ISSUE 01 | MARCH 2018

METALS MAGAZINE

INNOVATION AND TECHNOLOGY FOR THE METALS INDUSTRY

FOCUS TOPIC: THE SMART PLANT OF THE FUTURE

DISCOVER THE CHRISTCHURCH LOCATION OF PRIMETALS TECHNOLOGIES

SPECIAL REPORT: INSTALLATION OF NEW AOD CONVERTER AT SIJ ACRONI

PRIMETALS TECHNOLOGIES

“Digitalization can take many forms, and it sometimes comes in disguise.”

EDITOR'S COLUMN

TOM WIDTER

DEAR READER,

Digitalization has become an integral part of our lives, and it comes as no surprise that we are also seeing it impact the steel industry. However, for several reasons, the changes brought about by digitalization in the field of metals production are harder to grasp than the steady transformation of certain aspects of the private realm. Most of us carry a smartphone and have seen virtual reality devices in action. Some of us might even have experienced self-driving cars. Not everything about these technologies is clear to us, but their complexity appears to be somewhat manageable —in part because we tend to trust the likes of Google and Apple to deliver reliable solutions. When it comes to "Industry 4.0"-type technologies for the steel industry, though, even seasoned plant operators are occasionally overwhelmed with what to make of them. There is the feeling that these solutions will inevitably be characteristic of the future of steel production, but their full potential and their optimum implementation strategy have a huge question mark attached to them. More guidance and support are needed, giving the customer magazine of Primetals Technologies a solid reason to thoroughly and responsibly address open questions around the subject matter of digitalization.

What you can expect from this issue of Metals Magazine is a comprehensive overview of the solutions of Primetals Technologies that will bring your steel-production plant into a fully digitalized future. Many of these solutions will be new to you, and we hope that they will pique your interest. But some you might have known of for several years. Therefore, you might wonder on what grounds they were chosen for inclusion in this magazine edition. Shouldn't Primetals Technologies offer a completely new set of innovations to tackle the challenge of digitalization?

The short answer is "no." The steel industry has been ahead of other fields for decades and should be proud of its far-advanced technologies, for instance of the process models in continuous casting. It is quite appropriate to put these sophisticated, proven solutions into the context of digitalization—as long as one important factor is maintained, which is their "digital orchestration." Making all production stages and all involved equipment work together in harmony is what's truly at the heart of achieving "Industry 4.0"-compatible steel-production plants.

Digitalization can take many forms and sometimes comes in disguise. To the left, hidden behind the zeros and ones, there is meaning: it is "Primetals Technologies" in binary code. I hope that you will find this issue equally revealing.

Yours sincerely,

Dr. Tom Widter
Editor-in-Chief of Metals Magazine
metalsmagazine@primetals.com

Plant operators at Arvedi Group's Cremona ESP plant

The 72-page focus topic of this issue discusses the impact of digitalization on the metals industry—and presents the solutions of Primetals Technologies, which can bring today's steel plants into the world of tomorrow.

PRIMETALS TECHNOLOGIES APP

Scan this QR code with your iOS or Android tablet for a free download of our app.

COMPANY LOCATIONS

SPECIAL TOPICS

YASUKUNI YAMASAKI
CEO and Chairman of
Primetals Technologies

“It is clear to me that digitalization will be a major driver of progress for the metals industry, and I am proud of the solutions that my company has to offer to facilitate the transition ahead.”

Yasukuni Yamasaki

MESSAGE FROM THE CEO

DEAR CUSTOMERS,

For ages now, metals production has been of extraordinary significance to human civilization. Even the first comparably crude forms of metal were viewed as enormously precious base materials. Their novel existence revolutionized the tools available to man and determined what technological progress the ancient societies could make. The terms "Bronze Age" and "Iron Age" still remind us of that fact.

Today, we have firmly arrived in the digital age. This new era is not limited to information technology alone. It has already begun to shape our idea of how industrial manufacturing will be executed in the future—and importantly, it has started to change how steel and non-ferrous metals are produced.

So what will a fully digitalized steel plant look like? How will it differ technologically from the production environments we are familiar with? And what are the crucial steps that metals producers should take today to become the market leaders of tomorrow?

There are no simple answers to these questions, and let me tell you why. Firstly, every metals producer relies on a unique combination of production equipment in a distinctive setup. The investment costs associated with the existing equipment are usually high enough to demand that any addition, however groundbreaking, must maximize the potential of what is already in place.

Secondly, digitalization will impact all steps of the metals-production chain, but it will change them with different solutions. Let me give you two examples: We are offering sensor technologies that are perfect for cold-rolling applications, but they couldn't be used in a hot-rolling context. We have automation systems that introduce immense amounts of application knowledge into a particular area—for instance, with the aim of minimizing scrap in continuous casting—but these systems were optimized to excel in their field and could not be easily converted to fit another purpose. So as you can see, digitalization in metals production is complex and requires a multitude of separate technologies working together.

At Primetals Technologies, we have found that this complexity is best captured by use of a metaphor. Our "Metals Orchestra" concept was developed to illustrate that every metals-production plant consists of many different pieces of equipment, which can be seen as the players of an orchestra. All of them need to be brought to a certain level of proficiency, and they also have to be properly directed in order to perform in harmony. In an orchestra, an experienced conductor will ensure the alignment of all players; in a metals-production plant, sophisticated software systems take charge of all connected equipment.

This issue of Metals Magazine gives you an overview of numerous important solutions that Primetals Technologies has at its disposal to prepare your production equipment for a digitalized future. Depending on your situation and your targets, a distinct combination of technologies will be ideal for taking your plant to the next level.

It is clear to me that digitalization will be a major driver of progress for the metals industry. As I stated earlier, we are at the beginning of the digital age of metals production, and I am proud of the solutions that my company has to offer to facilitate the transition ahead. At Primetals Technologies, the entire staff is fully dedicated to advancing digitalization in metals production.

I want this issue of our customer magazine to underline our commitment: We are ready to support you in pioneering the future of metals production—in advancing your very own Metals Orchestra, wherever you are located and whatever your goals may be.

RECENT PROJECT AND **COMPANY NEWS**

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

1. Orizaba, Mexico
2. Volta Redonda, Brazil
3. Siegen, Germany
4. Odolo, Italy
5. Linz, Austria
6. Leoben, Austria
7. Gubkin, Russia (see page 9)
8. Dolvi, India
9. Tangshan, China
10. Rizhao, China
11. Shanghai, China
12. Kaohsiung, Taiwan
13. Fukuyama, Japan

Geographic locations of the project news topics addressed in this section

Metalloinvest's new Midrex HBI plant will increase the company's HBI production capacity to 4.5 million tons per year.

Direct-reduction HBI plants near the city of Gubkin, Belgorod Region, Russia

PERFORMANCE-TEST CERTIFICATE RECEIVED FOR NEW HBI PLANT

RUSSIA: The new hot-briquetted iron (HBI) plant at Lebedinsky Mining and Processing Integrated Works in Gubkin, Russia, has announced the completion of its performance-guarantee test. Going by the name "Midrex HBI-3," the plant is owned by the Metalloinvest group and has a capacity of 1.8 million tons per year. It is already Metalloinvest's second HBI plant and was supplied to Metalloinvest by a consortium of Primetals Technologies and Midrex Technologies, Inc. The consortium companies were responsible for the engineering and supply of mechanical and electrical equipment, steel structure, piping and ductwork, as well as training and advisory services. Metalloinvest also utilized the expanded project financing capabilities of Primetals Technologies Austria and Midrex. The plant produces high-quality HBI from iron ore pellets using the natural-gas-based and environmentally friendly Midrex direct-reduction process. The HBI-3 will increase Metalloinvest's HBI production capacity to 4.5 million tons per year, strengthening the company's leadership in commercial HBI and bringing its world-market share to over 40%.

The aim of the modernization project at CSN is to improve product quality and reduce maintenance costs.

TYASA ORDERS COMBINED GALVANIZING AND COLOR-COATING LINE

1. MEXICO: Mexican steel producer Tyasa has placed an order with Primetals Technologies for a combined galvanizing and color-coating line (CG-CCL), to be installed at its steelmaking plant in Orizaba. The scope of supply includes an entry section with double payoff reel and scrap evacuation, a mash-lap welder, a horizontal looper, a horizontal direct-fired furnace and after-pot cooling tower, a GI coating pot, a wiping system with Dynawipe air knives, a 4-high skin-pass mill, a 6-high tension leveler, and an in-line chemical surface treatment section for passivation and paint pre-treatment. The production of the first galvanized coil is planned for December 2018, and the first painted coil for March 2019.

Excavation works at Tyasa's Orizaba site prior to construction of the new CG-CCL

Exit section of a continuous slab caster at the Volta Redonda, Brazil, production site of Companhia Siderúrgica Nacional (CSN)

PRIMETALS TECHNOLOGIES TO MODERNIZE THREE CONTINUOUS SLAB CASTERS OF CSN IN VOLTA REDONDA, BRAZIL

2. BRAZIL: Brazilian steel producer Companhia Siderúrgica Nacional (CSN) has awarded Primetals Technologies an order to modernize three continuous slab casters at its Volta Redonda production site in Rio de Janeiro state. The focus of this turnkey project lies on the revamp of the electric and basic (Level 1) automation, including the implementation of a number of technological packages, the installation of new automation and drive technology, as well as the construction of new auxiliary systems and several control rooms. The aim of the modernization project is to improve product quality and to reduce maintenance costs related to Electrics & Automation. Installation work is scheduled for the second half of 2018 during a regular shutdown. Commissioning is planned for the third quarter of 2018.

LIQUIROB CASTING-PLATFORM ROBOT BROUGHT INTO OPERATION AT DEUTSCHE EDELSTAHLWERKE

3. GERMANY: A LiquiRob casting-platform robot from Primetals Technologies was brought into operation at the Siegen plant of Deutsche Edelstahlwerke GmbH in the fall of 2016. LiquiRob is used at the plant's continuous billet caster, where it handles the automatic lancing of the ladles—a task that was previously performed manually. LiquiRob has significantly increased worker safety at the caster, as operators no longer need to enter the potentially hazardous area where liquid steel can get out of control. It also facilitates the use of heavier and more efficient lances. LiquiRob was specifically developed by Primetals Technologies to address the issues of occupational safety and measurement quality in the most challenging operating conditions. It has been widely successful: Numerous LiquiRob systems are currently in use at continuous casting plants around the world, including applications at electric arc furnaces and converters. Find out more about LiquiRob on pages 50-51 of this magazine issue.

NEW ERT-EBROS BILLET-WELDING SYSTEM FOR ROLLING MILL TO BE SUPPLIED TO FERRIERA VALSABBIA

4. ITALY: Italian steel producer Ferriera Valsabbia S.p.A. has ordered ERT-EBROS endless-rolling technology for the company's existing bar-rolling mill in Odolo, Brescia province. The aim is to boost plant output and utilization levels. The system welds together billets intended for rolling, thus enabling a continuous rolling process with consistently high product quality. Primetals Technologies will be responsible for project engineering, assembly, and supervision of the commissioning of the new equipment. The scope of supply comprises the ERT-EBROS billet-welding system, a deburring station, an extraction system, and complementary equipment such as a pinch roll, shear, and roller table. Fluid systems, the electrical equipment, and an automation system are also included. The ERT-EBROS system will be designed for an annual production capacity of 900,000 tons. It represents the first ERT-EBROS system in Italy to date, and is scheduled to commence operation in September 2018.

Andreas Gahleitner of voestalpine (to the right) and Dr. Alexander Fleischanderl of Primetals Technologies.

10 YEARS OF MEROS: PIONEERING GREENER SINTERING SOLUTIONS

5. AUSTRIA: Steel producer voestalpine Stahl and Primetals Technologies Austria celebrated the 10-year anniversary of the MEROS emission-reduction solution in December 2017. MEROS enables a dry-type offgas-cleaning process that dramatically reduces harmful emissions from sinter plants. The technology is a huge step forward in terms of reaching environmental compatibility: in a series of successive treatment steps, dust and harmful metallic and organic components found in sinter off-gas are lowered to levels previously unattained with conventional gas-treatment techniques.

> **"MEROS is still the solution of choice to make sintering environmentally friendly."**
>
> Dr. Alexander Fleischanderl, Technology Officer Upstream and VP of Iron- and Steelmaking at Primetals Technologies

Primetals Technologies will supply the CC4 4-strand continuous bloom caster for the voestalpine steel works in Leoben, Austria. The photo shows the CC3 continuous bloom caster in the same works, which was also supplied by Primetals Technologies.

