertel region
of Upper Austria

TALK IS SILVER, **WRITING IS GOULD**

**INTRODUCING DR. LAWRENCE "LARRY" GOULD,
CHIEF EDITOR OF METALS MAGAZINE SINCE ITS LAUNCH IN 2006**

Larry Gould's eager eye, indeed his strict scrutiny, made it quite a challenge to sneak this column past him all the way to printer's press.

LARRY GOULD IN FIGURES

34

years with the
company

10

years as the
Chief Editor of
Metals Magazine

4

marathons run in
different countries

There is hardly a man alive who embodies Primetals Technologies' history to date quite as well as Dr. Lawrence "Larry" Gould, the accomplished and meticulous editor of the magazine you currently hold in your hands. We would like to take this opportunity to introduce you to the metallurgical mastermind that he is. His eager eye, indeed his strict scrutiny, made it quite a challenge to sneak this column past him all the way to printer's press. With any luck, he will be quite surprised to be reading these lines – and for once we will have managed to throw him off the scent and foil his perfectionism.

FIRST VIOLIN

Larry Gould not only holds a doctorate in exploration geology, he also has a flair for the written word, and he is no stranger to the occasional pun. He enhances the technical content of this magazine while striving to present it in a compact, catchy and polished way. His writing style is suffused with a certain melody, and those who know him, know he is very much a musical person. In fact, he is not only first violin at our magazine – he also played the violin in the orchestra at Johannes Kepler University in Linz until the early 1990s. Even his voice has a melodic quality, and hearing him recite literature in English is a particular pleasure.

ONE OF THE LOCALS

But what made Larry Gould, a native of Elisabeth, New Jersey, U.S.A., venture across the pond to Austria? Before his career in industrial plant construction, it was his interest in natural sciences and a desire to study at the Montanuniversität Leoben, with its specialization in mining, that brought him to Europe. Austria soon became his new adoptive home, and was the place where he met and married Gaby. Together with his wife, he now lives in the Mühlviertel region of Upper Austria. Larry Gould spends much of his free time on his farm, and he continually surprises his colleagues with the exceptional tomatoes he grows. As many as a hundred different tomato plants can be found in his greenhouse. Larry Gould has even managed

to endear himself to the Mühlviertel "natives," which itself is no mean feat. This was surely aided by his being the only American in the volunteer fire department, and by his enthusiastic use of the linguistic peculiarities of the local dialect. He draws strength from the unspoiled nature of the Mühlviertel region, which also inspires him to keep fit. Larry Gould has run several marathons and half-marathons, and he has also clocked up considerable mileage on his bicycle.

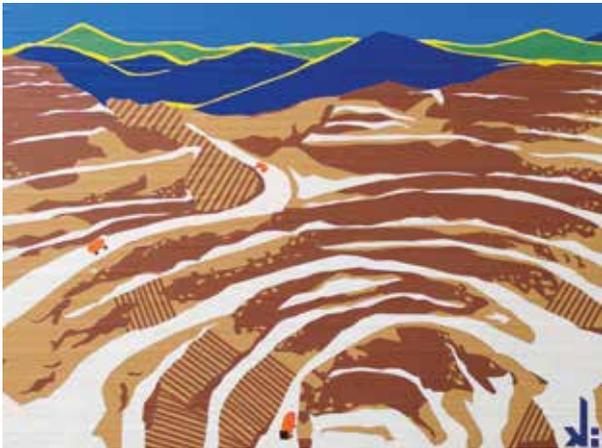
We at Primetals Technologies say thank you, Larry, for your dedication and commitment. Your extraordinary efforts have made Metals Magazine into a mainstay publication in the metals industry. ●

BIO LARRY GOULD

Born in 1952 in Elisabeth, New Jersey, U.S.A., Lawrence Gould was only 20 when he spent his first year in Europe. In 1975 he came to Austria to study in Leoben. In January 1981, as a doctoral graduate in exploration geology, he began working in industrial plant construction at Voest (today Primetals Technologies). As a geologist, he has supervised a wide variety of mining projects. Larry Gould has spent much of his long career abroad, with stays in China and the United Arab Emirates. In 1984 he spent almost a full year working in Barbados. He also often visits friends and family in the United States. Larry Gould is a much-valued colleague at Primetals Technologies. He performs an admirable balancing act, combining his metallurgical expertise with linguistic prowess as an editor and even translator. Those who work with him also appreciate his clever sense of humor and self-irony.

WHERE STEEL MEETS ART

CREATIVE SOLUTIONS ACROSS THE COMPLETE METALS VALUE CHAIN



1.