VOESTALPINE ORDERS 4-STRAND CONTINUOUS BLOOM CASTER FOR LEOBEN STEEL WORKS

6. AUSTRIA: voestalpine steel Donawitz GmbH, a subsidiary of the voestalpine corporation, has awarded Primetals Technologies with an order to supply a 4-strand continuous bloom caster for its steel works in Leoben, Austria. The CC4 plant will replace the existing CC2 continuous caster. In 4-strand operation, it is designed to produce 950,000 metric tons of highest-quality blooms per annum. The new plant is scheduled to be brought into operation at the end of 2019, when it will become the world's most modern caster of its type. The plant is also "Industry 4.0"-compatible. The continuous caster will produce round blooms with a diameter of 230 millimeters and rectangular blooms with a cross-section of 270 x 360 millimeters, and it is designed so that it can also produce a format of 440 x 330 millimeters. The following can be processed: rail steels, case-hardening steels, machining steels, steels for seamless tubes, heat-treated steels, spring steels, cold-headed and cold-extrusion steels, tire cord steels, cold-work steels, bearing steels and welding electrode steels. The continuous bloom caster is equipped with the DynaFlex hydraulic mold oscillator and the LevCon mold level control. The combination of the Dynacs 3D secondary cooling system and the fully automated casting clearance DynaGap Soft Reduction 3D ensure cast blooms of a consistently high quality. The plant also has an online traversing strand stirrer, with a traversing range controlled by Dynacs 3D. The scope of delivery additionally includes special mechatronics packages and an integrated automation solution. Read more about some of these technologies on pages 62-63 of this issue.

A number of technology packages, such as DynaGap Soft Reduction and the Dynacs 3D cooling model, will ensure that the slabs have high internal and surface quality.

Example of a continuous slab caster from Primetals Technologies. A similar caster will be installed in the Dolvi plant of JSW Steel in India.

TWO CONTINUOUS SLAB CASTERS AND HOT-STRIP MILL FOR JSW STEEL

8. INDIA: Primetals Technologies has won an order from JSW Steel Ltd., an Indian steel producer, to supply two continuous slab casters to its plant in Dolvi, Maharashtra. Together, the two two-strand casters will have an initial annual capacity of around 4.5 million metric tons of slabs with a future capacity potential for 6 million metric tons. The casters are scheduled to come on stream in the middle of 2019. A number of technology packages, such as DynaGap Soft Reduction and the Dynacs 3D cooling model, will ensure that the slabs have high internal and surface quality. In addition to the casters, Primetals Technologies has received the order to supply a hot-strip mill to the Dolvi site. The mill has an annual capacity of 5 million metric tons per year. JSW Steel already operates three continuous casting plants from Primetals Technologies at its steel works in Toranagallu, Karnataka.

HBIS ORDERS TWO CONTINUOUS SLAB CASTERS FOR LAOTING PLANT

9. CHINA: Chinese steel producer HBIS Laoting Steel Co. Ltd. has ordered two new twin-strand continuous slab casters from Primetals Technologies. The casting plants have a combined capacity of 4.2 million metric tons of slabs per annum and will form part of a new production facility for high-quality steels being built in the Laoting district in the south east of the autonomous city of Tangshan. The plants are scheduled for commissioning in February and March 2019. Primetals Technologies is responsible for the detail engineering of the casting platform and the strand-guiding system, the basic and detail engineering of the maintenance area, as well as the engineering of the automation and the software for the new continuous slab casters. The scope of supply includes the complete electrical installations and automation, as well as core components, such as molds and mold oscillators, and Smart Benders and Smart Segments for the strand-guide system. Potentially hazardous tasks will be handled by LiquiRob casting platform robots. (See also pages 50-51.)

Twin-strand continuous slab caster from Primetals Technologies

The project includes the replacement of obsolete or redundant features via the modernization of the mold and the installation of proven technology packages.

RIZHAO ORDERS THROUGH-PROCESS OPTIMIZATION FOR FULL PRODUCTION ROUTE

10. CHINA: Chinese steel producer Rizhao Steel Group Co., Ltd., awarded Primetals Technologies with an order for implementing the newly developed Through-Process Optimization solution (TPO) at its site in Shandong Province. The system will continuously monitor and manage product quality by recording all process parameters as well as measured production and product data, starting from the liquid phase to the casting-rolling (Arvedi ESP) lines and on to final processing. Among other things, it allows for comprehensive quality conformance checks and root cause analysis in case of quality deviations. (See also pages 27-29.)

INDUSTRY 4.0 PACKAGE FOR HOT STRIP MILL AT BAOSTEEL, CHINA

11. CHINA: Baoshan Iron & Steel Group Co., Ltd., (Baosteel, now part of Baowu Steel Group), has recently signed a contract for the supply of the technology package "Dynamic Width Control"—a part of the Industry 4.0 portfolio of Primetals Technologies. The technology manipulates the width by means of tension control in the finishing mill, using width change prediction based on machine learning (see also page 53). The package will be installed on a hot-strip mill in Shanghai, China, as part of Baosteel's "Intelligent Workshop" pilot project in the "China Manufacturing 2025" program. The aim is to improve width performance and reduce waste material.

Continuous slab caster at the Kaohsiung plant of Taiwanese steel producer China Steel Corporation (CSC).

UPGRADE FOR CSC'S CONTINUOUS SLAB CASTER IN KAOHSIUNG, TAIWAN

12. TAIWAN: Primetals Technologies has received an order from Taiwanese steel producer China Steel Corporation (CSC) to upgrade the continuous slab caster S6 at the company's Kaohsiung plant. The project includes the replacement of obsolete or redundant features via the modernization of the mold and the installation of proven technology packages. The aim is to increase flexibility and product quality, and to minimize breakouts. Startup of the modernized caster is expected in mid-2018. Primetals Technologies will equip the caster with the DynaWidth hydraulic mold width adjustment to allow accurate slab width change, the Mold Expert breakout prevention and mold monitoring system to minimize the possibility of breakouts, and the DynaFlex hydraulic mold oscillator to maximize product surface quality. For more information on digital solutions in casting, see pages 56-65 of this issue.

Computer-generated image of the new sinter plant from Primetals Technologies to be supplied to Japanese steel producer JFE Steel Co.

JFE STEEL ORDERS NEW SINTER PLANT FOR FUKUYAMA 3 SITE

The sinter plant features a state-of-the-art waste gas recirculation system, thus reducing environmental impact.

13. JAPAN: Primetals Technologies has received an order from Japanese steel producer JFE Steel Co. (JFE Steel) to supply a new sinter plant for its Fukuyama, Japan, production site. The order includes the 4.8 million-ton-per-annum sinter plant, the sinter cooler and the product handling system. The new plant will replace the existing sinter plant No. 3. It features a state-of-the art waste gas recirculation system, thus reducing environmental impact. The new plant is expected to be started up in the fourth quarter of 2019.

The new sinter plant for JFE's Fukuyama works, located in the east of Hiroshima Prefecture, will have a sintering area of 387 square meters. Supplying the sinter plant, sinter cooling and product handling system, Primetals Technologies will also be responsible for engineering and on-site supervision. JFE Steel will be in charge of erection, civil works, and electrics and automation. The new sinter plant will be equipped with the latest waste gas recirculation technology to ensure a reduced environmental impact through the sinter process. Latest designs and developments for major equipment will be tailor-made as per JFE Steel's requirements for this project (e.g., water-cooled star crusher). The main reasons that JFE Steel cites for awarding the order were the high technological standards of Primetals Technologies' sinter plant solution as well as the international references in this field.

THE SMART PLANT OF THE FUTURE

THE FUTURE OF STEEL PRODUCTION IS BASED ON THE "INTELLIGENT ORCHESTRATION" OF ALL EQUIPMENT. WE TAKE A DETAILED LOOK AT HOW TO ACHIEVE IT.

THE SMART PLANT OF THE FUTURE— INTRODUCTION

Where is the steel industry going, how will it embrace digitalization, and what are the long-term benefits that can be expected from the recent advances in automation technologies? In this article, we lay out the strategy Primetals Technologies has devised for how steel producers can best prepare their operations for the years ahead.

Technology has recently made a giant leap forward. Our phones are now smarter than ever, our computers seemingly anticipate our every need, and our home devices can regulate room temperature, turn on the lights, set daily schedules, plan our commute, conjure up virtual-reality environments, and help improve our health. Autonomous cars are on the verge of large-scale commercial deployment, and self-driving trucks and other forms of transport will follow them shortly. Our lives are changing fast, and one senses that the acceleration curve of innovation has never been steeper.

THE UBIQUITOUS CLOUD

Powered by large server arrays that we call the "cloud," many of today's consumer technologies exhibit a level of intelligence that is both remarkable and overwhelming. We may take it for granted that the contacts on our mobile phones are updated automatically and that we can dictate search queries instead of typing them in letter by letter. Yet the underlying complexity of these tasks is something we usually only have a vague idea of. Exactly how cutting-edge electronic products build up their intelligence is hard to grasp—even if it appears that their continual connection to the cloud must have made a vast contribution to the recent increase in performance. This is why it can be fascinating but also somewhat intimidating to use cutting-edge smart devices.

SMARTER TECHNOLOGY

It is not only consumer technology that has made giant advancements. The same is true for steel-production solutions. They too have become "smarter," and they too have reached a level of sophistication that is both awe-inspiring and occasionally intimidating—even to seasoned industry professionals who have continuously worked hard to stay up-to-date with innovations made in the steel industry. Terms such as "Industry 4.0," "digitalization," and the "Industrial Internet of Things" have tried to capture some of the pivotal aspects of the recent technological progress. But so far, these keywords have

WHAT IS THE "CLOUD?"

The word "cloud" has become synonymous with "an array of network servers located somewhere in a remote location." Generally, cloud computing as a concept is based on the combination of computing infrastructure and a supporting software model to enable universal access to shared pools of processing power and data-storage resources. For the steel industry, cloud-based services introduce the option of outsourcing the collection and evaluation of production data via a secure connection to a third party with experienced data scientists and process know-how experts.

fallen short of clarifying the ultimate goal of the initiatives associated with them.

THE FUTURE IS CLEAR

In this issue of Metals Magazine, it is our goal to thoroughly demystify these terms. Rather than talk of an abstract "Industry 4.0," we at Primetals Technologies would like to discuss the path we see leading into the digitalized future of steel production. It is clear to us that this path encompasses a multi-dimensional, comprehensive digital integration of all production equipment found in a typical steel plant. What is crucial for meeting this target is not only interconnected components but also innovative software that makes the complexity arising within a production facility more manageable.

As in other industries, the accumulation of a plant's production data by use of smart sensors is only the first step. It is a prerequisite for the creation of a "digital twin" of the respective facility, which then takes transparency in steel production to the next level. In the end, the target is to enter a world in which steel is made with fewer resources on all fronts—from energy requirements to raw-material expenditures to labor costs.

Steel producers will also be more flexible. No longer will the paradigm of "producing more for growth's sake" be the reasoning of choice. Instead, producers will be able to re-adjust their production setup with such ease that very small lot sizes can be achieved and customization can reach new levels of depth. Seamless documentation of the manufacturing process will ensure that all end products not only meet their specifications but that their full production history is known in detail, which is a decisive factor for complete and lasting customer satisfaction.

WHERE ARE WE NOW?

So if this is where we are going, then where are we now? Let us make a brief assessment. When it comes to process automation, the steel industry has been ahead of other sectors for decades. While most steel producers have employed and refined "Level 1" and "Level 2" automation for years now, many companies belonging to the discreet-manufacturing sector are lagging behind in terms of automation. And that is really just one example of an industry that has some catching up to do.

Automation in steel production is special in that it is not only based on process models but also on abstractions of what happens inside the liquid steel itself—particularly at the stage of solidification. Thermodynamics play a huge role in this context, and the related mathematical models are indeed as complex as one would expect them to be. The next step of course is to use three separate but linked types of models simultaneously: a model of the steel as it is being transformed, a model of the entire steel-production process from the ironmaking stage to the final treatment, and a model of the complete plant, as built, including "invisible aspects" »

TODAY'S SMART DEVICES

Smart devices are defined by three characteristics. First, they have a means of connecting to a network or to other smart devices using data-transfer technologies and protocols such as mobile broadband, Wi-Fi, and Bluetooth. Secondly, they are often small in size but carry sufficient processing power to enable complex operations as well as interaction with one another and the Internet. Thirdly, they are capable of collecting input from the human end user in a variety of forms (text-based input, speech, pattern recognition, etc.) and provide information and entertainment in a multitude of forms. As for the form factor of today's smart devices, they range from small-sized smartphones to larger hand-held tablets to surface computers, TV sets, and household appliances. They are also an integral part of the smart steel plant of the future, for instance in the form of smart sensors.

WHAT IS A "DIGITAL TWIN?"

The term "digital twin" refers to a detailed digital representation of physical assets including the processes that these assets allow to be executed. Importantly, a digital twin has to dynamically reflect any changes made to its actual, physical counterpart. This is done by bringing together a semi-modular base structure, advanced process models, machine learning, software analytics, and artificial intelligence with clearly defined targets. The strength of a digital twin is that it continuously learns and updates itself ideally in real time, utilizing the combined information from a variety of sources. Besides sensor data, a capable digital twin relies on expert knowledge gathered from skilled human operators, on the technical expertise of specialized engineers, on findings stemming from similar digital twins, and on the larger environment that the digital twin may be a part of. Of course, historical data also plays a big role in advancing a digital twin's depth. When applied to a steel-production facility, the main benefit of introducing a digital twin is that any envisaged changes to the physical production chain can be tested and evaluated beforehand in the digital domain at zero risk.

THREE CLASSES OF MODELS

A unique feature of the advanced automation systems developed for the steel industry is that three classes of models can be used simultaneously and in conjunction with one another. This is an area in which Primetals Technologies has done significant pioneering work. Among the first class of models are those that capture the overall setup of a metals-production plant. A model belonging to this group encompasses the core plant layout including the production equipment of all process stages. The second class relates to the processes taking place inside the plant. These types of models are detailed abstractions of what is done by any given piece of equipment over the entire length of the production chain, and at any given time. The third class is arguably the most complex of the three. Its models are representations of what goes on inside the product itself as it is being created and formed. They capture the changes that occur in the liquid steel when it is being cast and when it solidifies. Models of the third class extend to the rolling, further processing, and coiling of the steel, thereby making tremendous complexity much more manageable. It is the parallel existence of these three classes of models that make the steel industry stand out.

HOW CAPABLE IS TODAY'S AI?

It is no secret that artificial intelligence (AI) is still at the beginning of its development. However, the impact it could have on our society once it reaches a more advanced stage is already a much-discussed subject. The core idea behind the concept of AI is that machines are brought to a stage where they can perceive their environment and take action to maximize the probability of a certain outcome. In consumer electronics, AI can be seen at work in speech recognition, the anticipation of Internet search queries, the automatic display of context-related information, and many other applications. When it comes to steel production, the engineers of Primetals Technologies have already started to implement AI technology in a selection of established data-evaluation processes. Eventually, AI is expected to greatly facilitate the analysis of all production steps within a steel plant. For this to become reality, (smart) sensors must continually collect large amounts of data at all stages of the manufacturing route and for all of the involved equipment. While predictive maintenance has already made great advancements in steel production, AI will push the boundaries of what is possible and significantly increase overall efficiency as well as the reliability of the production process.

related to equipment that is not a direct part of the production chain.

THE SMART PLANT

With these three classes of models in place, the groundwork has been laid for a steel plant to become an "intelligent" plant. What we mean by this term is the following: A smart plant "knows" the state it is in, thanks to condition monitoring, and can make adjustments based on its findings with elaborate automatic functions. Artificial intelligence will increasingly find room to grow in this area, despite being in its infancy today. The plant of the future also facilitates "smart work," which involves all staff members being given the information they need to execute the tasks at hand. Predictive maintenance ensures that production stops are proactively avoided—and that they can be scheduled far in advance, if necessary.

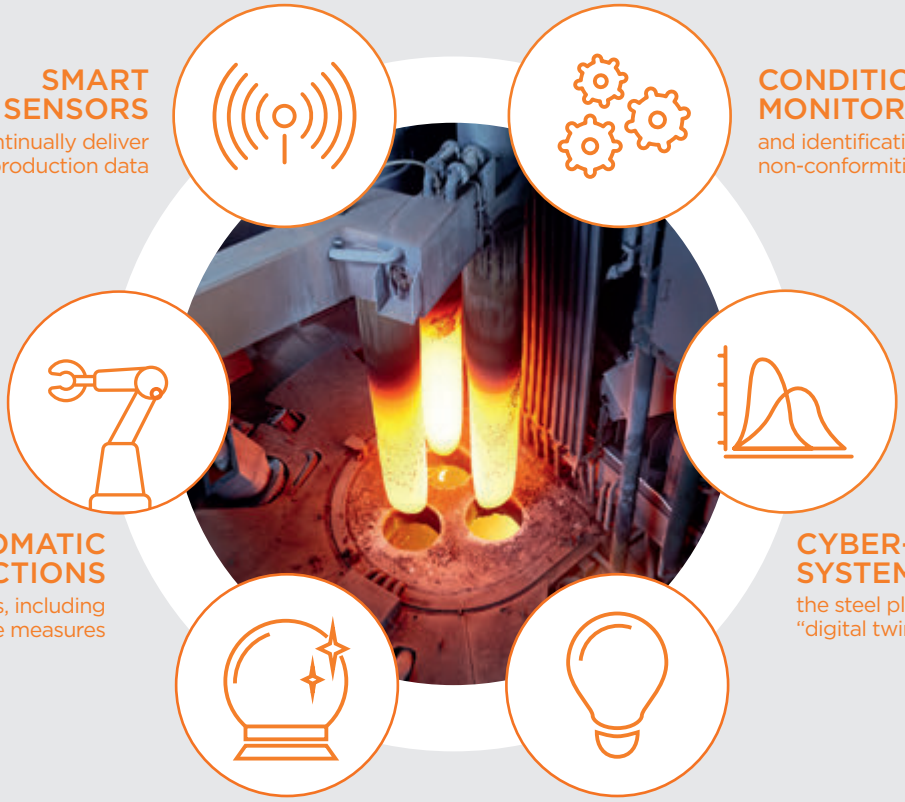
INTERCONNECTED EQUIPMENT

The smart plant we envision relies on three dimensions of integration. The first dimension is that of horizontal transparency and interconnectedness. This means that, for instance, the rolling section of a steel-production plant "knows" precisely what was done at the earlier casting stage, and can therefore react and adjust its parameters accordingly. Depending on the raw materials used, the entire plant has to be run in a specific manner. The smart plant can accommodate a variety of different input-material choices. In other words, it allows producers to benefit from greater "input-material flexibility."

LIFECYCLE PARTNERSHIPS

The second dimension is about time. Every piece of equipment in a steel plant has a particular story, which usually begins with the basic engineering at the planning stage of the respective unit. Once the new facility is built, or, in the case of a revamp, once the new components are added, a period of maintenance-supported operation follows. The smart plant ensures that the overall lifetime of all equipment is maximized, and that any service work is scheduled for such times when the impact on productivity is lowest.

WHAT MAKES A STEEL PLANT "SMART?"



SMART SENSORS
that continually deliver production data

CONDITION MONITORING
and identification of non-conformities

AUTOMATIC FUNCTIONS
of various tasks, including corrective measures

CYBER-PHYSICAL SYSTEMS
the steel plant and its "digital twin"

PREDICTIVE MAINTENANCE
for largely uninterrupted operation

SELF-LEARNING CAPABILITY
for the optimization of production processes

THE DIGITAL UNITY

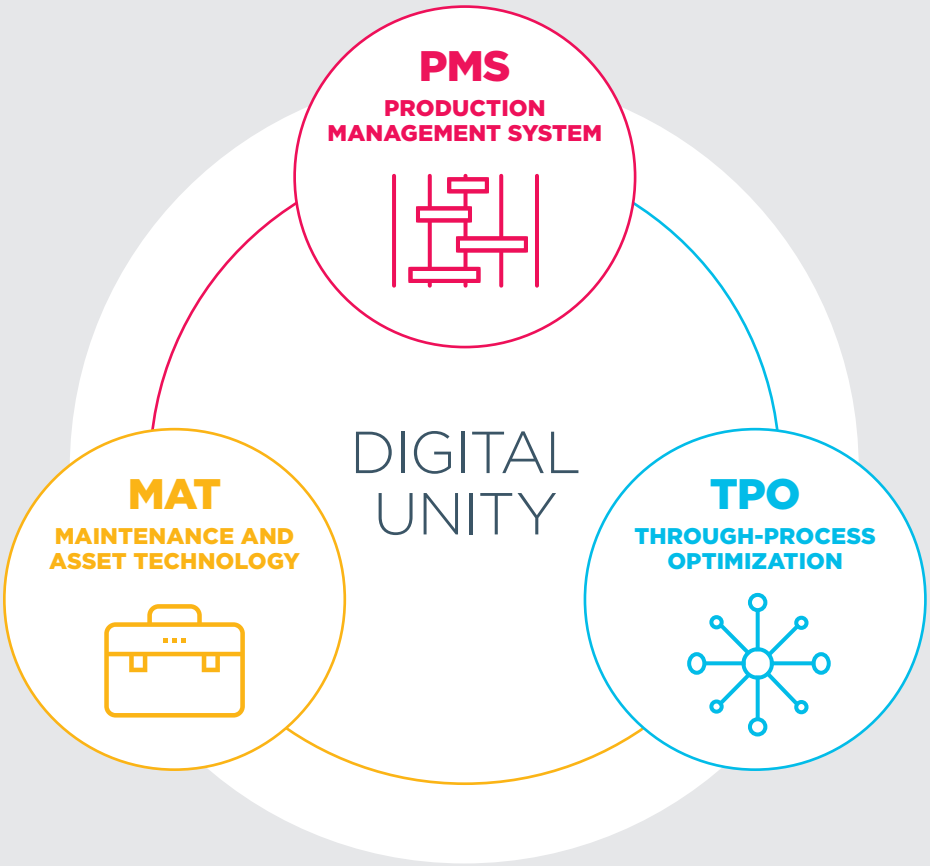
A combination of three software layers represents the third dimension of integration in a smart plant. At Primetals Technologies, we have chosen to partner with German-based PSI to provide our customers with a state-of-the-art production-management system (PMS). This software solution dynamically plans and tracks all plant activity at every step of the production chain. Customer orders are transformed into instruction sets that are then executed in a highly optimized way.

The PMS is accompanied by Primetals Technologies' own Through-Process Optimization (TPO), which scans the entire production process for non-conformities and identifies areas of improvement. When used in a smart plant, TPO can dramatically accelerate a producer's time to market with cutting-edge, high-value steel grades.

Finally, the Maintenance and Asset Technology (MAT) of Primetals Technologies assists and simplifies the maintenance efforts in a smart plant. This system features comprehensive, built-in application knowledge that generates actionable items for the maintenance staff to carry out. All suggestions are devised in accordance with a customized maintenance strategy for optimum efficiency. Advanced analytics give further insight into the inner workings of the plant and into maintenance activities in particular.

VIRTUAL START-UPS

Arguably one of the most impressive characteristics of a smart plant is the possibility to run "virtual startups" within a dedicated software environment called "Maintenance and Simulation System" (MSS, see pg. 60). The MSS lets engineers test new equipment configurations so that only the most efficient setups will be implemented in the real plant. Highly detailed abstractions of some of the steel plant's physical components serve as the basis for the MSS. These abstractions are sometimes introduced into "cyber-physical systems." These systems are bridges between the physical world and the digital domain, and represent aspects from both areas. They are a reflec- »



THREE DIMENSIONS OF SOFTWARE-BASED INTEGRATION

Primetals Technologies has devised a concept for the software-based integration of all aspects of steel production—from order management and the purchasing of raw materials to an optimized execution of all production steps to the management and scheduling of maintenance activities. Importantly, these three software components with know-how based rule sets work toward one common goal, namely to ensure flexible production of consistent-quality steels at the highest-possible productivity levels. Hence, we have chosen to call them a "digital unity" of intelligent orchestration.

tion of the immense complexity at work in a steel plant, and point the way to the future. Besides startup simulations, the MSS can greatly ease the development of new production strategies, for instance, when a change in the core product mix is desired.

NUMEROUS BENEFITS

The smart plant is a major step forward for metals production. Among its main benefits are the possibility to tailor end products to even more specific customer requests. Smaller lot sizes can be achieved without a significant loss in productivity. Everything that is produced at the plant is constantly monitored, tracked, and evaluated, resulting in seamless production documentation for every single order. The smart plant frees up producers to obtain input material from a multitude of sources, as the manufacturing chain can be more easily adjusted to accommodate changes in raw-material quality. Efficiency is improved on many levels. The associated optimization ranges from a reduction of energy consumption to a more effective distribution of human labor. Importantly, the smart plant introduces significant advancements in terms of lowering the carbon footprint and increasing environmental friendliness.

Two of the main characteristics of a smart plant are that the facility can determine its own state, and that it can learn from its own assessments and analyses over time. Both aspects can only be achieved with a holistic approach toward the steel-production process. It is precisely the perfect alignment of all components at work in the facility—by means of their interconnectedness—that can make the smart plant a reality.