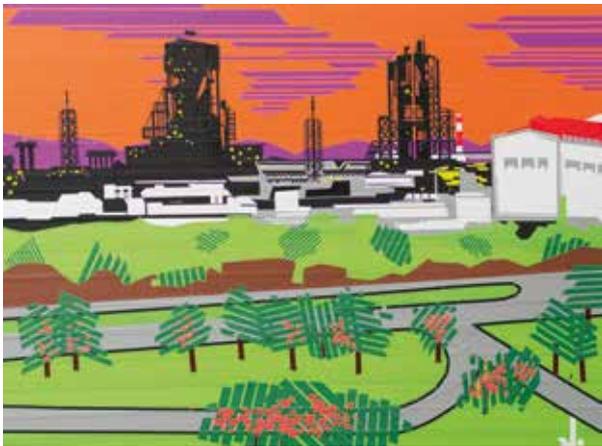
Steelmaking is an art. This was demonstrated during Metec 2015 at the Primetals Technologies exhibition stand by the “Klebebande Berlin” tape artists. Using vividly colored strips of tape, this group of young artists visualized various process steps from the iron and steel production route in a highly original and creative way. This unique artistic expression of metallurgical plants with tape offers an unprecedented perspective on various elements of the product portfolio of Primetals Technologies. The combination of steelmaking and art also symbolizes the innovative solution approach that Primetals Technologies applies toward finding solutions to meet the global challenges faced by the metals industry as well as the company’s vision of

»



2.

**Creating the future
of metals as one.**



3.

The Klebebande Berlin tape artists at the Metec 2015 exhibition stand of Primetals Technologies; from left to right: Nikolaj Bultmann, Bodo Höbing and Bruno Kolberg; www.klebebande-berlin.com/



4.

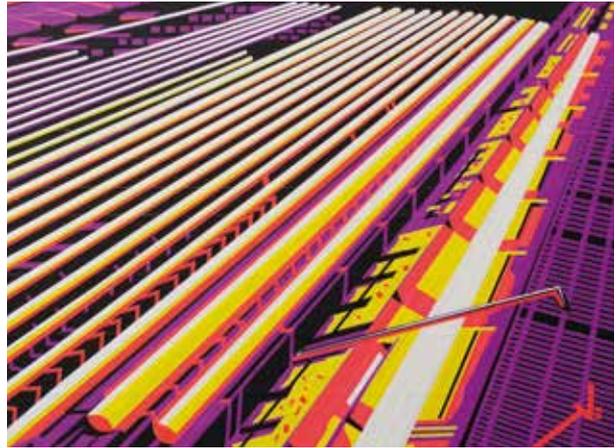


5.

- 01 / Iron ore mine (beneficiation and agglomeration)
- 02 / Blast furnace ironmaking
- 03 / Corex ironmaking
- 04 / Electric steelmaking
- 05 / LD (BOF) converter steelmaking



6.



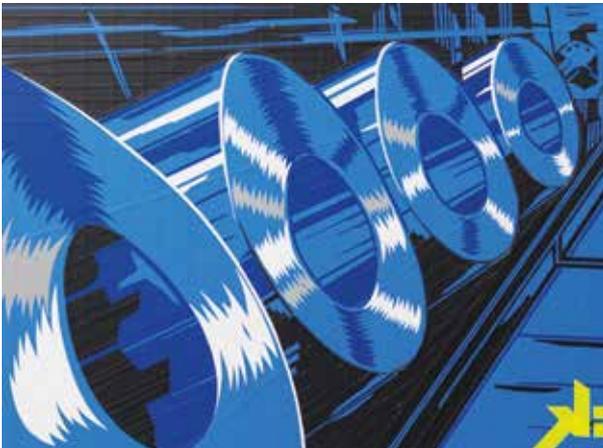
7.



8.



9.



10.



11.