OUR METALS ORCHESTRA

At Primetals Technologies, we have devised the concept of the "Metals Orchestra" to illustrate both the finely tuned interaction of all production equipment and its automated operation by the introduction of one unifying metaphor. Just as an orchestra consists of many profi-

MORE ON THE METALS ORCHESTRA CONCEPT

The concept of the "orchestra of steel" was created to reflect our approach for how steel producers can prepare their plants for the decades ahead.

Watch our Metals Orchestra video presentation on YouTube:
bit.ly/orchestravideo

Download our Metals Orchestra brochure by following this link:
bit.ly/orchestrabrochure

cient players, a smart plant comprises numerous different components that must all act in harmony to deliver a standout performance. While it is essential that all players can reach similarly high levels of virtuosity, they also need to be optimally directed to effectively complement each other. This is where, in an orchestra, the conductor comes in. The same is true for a smart steel plant—but here, there are no fewer than three conductors doing their job in perfect unity: the PMS, TPO, and MAT, the software and know-how systems we mentioned earlier.

More needs to be said about these conductors, and the same is true for the many individual players of the "orchestra of steel." Over the course of the next 64 pages of this issue of Metals Magazine, we are therefore presenting a selection of those technologies that ideally prepare a steel plant of today for the world of tomorrow. These components and software solutions will take a steel plant to the next level—and make it one of the first smart, self-learning plants of the future.

BENEFITS OF DIGITALIZATION

- Steel producers can obtain raw materials from different sources and easily adapt to variations in quality
- Higher degree of customization of orders
- Smaller lot sizes without a significant loss in productivity
- Seamless documentation of production history for every single end product
- Higher degree of plant optimization leading to a more efficient operation
- Fully transparent processes and workflows
- Improved environmental friendliness
- Lower energy consumption

SMART SOLUTIONS FOR DIGITALIZATION

THE DIGITAL UNITY | **Through-Process Optimization** | **Production-Management System**

IRONMAKING

- Expert System Blast Furnace → pg. 43
- Expert System Direct Reduction → pg. 40
- Expert System Pelletizing → pg. 39
- Expert System Sintering → pg. 42
- Holistic Ironmaking Optimization → pg. 44
- Tuyere Camera

STEELMAKING

- AOD Optimization
- Automated Scrap Material Flow → pg. 48
- AutoTap
- Bag-Break Detection System → pg. 52
- BOF Optimization
- Condition-Monitoring System for the Converter
- EAF Heatopt
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CONTINUOUS CASTING

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- DynaWidth
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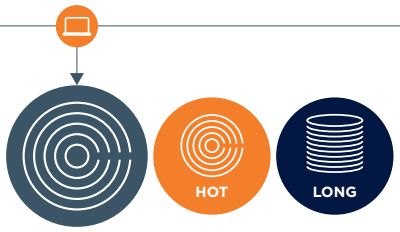
- Inline Strand Checker
- Intermix Expert → pg. 59
- LevCon
- Maintenance and Simulation System → pg. 60
- Mold Expert & Mold Expert Fiber → pg. 57
- Nozzle Expert → pg. 59
- Opal (Condition-Monitoring System)
- OsciChecker Wireless → pg. 64
- OsciMon
- Quality Expert → pg. 58
- Speed Expert → pg. 57
- Taper Checker Wireless → pg. 65
- Yield Expert → pg. 58

Primetals Technologies offers its customers a wide selection of solutions that will propel today's steel-production plants into the digital age. Many of these technologies were specifically crafted to tackle challenges associated with the concept of "Industry 4.0." Others were refined to optimally support their integration into a fully digitally orchestrated plant. All of them exhibit the innovative power and quality that Primetals Technologies stands for.

Maintenance and Asset Technology | BOX Concept (Condition Monitoring)



HOT ROLLING

- Crop Optimization
- Cyber-Physical Model for Cooling → pg. 67
- DIAG Plate Mill Diagnostics System
- Enhanced Temperature Control
- Arvedi Endless Strip Production Level 2 Automation
- Hot Strip Mill Level 2 Automation
- IDRHA+
- Induction Heating
- Long-Rolling Process Expert → pg. 78
- Long-Rolling Roll Master → pg. 79
- Looper ShapeMeter
- Model-Based Strip-Width Control → pg. 67
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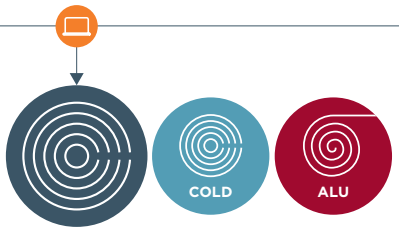
- Wedge and Camber Control → pg. 68
- Width Gauge



COLD ROLLING

- Air-Bearing ShapeMeter → pg. 70
- ChatterBlock → pg. 71
- Coil-Eccentricity Compensation → pg. 74
- Contactless Flatness Measurement
- EdgeWipe
- Minimum-Quantity Lubrication → pg. 76
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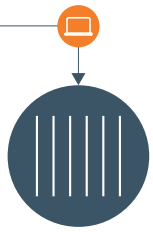
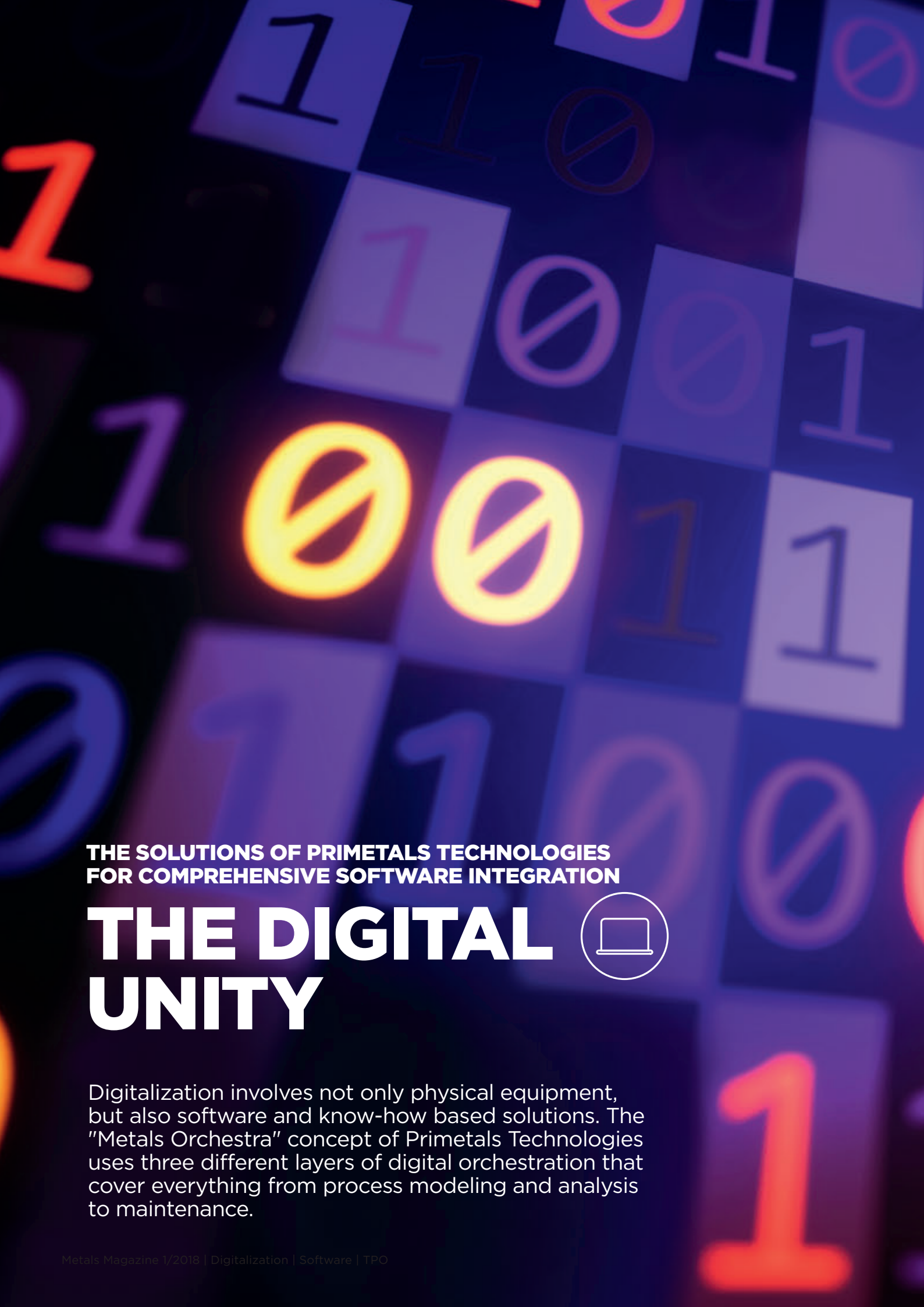
- Orbis+ → pg. 71
- UCM Flat → pg. 72
- Reversing Cold Mill Level 2 Automation
- Tandem Cold Mill Level 2 Automation



PROCESSING

- Condition-Monitoring System for Processing Lines → pg. 84
- DynaWipe
- EdgeMon
- FAPLAC
- PropertyMon
- SIAS Surface-Inspection System → pg. 83
- Speed Optimization System



THE SOLUTIONS OF PRIMETALS TECHNOLOGIES FOR COMPREHENSIVE SOFTWARE INTEGRATION

THE DIGITAL UNITY

Digitalization involves not only physical equipment, but also software and know-how based solutions. The "Metals Orchestra" concept of Primetals Technologies uses three different layers of digital orchestration that cover everything from process modeling and analysis to maintenance.

THROUGH-PROCESS OPTIMIZATION

The progress of digitalization in many industries is creating new opportunities for the improvement of overall efficiency and quality in steel production. At the same time, end-customers are demanding steel products at higher quality levels. They look for tailor-made steel-grade solutions, short development times for new steel grades, and the manufacturer's ability to swiftly respond to quality deviations that have resulted in rejections. The number of customers requesting zero-defect products is constantly growing. As a consequence of this trend, steel producers need to target even higher quality levels, increased process stability, greater process flexibility, and high production efficiency, in order to be successful at manufacturing challenging products for demanding customers.

This means that steel producers need to become even more capable and to use a system that ensures accurate and stable control of all process parameters. Producers require quick and complete access to quality- and process-relevant data, a deep understanding of how a change in process parameters will affect the properties of their products, and the know-how to develop products quickly and successfully. To meet these requirements, Primetals Technologies has developed and introduced the Through-Process Optimization (TPO) solution, which targets the smart, digital interconnection of various process units and the accumulation of know-how along the entire steel-production chain.

GENEALOGY FOR EACH PRODUCT

The basis of the intelligent TPO solution is the Through-Process Quality Control (TPQC) system, which creates a central database by receiving quality- and process-relevant production data from all production units via the Level 1 or Level 2 automation systems. Additionally, laboratory measurements and data from all types of sensors and equipment are centrally stored. The TPQC creates an information-rich genealogy of each individual product that is processed, and makes it possible to retrieve process data of all production steps for every inch of the product. This allows users of TPQC to track quality issues in very little time and analyze them by reviewing process data for all relevant production steps, which is key for fast troubleshooting and claim management.

The essential functionality of TPQC is to ensure desired product properties and increase quality levels by monitoring all quality-relevant process parameters along the

Overview of the full scope of the Through-Process Optimization solution.

full production route at defined quality gates. Therefore, communication between the production-management system (PMS) and individual automation systems of each production unit is required to evaluate distinct steps of the production process. To ensure a continuous increase in achievable quality levels, the TPQC system allows for the implementation of freely editable rules, which are used for the execution of conformance checks during production.

In the event of deviations, TPQC supports operators and quality engineers with root-cause analyses and automatically generated suggestions for corrective and compensational actions. Thanks to the system's customizability, users can implement and preserve their process- and product-oriented know-how by creating and implementing rules tailored to individual steel groups or grades. The integration of all processing units into one interconnected TPQC-based network also permits the creation of "through-process" rules, which extend the corrective and compensational actions to the preceding and subsequent productions steps.

KPIS TO ENSURE QUALITY

The centralized collection of data enables the generation of key performance indicators (KPIs), which convey information about technical and business-related achievements and illustrate what progress has been made. Possible targets are new product-quality or process-efficiency levels, both related to individual processing steps or the entire production chain (throughout the complete production process, hence the attribute "through-process"). TPQC implements various types of graphical human-machine interfaces to support staff members from the quality and production departments, as well as top-management executives, in monitoring and benchmarking production conditions with respect to specific targets that are in alignment with the KPIs.

STATISTICAL PROCESS CONTROL

The TPQC also includes statistical process control (SPC) functionality to confirm that production processes stay within their predefined operational range. Besides improving product quality and process stability, SPC also supports maintenance scheduling and helps in detecting deviations and drifts of various measuring equipment.

MACHINE LEARNING CAPABILITIES

Big data mining and machine learning techniques can be introduced into TPQC via an interface that enables the direct and user-friendly transfer of data to commercial analytics platforms. Outside expertise can be obtained, for instance, when quality or process issues arise. All acquired data is structured and bundled by the genealogy function, which makes it easy to handle even highly detailed inquiries about product properties.

KNOW-HOW FOR SYSTEM TUNING

For the implementation of TPO and in order to resolve specific problems, Primetals Technologies supports its customers with its own experts and with external consultants. These specialists are highly experienced and cover various disciplines, acting as consultants for a wide range of topics; for example, plant operation, quality management, maintenance, or end-customer qualification. Primetals Technologies also provides training sessions for steel producers who decide to implement TPO. In close cooperation with the respective customer, the team of experts devises and incorporates an optimal set of rules into the customer's TPQC system. These rules will ensure better control of the steel-production process, optimize product-quality consistency, and improve general plant operation. Overall, the TPO solution of Primetals Technologies is a powerful enabler for the digital advancement of steel production.

MAIN BENEFITS OF THROUGH-PROCESS OPTIMIZATION

- Improved yield and productivity
- Improved product-quality levels
- Production of more advanced products
- Far greater product-development capabilities
- Benchmarking (KPIs)
- Archival system for quality and process data
- Faster claim management
- Shorter time-to-market for new products
- Build-up of know-how using the TPQC system

The TPO solution of Primetals Technologies is a powerful enabler for the digital advancement of steel production.

PROMOTING THE **DIGITALIZATION OF STEEL PRODUCTION**

Dr. Thomas Pfatschbacher is Head of Technology and Innovation for Casting & ESP, Rolling, Mechatronics, and Through-Process Know-How at Primetals Technologies. Pfatschbacher co-initiated and facilitated the development of the Through-Process Optimization solution, and led the Mechatronics Competence Center in Linz, Autria.

In a nutshell, what are the main goals of Through-Process Optimization?
Dr. Thomas Pfatschbacher: Simply put, our Through-Process Optimization (TPO) increases production efficiency and end-product quality at our customers' steel plants. This is not just an ambition. We can reliably achieve this with our TPO solutions and services. TPO consists of our new intelligent Through-Process Quality Control (TPQC) system and our Through-Process Know-How (TPKH) packages. In essence, it is already a highly advanced solution for the digitalization of steel production. TPO is a comprehensive solution that optimizes the entire production process—from the liquid phase to finalized products such as galvanized steel coils. The new and quite revolutionary aspect is that TPO combines data and information with all kinds of application knowledge; for instance, with operational, metallurgical, quality-assurance, and process know-how. All of this information is then brought together and digitalized by our Through-Process Quality Control (TPQC) system, which we use to create customer-specific "know-how rules" to guide production.

What was the biggest challenge in developing TPO?
Pfatschbacher: There were two. The first challenge was to bring our excellent experts from all individual process units together and ask them to think outside of the box, in order to get a precise understanding of the interdependence between different production stages. Overall end-product quality and operational efficiency are not just the sum of all contributing parts but of their optimal alignment, and this required significant research and permanent optimization. The second challenge had to do with finding a way of digitalizing know-how. It took significant effort before everyone involved started to believe it was possible at all. Even I myself was sceptical in the beginning. But today, the know-how rules we create enable the TPQC to act as an interactive digital assistant that gives advice and support. And we know now that the system has immense potential for future applications.

What does "artificial intelligence" mean to you?
Pfatschbacher: Artificial intelligence (AI) is a topic that we are actively dealing with. For me, it is the combination of data analysis—often "big data" analysis—with statistical and mathematical methods, algorithms, and domain know-how, the latter of which is always needed for AI to work. It is unfortunate that sometimes these factors are forgotten, because discussions about AI tend to get somewhat esoteric without them. I am convinced that the steady increase in processing power and data-storage capabilities will enable new solutions and different kinds of "self-learning systems."

How is machine learning used in the TPQC system?
Pfatschbacher: On the one hand, we are very proud to have exceptional physics-based models for our production plants, in order to capture production processes and evaluate product properties. On the other hand, machine learning is becoming increasingly powerful. We are already using it in several ways. To give you an example, we employ machine learning to implement data-based decision modules and algorithms, to monitor trends, and to introduce corrective actions. We are also developing methods for the classification of defects found by surface-inspection systems. And there are more applications to come.

Among all the "Industry 4.0" technologies Primetals Technologies offers, which is your favorite?
Pfatschbacher: To be honest, my favorite would be the TPO solution. Before joining Primetals Technologies, I worked at the Austrian steel producer voestalpine for almost 15 years. This has given me invaluable insight into the "customer side" of things, and I am fascinated by how much TPO can already support our customers in the steel industry. 10 to 15 years ago, TPO was merely the vision of a handful of innovative and creative people. Today, it combines vast amounts of mechanical, automation, metallurgical, process, and operational know-how, all of which is essential for optimum performance. So I am glad to be a driver for digitalization at my company.

PRODUCTION-MANAGEMENT SYSTEM

Production-management systems for steel plants should ideally cover the entire metals production process from iron- and steelmaking to rolling and processing to shipping of the final product. The production-management solution offered by Primetals Technologies is based on PSImetals, a comprehensive software suite that provides a large number of modules specifically tailored to the metals industry. It is a system that has already proven its merits in numerous steel-production plants worldwide. PSImetals was created and is continually developed and adapted by PSI, a German-based company Primetals Technologies forged a partnership with in the summer of 2016. As a result of this cooperation, customers receive perfectly matched, complete solutions from a single source—consisting of equipment, basic automation, and process automation from Primetals Technologies, as well as a production-management system (PMS) that combines the deep metallurgical know-how of Primetals Technologies with the PSImetals software solution of PSI.

At the core of the PMS lies the capability to evaluate whether it is feasible to manufacture a given product with the available plant equipment, and to determine exactly how the production process will be executed. To enable this kind of sophisticated assessment, the PMS requires extensive knowledge about the explicit and implicit processes taking place at every step of the steel-production chain. It needs to incorporate detailed information about both the production process with all associated equipment, and the transformation that the product itself undergoes until it is finalized. Primetals Technologies has laid the necessary groundwork with its Through-Process Optimization technology and know-how related services, which are separately discussed in this issue of Metals Magazine.

PRODUCT AND MATERIAL TRACKING

In order for the PMS to work effectively, it is crucial to define rules that allow for a dynamic translation of customer orders into concrete instructions for produc-

Aspects covered by the PMS

Planning and scheduling

- Anticipation of future demand
- Material-flow optimization
- Capacity utilization
- Material allocation
- Order and line scheduling
- Evaluation of planning

Production management

- Order-based production management
- Manufacturing execution
- Raw-material and stock management
- Production tracking
- Management of production equipment

Logistics

- Stock management
- Order-based transport coordination
- Transport optimization and execution
- Shipping and delivery

Quality

- Comprehensive quality from definition through quality control
- Seamless integration and application of Through-Process Optimization
- Handling of quality deviations by integration of deviation management with production control

The PMS allows steel producers to dynamically enforce a strategy of highly customizable end-products.

CORE BENEFITS OF THE PMS

- Optimal plant and equipment utilization through planning and scheduling
- Reduced order-turnaround time
- Reduced inventory
- Improved delivery performance
- Higher product quality
- Lower production costs
- Lower energy costs
- Reduced logistics costs

tion execution. The system has to be able to guide and track raw materials and products over the course of their complete manufacturing route, through different facilities, and up to the point of the final product being shipped.

Since the PMS handles products at various stages of completion—in other words, since it handles "intermediate products"—the system design must be programmed to know precisely what the targets are at any step of the production chain. Also, instructions for testing and sampling need to be correctly set to reflect both pre-established standards and end-customer requirements.

The PMS can schedule orders according to plant utilization, and considers machine capabilities and throughputs as well as planned maintenance efforts and temporary equipment deficiencies. This approach allows steel producers to dynamically enforce a strategy of highly customizable end-products, and they no longer need to restrict themselves—or their customers—to a static product portfolio. The steel producer's sales team also profits immensely from the PMS, as the system makes it easy to determine what products can be delivered within what time frame. In the end, the ultimate beneficiary is of course the producer's end customer, who profits from faster order fulfillment and a greater degree of freedom in choosing optimal product specifications.

COMPREHENSIVE OPTIMIZATION **WITH DIGITAL SOLUTIONS**

Kai Ankermann is Head of Production Management at the Electrics & Automation Business Segment of Primetals Technologies.

How does the portfolio of PSI complement that of Primetals Technologies?
Kai Ankermann: The core idea behind our partnership with PSI is that steel producers can now obtain the added value of combining process know-how with IT technology from a single source. Our own Through-Process Optimization and Maintenance and Asset Technology, combined with PSI's PSImetals, form a "Digital Unity"—an incredibly strong and complete technological package.

What is the main benefit for customers?
Ankermann: In the end, our customers need to make money with quality products shipped on time. All components, which in this case mostly consist of powerful software, are an essential part in the effort of increasing a plant's productivity.

Can artificial intelligence play a role in metals production?
Ankermann: I think that the question really is what to expect from artificial intelligence (AI) in this context. Is the self-driving car with all its complexity a proper reference for what AI can and should do in our industry? I think that we should apply a different concept of AI in metals production. Up until today, it is still necessary for operations to plan extensively and react to malfunctions. These areas could be covered by AI in the future. Also, AI could be great at optimizing production planning, to streamline the overall workflow and quickly align all plant activity with incoming customer orders.

MAINTENANCE AND ASSET TECHNOLOGY

Maintenance and Asset Technology (MAT) from Primetals Technologies is a system for the intelligent management of all maintenance-related assets, and can do much more than cost tracking and maintenance scheduling. By applying Industry 4.0 principles to maintenance management, MAT delivers intelligence that transforms maintenance activities from a burdensome cost factor into a strategic advantage for more effective plant operations.

SUPPORTING PRODUCTION

The ultimate goal of maintenance management is not to perform maintenance for its own sake—its purpose is to support production. Great maintenance reduces risk and improves performance. Its benefits must continuously be balanced against the costs of personnel, materials and above all lost productivity. Plant maintenance today is often managed in a fairly traditional manner, as a cost center focused on staying on budget. Maintenance strategies are often reactive, or based on simple time intervals that were put in place based on the opinion of technicians. Condition monitoring may be in place, but often without a clear goal. Computerized maintenance management systems (CMMSs), when implemented, tend to concentrate on tracking and data archiving.

Meanwhile, due to increased cost pressure, plant maintenance teams face significant efficiency challenges. Resources—men, materials and machines—must be organized for highest productivity. However, in the dynamic 24/7 environment of a steel mill where every minute of downtime is costly, priorities can change fast, and the maintenance staff has to respond with the same speed. Standard enterprise resource planning software is not flexible enough and lacks domain expertise for decision-making support; changes can impact orders for weeks to come, requiring tedious rescheduling routines.

RISE OF THE "SMART FACTORY"

Fortunately, the rise of the Industry 4.0 "smart factory" provides a great opportunity to improve maintenance management. Now, plants and IT systems can talk to one another. Condition monitoring information can lead to maintenance suggestions in MAT and ensure that no important alarm is left unattended. Production planning, quality management, through-process optimization and maintenance/asset management can be connected to exchange information. MAT provides all of the Industry 4.0 intelligence needed for a highly flexible maintenance execution. Advanced visual scheduling makes the best use of both personnel and equipment, ensuring efficient planning with minimal production impact so that changes and their consequences can be easily understood.

MAT is a must for everyone involved in a steel plant's maintenance efforts, and key in gaining a competitive advantage.

MODULAR ARCHITECTURE

Four smart modular packages—Predictive Maintenance, Planning & Shutdown Optimizer, Reporting & Business Intelligence, Strategic Asset Management—provide intelligence and domain expertise and help customers step by step toward world-class maintenance. With decades of industry-specific experience behind it, MAT can come pre-loaded with everything from criticality assessments and maintenance strategies for specific equipment, to procedures, documentation and checklists for responding to specific alarms.

Furthermore, with MAT, the wealth of data available from your plant coupled with industry-specific expertise from Primetals Technologies, can transform tedious maintenance routines into a smart asset management program. Maintenance decisions can be made strategically and dynamically, based on data gathered from both condition monitoring and manual inspection. Instead of sifting through multiple data stores, with a single click the workshop can have access to the full history of a particular piece of equipment to understand how often the asset needed repair, which parts were changed, which improvements were implemented. Through data analytics, maintenance needs can be predicted and planned, and the focus can shift to creating value, reducing total cost of ownership, and increasing productivity.