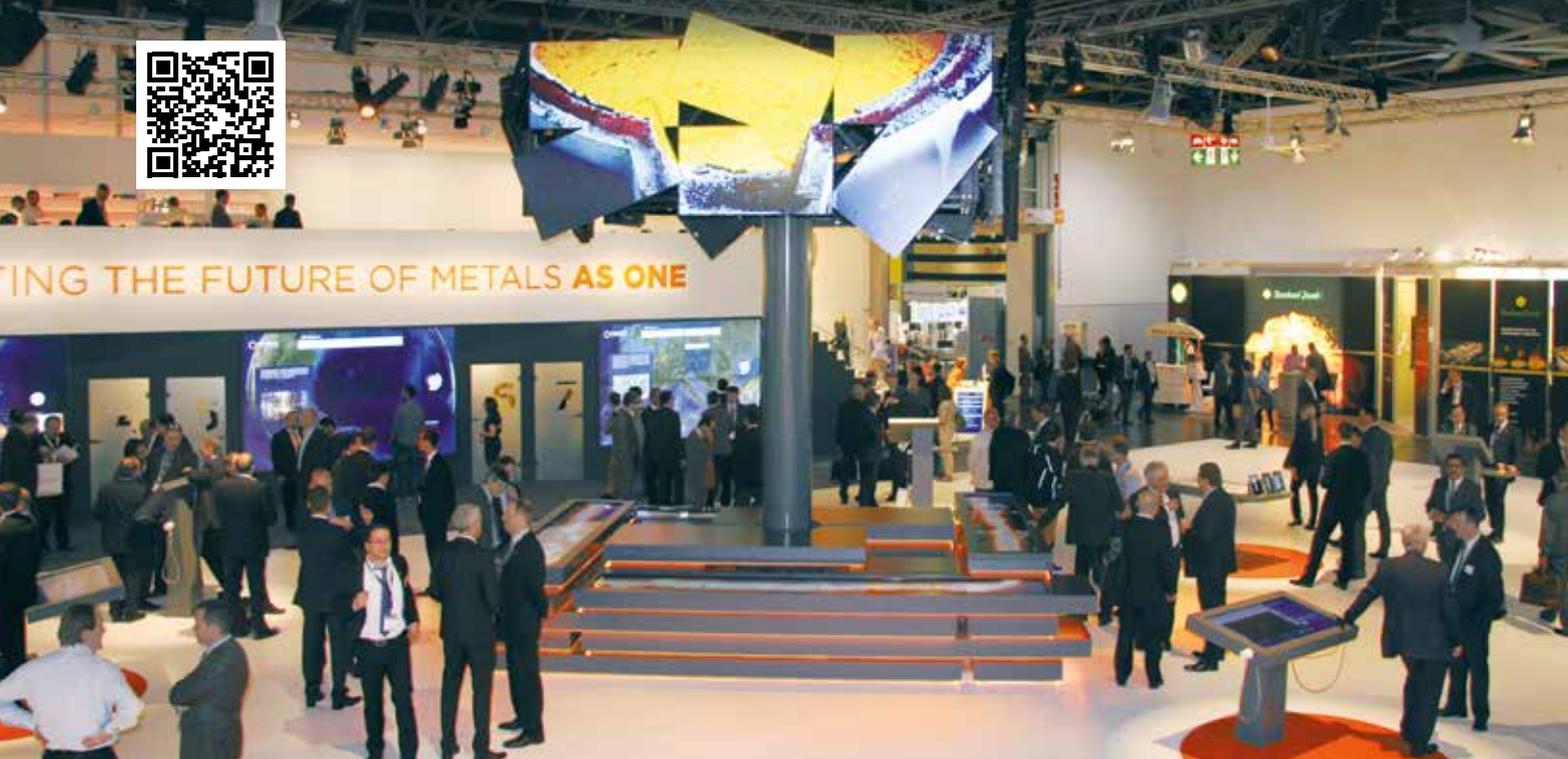


12.

- 06 / Continuous casting
- 07 / Long-rolling (cooling bed)
- 08 / Hot-strip mill
- 09 / Hot-strip mill (coiler section)
- 10 / Cold-rolling
- 11 / Strip processing
- 12 / Metallurgical services

THANK YOU!

The “hero object” at the Metec 2015 exhibition stand of Primetals Technologies: dancing screens projected scenes from the metallurgical process route in a baffling choreography of light, sound and emotion.



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W4 5YS, London, United Kingdom

Metals Magazine Team: Dr. Lawrence Gould, Managing Editor;
Miguel Micaelo, Brand Communication Designer;
Alexander Chavez, Freelance Editor (chavez@ac-communications.de);
Allison Chisolm, Freelance Editor (Chisolm@ChoiceWordsOnline.com);
Dr. Tim Smith, Consulting Editor (tjsmith560@btinternet.com);
Monika Gollasch, Art Director, Agentur Feedback;
Clarissa Jochum, Graphic Designer, Agentur Feedback

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(christof.huemer@qupik.com, www.qupik.com)
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(office@mmstudios.at, www.mmstudios.at/)

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Contact address for all reader inquiries:
primetals.com

COVER IMAGE



Galvanizing line

THE FUTURE IS VALUE-ADDED

With the founding of Primetals Technologies, an incredible array of downstream technologies is now available from a single company to support producers to meet all market requirements for ultra-high product quality, precise dimensional tolerances, superior steel properties and efficient, competitive steelmaking.

For inquiries and more information:
primetals.com