GAINING COMPETITIVE ADVANTAGE

Before you can even ask, MAT answers questions such as: What must be done when a specific alarm goes off? On what basis (time, usage, wear, etc.) should you maintain a specific asset, or should you simply wait until it fails? Can you postpone an inspection until after the next big order? Can a different material be produced until an equipment problem is resolved? Which preventive maintenance procedures are worth implementing and which are not? What investments in condition monitoring bring the greatest return? What conditions or products are associated with the most downtime? What maintenance procedures extend equipment lifespan? With MAT, such information is easily gained and the associated processes are streamlined—MAT is a must for everyone involved in a steel plant's maintenance efforts, and key in gaining a competitive advantage.

EXPERIENCING MAT FIRST-HAND

Paulo Marinho is Head of Operations at Primetals Technologies' workshop in Rio de Janeiro, Brazil. The site is located in the vicinity of the facilities of Ternium Brazil (formerly thyssenkrupp CSA). In 2009, the workshop started to provide metals producers with online and offline maintenance for the whole steel mill, including segments repair for continuous casting machines and roll refurbishment, as well as nickel plating for the molds. Marinho has overseen the on-site implementation of the Maintenance and Asset Technology (MAT) system of Primetals Technologies in his workshop, and participated in fine-tuning the system to meet the needs at hand.

How long have you been using MAT?
Paulo Marinho: We started the project in December of 2016 as a cooperation between our staff at the Rio de Janeiro workshop and our Metallurgical Services headquarters in Linz, Austria. Since then, we have thoroughly tested MAT's features. It has been a great product launch, and despite the steep learning curve we were able to meet the expectations of everyone involved.

Has MAT made your life—and that of your staff—easier, and how?
Marinho: We need to be more and more digital and get information from the workshop automatically in order to direct our resources to the activities that add the most value. MAT allows us to generate automatic reports that previously took us several hours to compile. The scheduling of workshop activities using visual tools makes it easier and faster to provide feedback to customers. It also makes it simple to eliminate any bottlenecks. The entire staff is very enthusiastic about the implementation of MAT, because they understand the need to work smarter instead of working physically harder.

Is there any one functionality of MAT that you particularly like?
Marinho: I am a huge fan of the equipment-history functionality, as this offers us the opportunity for developing better solutions for our customers. This feature analyzes the performance and all kinds of influences during equipment operation, and therefore helps to implement improvements that reduce overall maintenance costs and production downtime.

Who would you recommend MAT to?
Marinho: I recommend MAT to every company wanting to optimize their service resources by increasing equipment lifetime. The knowledge base generated through the use of MAT is very powerful and can surely bring companies a competitive advantage.

M.SPACE TO LAUNCH IN 2018

Primetals Technologies has developed a group of new web-based services, which are expected to launch in 2018. In the first phase, four services will be available to customers: **m.academy** will allow steel-plant operators to sign up for specialized training sessions, **m.doc** will be the place of choice for the storage of technical documents, **m.buy** will become the best source of spare parts for metals production, and **m.crane** will be the first automated online engineering service for hoisting drums. Later phases of the roll-out of m.space will bring a dozen more digital service innovations.

BOX CONCEPT: MORE THAN JUST A CMS

High-end maintenance concepts and technologies have recently gained more attention, partly because of the challenges facing steel producers on account of global overcapacity. BOX Concept, the highly advanced condition-monitoring solution of Primetals Technologies, was designed to minimize the risk of unplanned shutdowns, maximize plant availability, and ensure product quality and worker safety.

BOX Concept uses an architecture that is based on an Edge computing system. While other solutions typically require three separate system suppliers (one for data acquisition, one for data processing, and one for analysis and evaluation), the BOX Concept from Primetals Technologies comprises all three. The field-measurement data is acquired by special measuring devices, while other process data (e.g., related to material tracking) is obtained directly from programmable logic controllers through proprietary software interfaces. Core evaluation and data compression are executed on several Edge servers in one or more plants. The results are then sent via a machine-to-machine interface to a central, web-based information-management system called the "Info Broker," which encompasses a database.

WEB-BASED ARCHITECTURE

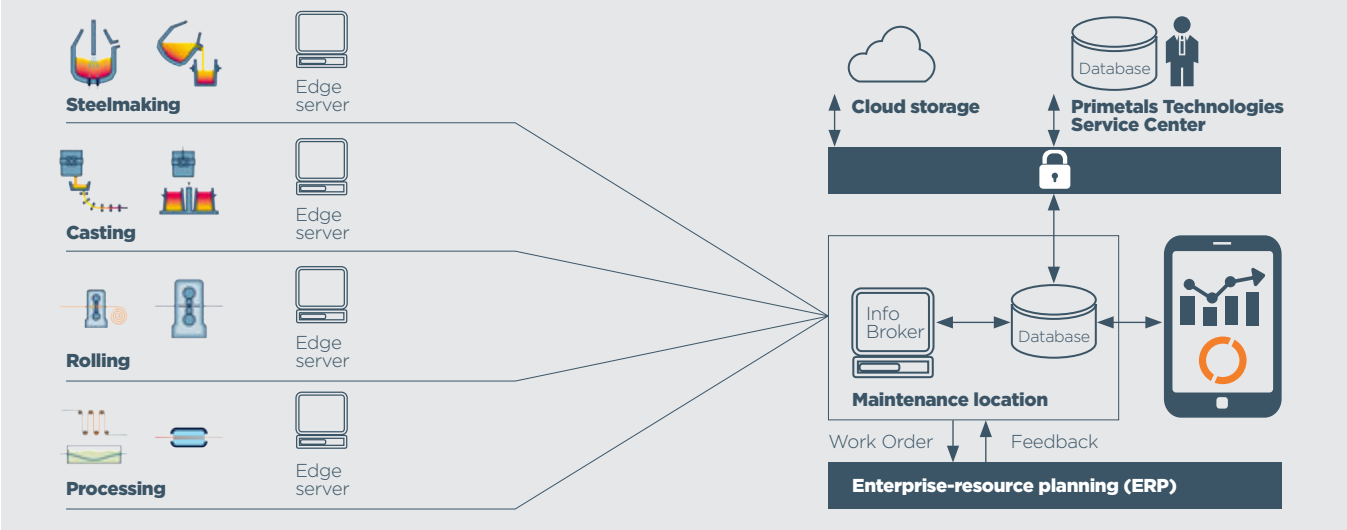
Thanks to the web-based architecture of the BOX Concept, plant managers can easily access the information or reports they desire using a smartphone or a tablet, either via an authorized connection to the plant network or by scanning a dedicated QR code on the respective piece of equipment. Additionally, datasets and evaluations can be uploaded to a cloud-storage solution for further utilization—such as investigations based on machine learning. Information can also be transmitted to the Primetals Technologies Service Center through a secure gateway for extensive analysis and customized reporting. Unlike more conventional condition-monitoring systems, the BOX Concept facilitates interfacing with superordinate functions such as enterprise-resource planning (ERP). The BOX Concept solution enables the maintenance staff to systematically generate work orders and send them to the ERP. A feedback loop back from the ERP to the BOX Concept for all work orders is also provided. Existing condition-monitoring systems and stand-alone measurement systems can be integrated into the BOX Concept.

KEY BENEFITS

- Early fault detection reduces repairs and costs
- Extended equipment lifecycle
- Lower maintenance expenditures
- Increased plant availability
- Optimized and more reliable production management
- More consistent end-product quality
- Highest safety levels for human operators
- Promotes technological leadership

THE CMS OF CHOICE

Overall, the BOX Concept is the platform of choice for high-end maintenance operations. It is one of the key technologies for the transition to Industry 4.0 and comprises extensive metallurgical and automation-related know-how. It was designed to monitor complex equipment and processes in both the upstream and downstream areas. Lastly, it is modular, easily operable, scalable, and has a short return-on-investment (ROI).

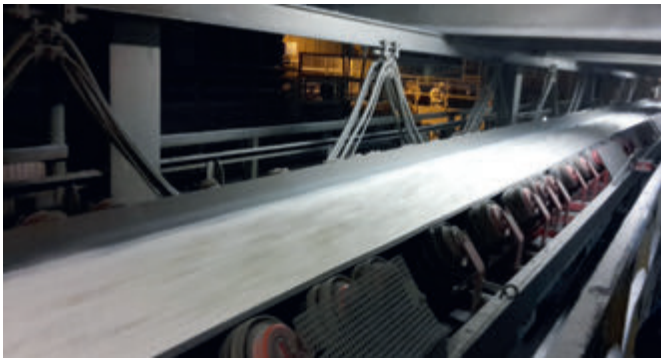


Simplified overview of the BOX Concept's web-based architecture.

ACOUSTIC EXPERT

Acoustic Expert is technology-led innovation at its best. During the uptime of various hardware, distinct tonal sounds that are characteristic for a particular component can be detected. These sounds can provide very accurate insights into the current state of the equipment. Acoustic Expert detects these sounds and uses advanced analysis routines to deliver automated status reports.

voestalpine AG in Linz, Austria, and AG der Dillinger Hüttenwerke in Dillingen, Germany, have formed close partnerships with Primetals Technologies, which is focused on identifying and exploring new areas of application for Acoustic Expert. The new areas of application that have been developed as a result of this collaboration include the following three fields.



MATERIAL-QUALITY AND MATERIAL-TYPE DETECTION AT TAKE OVER POINTS ON CONVEYOR BELTS

Characteristic sounds can be detected at take over points on conveyor belts or in bunkers. Fine sand and coarse-grained material emit different sound patterns; for instance, aluminum sounds different from lime. Acoustic Expert uses this phenomenon to automatically detect material type and quality.

TORCH CUTTER AT CONTINUOUS CASTING MACHINES

The torch cutter at the end of each continuous casting machine is crucial to the seamless operation of the plant. If it breaks down, unscheduled downtime could become the undesirable result. Acoustic Expert monitors the acoustic signals produced during the cutting process. A detailed analysis shows the current condition of the nozzle while also providing information about gas-mixture levels and cutting quality. The system monitors the torch cutter continuously, which means that preventive measures can be taken. Also, maintenance can be carried out before any breakdown occurs.

MONITORING OF COOLING AND LUBRICATION NOZZLES FOR ROLLING MILLS

The rolling mill is another area in which Primetals Technologies, together with its partner companies, is actively developing new applications for Acoustic Expert. The monitoring of spray nozzles with Acoustic Expert—for both lubrication and cooling—has already been tested. Most recent tests have been centered around the monitoring of the gearing mechanisms and drive shafts in rolling mills. The ultimate targets are to simplify maintenance, and to make operation of the metallurgical machinery as straightforward as possible.

MASTERING DIGITAL ORCHESTRATION

Kurt Herzog is Head of Industry 4.0 at Primetals Technologies. He has been with the company for 20 years and focuses on automation efforts that make the total complexity of steel-plant operation more manageable. Herzog also leads the team that created the "Metals Orchestra" concept. Metals Magazine finds out what continues to drive him in his daily work.

What inspired you to craft the concept of the "Metals Orchestra?"
Kurt Herzog: I wanted to capture the idea that in a steel plant, all parts of the production chain have to be in proper alignment to ensure streamlined operation. A production facility is much like an orchestra: All "players" need to be highly capable, and there can be no weak link. If any one unit fails, costs will arise due to production losses or a decrease in end-product quality. Also, it is essential to orchestrate all equipment so that everything acts in harmony—hence the necessity for a "conductor." What I particularly like about this metaphor is that it illustrates what I call the "three layers of integration": Vertical integration means that every player has to perform well on his own; horizontal integration means that all efforts need to be well aligned; and integration over time involves all the behind-the-scenes service and maintenance work required for smooth plant operation.

It is often stated that metals producers have already embraced digitalization, much more than businesses in other areas; for instance, in discrete manufacturing. Do you agree with this view?
Herzog: Well, it depends. Some aspects of digitalization have actually already been implemented in discrete manufacturing. But what is still unique to the steel industry is the use of cyber-physical systems. A cyber-phyiscal system is the combination of a physical production facility with its virtual representation, its "digital twin." In steel production, the use of process models has been indispensable for decades now, because it is the only way to determine what state certain equipment is in. To give you an example, it is impossible to take certain measurements from within an active blast furnace. Only sophisticated process models can give us a good idea of how changes we make in operational practices or in raw materials will influence the smelting process. The same is true for the solidification of the caster strand, the violent reaction to oxygen in the converter, or the forceful shaping of the steel during rolling. These process models are essential for both controlling the production process and for safety, and they are without equal in other industries.

Why then is digitalization still such a big issue—and a major challenge—for the metals industry?
Herzog: In the manufacturing of steel, every single step of the production chain is a complex system in itself—from the sinter plant to the processing line. At the same time, the overall process should be executed with as little interruption and delay as possible in order to minimize energy consumption and costs. As a result, the challenge is to orchestrate all of these systems and bring their automation into continual alignment. The good news is that it is relatively inexpensive for steel producers to implement new automation solutions, compared to the costs of the production equipment. And once interaction of all automation systems is reached, the achievable end-products will be higher in quality and more profitable. However, when upgrading steel plants with already respectable degrees of automation, our challenge is different: in these cases, we often have to integrate various types of equipment that came from different suppliers.

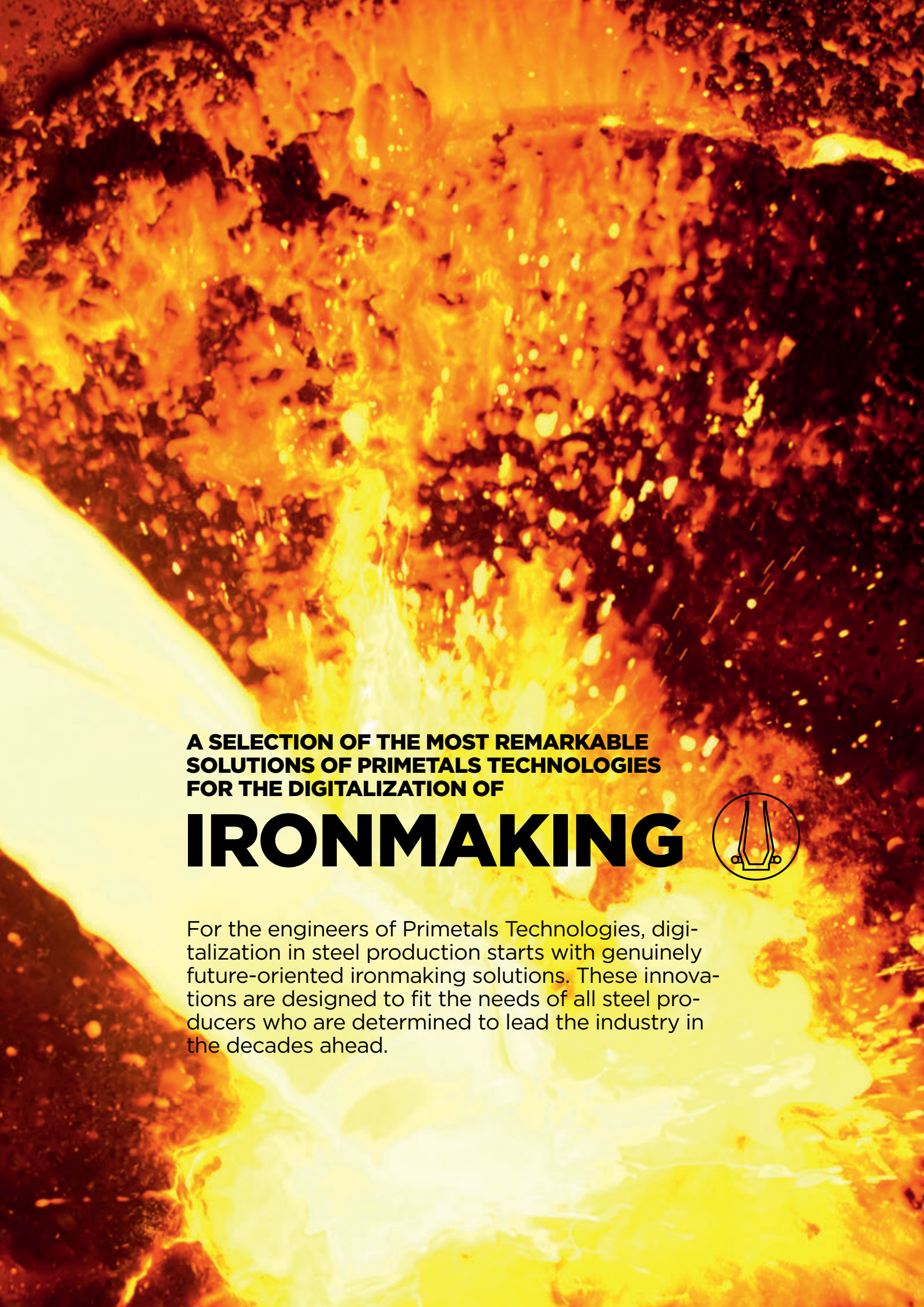
> **“Digitalization has enormous potential for any steel producer. It can effectively increase productivity, flexibility, and product quality.”**

Has the concept of the “Metals Orchestra” helped in communicating the importance of digitalization?
Herzog: I think that it has successfully conveyed that integration in steel plants needs to happen in three dimensions—vertically, horizontally, and over time. Actually, integration can go far beyond just the production process and include suppliers and end customers. For literally any steel producer, digitalization has enormous potential. It can increase productivity, flexibility, and product quality. And since the steel industry is still going through tough times, improvements in these areas are extremely important. They will help to ensure that steel remains a competitive base material in the decades ahead.

Out of all the technologies involved in promoting digitalization in steel production, which is your favorite? Do you have a “preferred soloist” in your “orchestra of steel?"
Herzog: Today, my preferred soloist is Arvedi Endless Strip Production technology [smiles]. There is one simple reason why: Arvedi ESP is not limited to merely digitalizing a distinct set of processes or one production step. It unifies continuous casting and hot rolling, and it does this not just in software but also in the world of nuts and bolts. The two stages are literally and physically made into one. In my opinion, Arvedi ESP is a new and exiting form of horizontal integration.

Is artificial intelligence a substantial factor in your Metals Orchestra?
Herzog: First off, it is important to differentiate between data analytics and artificial intelligence (AI), and at Primetals Technologies we use both. Having said that, AI is certainly a factor in digitalization, even if some of its applications have yet to be developed, tested, and refined. It can, for instance, help to increase end-product quality. From a safety and a legal standpoint, however, AI is not without problems. The architecture of AI systems is based on non-causal learning. So whenever AI is put in charge, it becomes impossible to explain how the system arrived at its conclusions and why it made the decisions it did. But safety standards depend on clear instructions and causal rule sets. How larger AI systems will be integrated into steel production has yet to be figured out.

My final question is a personal one: do you play an instrument yourself?
Herzog: Yes, I play the guitar, the electric bass, and the saxophone. I also like to try out new instruments to see what sounds I can evoke from them. Occasionally, I play in a group, and I know very well how important proper orchestration is for the quality of the music.



A SELECTION OF THE MOST REMARKABLE SOLUTIONS OF PRIMETALS TECHNOLOGIES FOR THE DIGITALIZATION OF

IRONMAKING

For the engineers of Primetals Technologies, digitalization in steel production starts with genuinely future-oriented ironmaking solutions. These innovations are designed to fit the needs of all steel producers who are determined to lead the industry in the decades ahead.

Equalizing operations in pellet production over all shifts increases output and minimizes costs.

EXPERT SYSTEM PELLETIZING

The ultimate aim in pelletizing is to produce consistently high pellet quality at high productivity rates and low conversion costs—all while keeping an eye on the emission limits that the operation is subject to.

Due to the mutual interdependence of the different pelletizing process steps, precise simulation is an essential basis for reliable process optimization. Primetals Technologies has therefore developed the Expert System for pelletizing, which is supported by advanced process models that provide additional insight into the process, and support operational decisions. As the material on the surface, the bottom, the walls, and the center faces different process conditions, the process models predict, evaluate, and track these conditions on a fine-meshed grid in all cross sections throughout the whole process chain. Extended simulation capabilities support the identification of optimal operational points—in order, for example, to optimize the trade-off between the energy supply to the different process steps in the drying and induration zones.

Different shift operators tend to operate the machine in different ways. Equalizing operational decisions over all shifts will lead to maximum production of quality pellets at minimal production costs. This is where the Expert System for pelletizing from Primetals Technologies is at its best. It models knowledge of experienced pelletizing process engineers and operators, the cause-and-effect relationships of process disturbances, metallurgical know-how, and the prevailing control philosophy. It thus monitors and foresees the process status, provides graphical displays, counteracts process disturbances, suggests control measures, and explains suggested measures in the form of verbal messages.

The Expert System uses the information from the Process Information and Data Management System and the advanced process models to standardize the operation, gain stabilized product quality, and lower fuel consumption. Thus process-control practice becomes more uniform—and efficient—across different shifts.

The hot-briquetted iron direct-reduction plant of voestalpine in Corpus Christi, Texas, U.S.A., at night.

EXPERT SYSTEM DIRECT REDUCTION

Keeping the operation of Midrex direct-reduction (DR) plants smooth and stable in order to produce consistent-quality direct-reduced iron can be a demanding task. But thorough process optimization is rewarded by considerable savings in the downstream area or by higher product prices on the market. One of the challenges for direct-reduction plant operators is to cope with the delay of several hours between a process change and the arrival of laboratory measurements performed on the resulting product. Primetals Technologies and its partner Midrex Technologies have therefore devised a new Level 2 process-optimization system called "DRIpax," which more accurately predicts product quality based on sensor input and physical and mathematical models, and delivers the result hours faster than any laboratory could. The ability to predict metallization and carbon levels quickly after a change in the reduction process or in raw-material properties enables better control of DRI consistency. DRIpax thus typically reduces deviations from target values of metallization and carbon by about 30%.

The DRIpax DR Plant Expert System is a rule-based advisory system and was created to assist panel operators in decision making and—if the operator so chooses—make data-driven decisions entirely on its own in "closed-loop" mode. Among other things, the system helps avoid inconsistencies in plant operation due to shift changes.

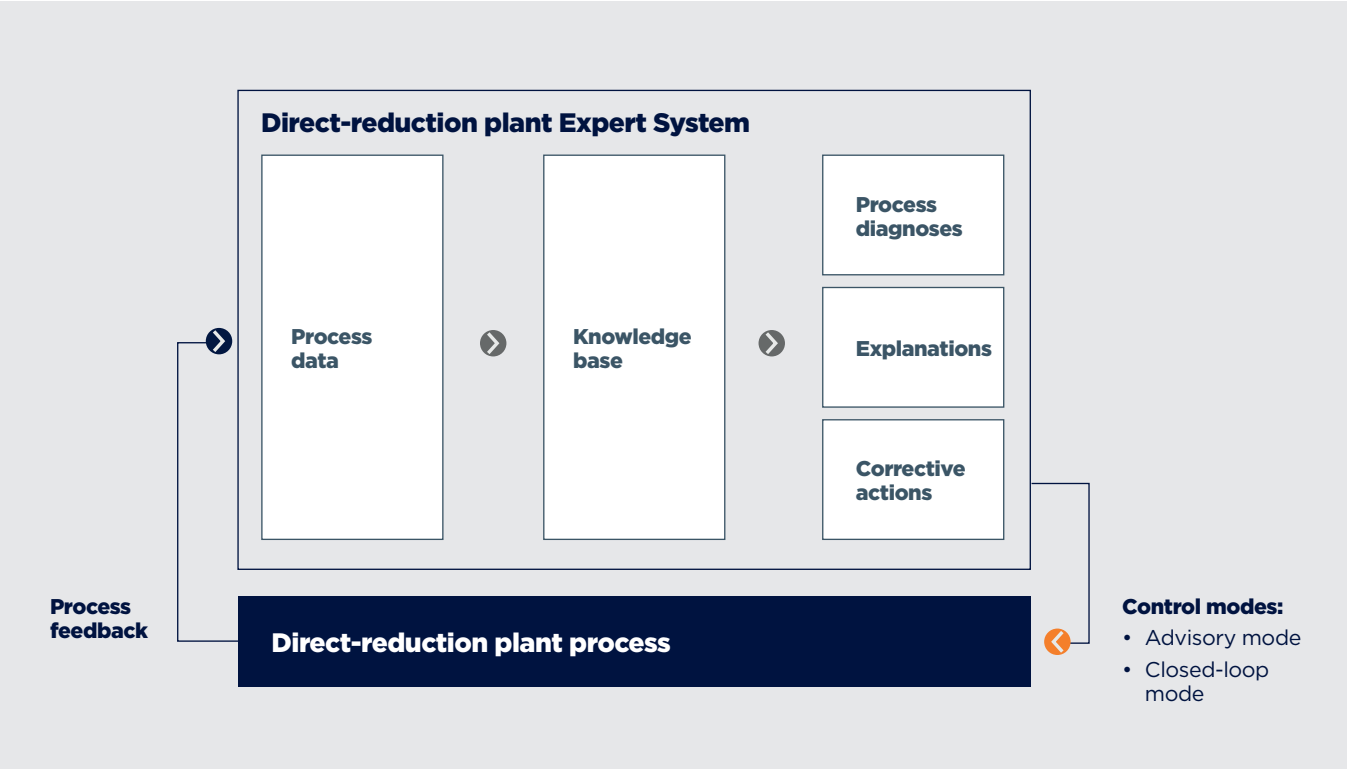
At the heart of the Expert System is a knowledge base that incorporates comprehensive metallurgical and automation know-how from Primetals Technologies and Midrex as well as plant-specific operational know-how and control philosophies of the individual customers. In this sense, each customer gets an Expert System perfectly tailored to their needs.

Based on continuous observation and evaluation of the actual process conditions, the Expert System fulfills the following three essential tasks:

- **Provide process diagnoses:**
  The current situation of the plant is evaluated and process-relevant phenomena are identified.

- **Suggest corrective actions:**
  Based on the diagnoses, corrective actions are generated to avoid or counteract undesired process conditions. Appropriate plant set points are suggested to keep the process stable and run the plant close to optimal process conditions.

- **Provide explanations:**
  A textual explanation is prepared to offer detailed background information regarding the current diagnoses and the corrective actions suggested to the operator.



The architecture of the DRIpax Expert System (Level 2) from Primetals Technologies for direct-reduction plants.

Process evaluation is performed on a regular cycle every few minutes. The diagnoses, corrective actions, and explanations given by the Expert System are based on the logic defined in the knowledge base. An adaptive system design makes it easy to expand and adjust the Expert System to each individual type of Midrex DR plant. If required, diagnoses or corrective actions can easily be adjusted or added depending on the particular plant situation.

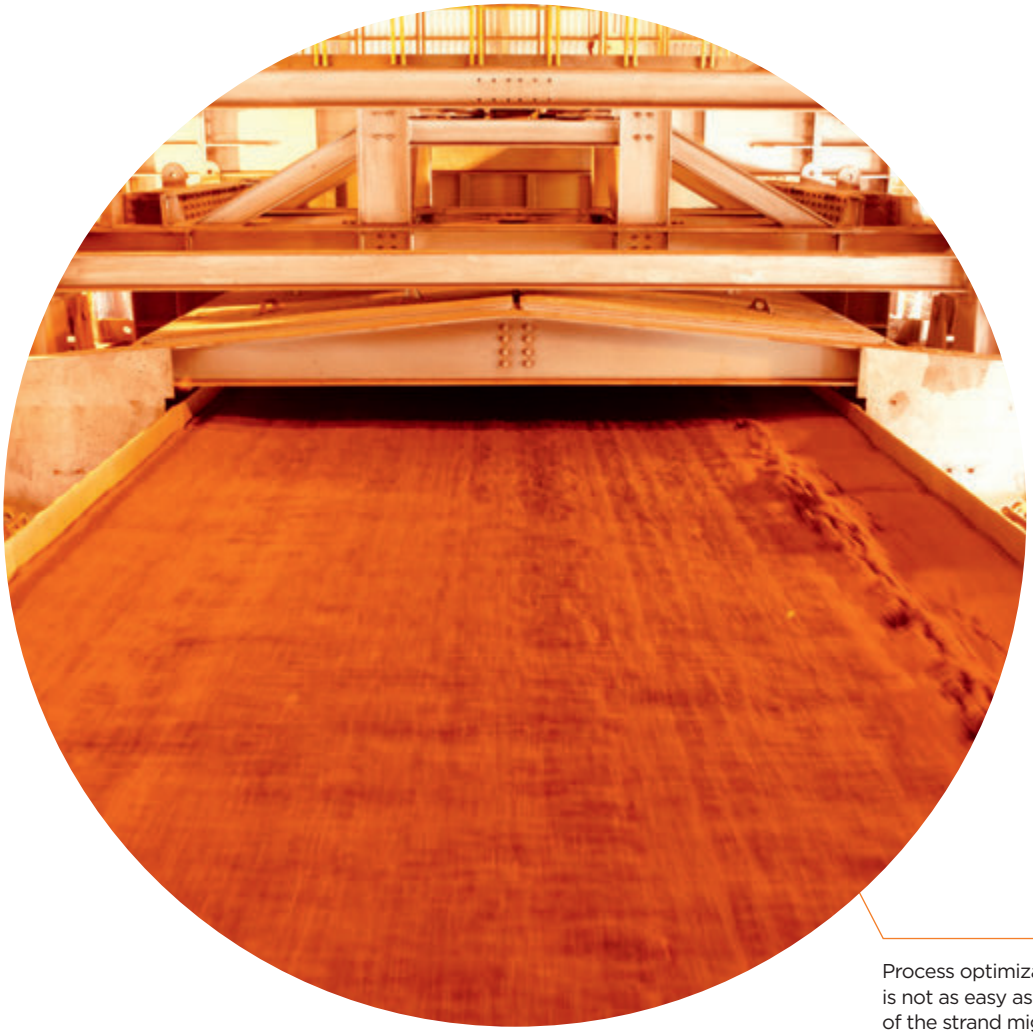
The Expert System has two operational modes with regard to the execution of suggested corrective actions: "advisory mode" and "closed-loop mode." In advisory mode, the system merely suggests corrective actions to the operator, who can then either execute them or reject the suggestions. In this mode, suggestions by default expire after a pre-set period of time. In closed-loop mode, on the other hand, suggestions are automatically accepted and executed—after the expiration of a pre-set time period, during which the operator has the option to reject the suggestions.

In conjunction with the full scope of the DRIpax process optimization system, the Expert System represents a major step in the direction of fully automated quality control in DR ironmaking that is uniform across all operators and allows for shift-independent "best practice" plant operation.

EXPERIENCE VOESTALPINE'S U.S. DR PLANT IN VIRTUAL REALITY:

The DRIpax process optimization system, including the Expert System, was recently installed at the new Midrex DR plant of voestalpine in Corpus Christi, Texas. This facility was commissioned by Primetals Technologies and Midrex Technologies, and started operation in October, 2016. Should you be interested in obtaining a free pair of "Primetals Technologies"-branded VR glasses (Google Cardboard), just send a request to contact@primetals.com.

bit.ly/gowestvr



Process optimization in sintering is not as easy as the slow motion of the strand might suggest.

EXPERT SYSTEM SINTERING

Despite not being the main focus for investments, sinter plants often hold significant potential in terms of improvements that can be made to reduce conversion costs. One of the measures with the shortest payback time is in many cases the installation of a VAiron Sinter Process Optimization system. Due to the usage of a variety of different raw materials, the delay caused by long-belt conveyors, the interaction of the material on the strand with the ignited gas suction, and last but not least increasingly stringent environmental regulations, process optimization is not as easy as the slow motion of the sinter strand might suggest.

In order to achieve optimization goals under these conditions, a process optimization system must provide sophisticated tracking, diagnosis, and control models to ensure stable, reliable, and efficient production. The Expert System for sintering devised by Primetals Technologies has been designed according to the principle, "As few actions as possible, as many as necessary." When set to closed-loop operation, the system will execute all necessary changes fully automatically. The Expert System—a rule-based decision system—counteracts process fluctuations caused by changes in the raw-mix composition and quality, or process conditions. The sooner the system responds to an abnormal or changing process situation, the smoother the overall sinter operation will be. Accurate timing of control activities and anticipation of disturbances are of utmost importance to maintaining high production rates at low costs.

After numerous successful installations, Primetals Technologies is in a position to guarantee significant improvements in product quality and reduced fuel consumption for sinter plants using the Expert System solution. In conjunction with sinter process control and process optimization systems from Primetals Technologies, the Expert System ensures high productivity and product quality as well as stable and shift-independent operation 24 hours a day. It can easily be integrated into an existing automation environment, and the standard period of amortization can be expected to be less than a year.

Blast furnaces run by an Expert System produce stable hot-metal quality at lower costs.

EXPERT SYSTEM BLAST FURNACE

Primetals Technologies is the leading supplier of blast furnace automation systems for the iron and steel industries. This is especially true for blast furnace process optimization systems, which are operating in more than 70 installations worldwide—with furnaces of all sizes, ranging from 500 m^3 up to 5800 m^3.

The package of solutions for automated blast furnace operation—the VAiron Blast Furnace Optimization system—was developed in close cooperation with voestalpine Stahl in Linz, Austria. Its technology is based on advanced process models, artificial intelligence, mass and energy balances, a closed-loop Expert System for fully automatic operation, and other advanced software.

The ultimate aim in blast furnace operation is to reach stable furnace conditions and stable hot-metal quality at the lowest-possible production costs. The VAiron Blast Furnace Optimization system monitors the process 24 hours per day, taking corrective actions in a closed loop if necessary. The system thus counteracts changes in the process caused by fluctuations of process parameters such as raw-material quality. In doing so, the Expert System provides explanations of its decision-making process for full transparency.

A vitally important part of the system is its knowledge base, which was built and which is supplied to steel producers on the basis of vast experience gathered in various blast furnace projects. This knowledge base can be modified and extended to adapt to the customer's specific operational philosophy and practice.

A blast furnace working under the supervision of the Expert System helps to avoid heavy control actions and critical process situations by reacting quickly as conditions change—increasing the furnace lifetime. Rule-based operation equalizes the operational decisions over all shifts, leading to highly stable furnace conditions, consistent hot-metal quality, and reduced coke rate. As a result of these benefits, the investment typically pays for itself within only a few months.

HOLISTIC IRONMAKING OPTIMIZATION

While process optimization systems have been widely introduced in many facilities of ironmaking plants, in a lot of cases there is no overall automation system, supporting coordination and Through-Process Optimization of all ironmaking facilities in place. Together with voestalpine, one of the most innovative steel makers, Primetals Technologies has developed a holistic ironmaking concept, adding the superimposed VAiron Ironmaking Expert System to the local process optimization systems.

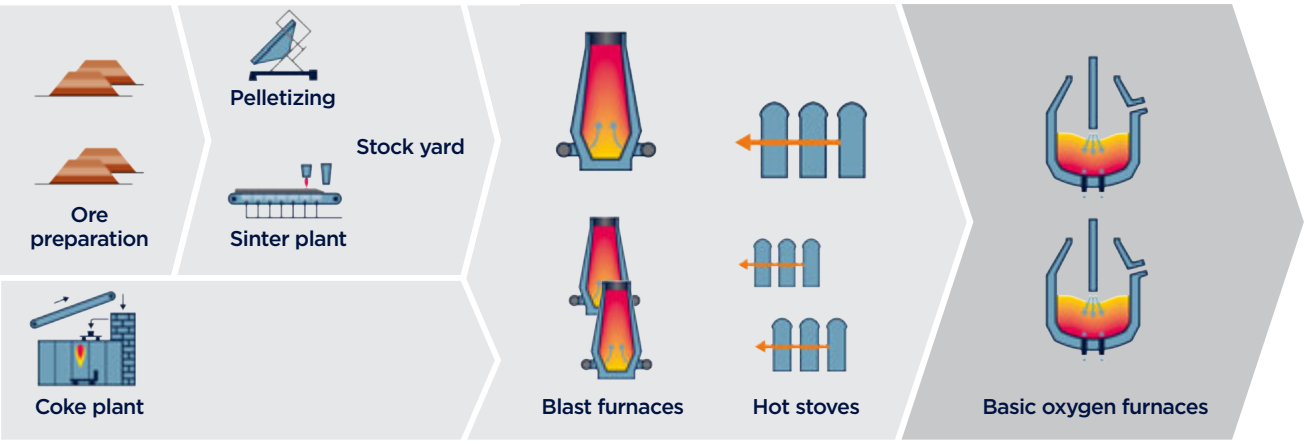
The VAiron Ironmaking Expert System provides an automated production control system to achieve standardized operation throughout all ironmaking facilities by coordinating the individual aggregates, such as raw-material management, coke oven plants, sintering, pelletizing, direct reduction, pulverized coal injection plant, and blast furnace operation. When implementing the VAiron Ironmaking Expert System, we recommend proceeding in a stepwise fashion, avoiding the incorporation of all ironmaking plants in one huge project. Starting with the hot metal requirements of the steelmaking plant, the production and quality targets are defined for the upstream ironmaking plants. As a first step, operating points (with respect to hot metal rate, blast and oxygen amount, and fuel rates) are derived for every blast furnace—which are then executed by the local optimization systems. Potential boundary conditions, such as limited oxygen contingents, are considered.

Additionally, the hot stoves switchover of the different blast furnaces is synchronized, minimizing the impact on the pressure fluctuations and flaring losses in the plant-wide gas network. In a similar way, the operating points for the sinter-, pelletizing-, and coke-making plants are calculated. The Ironmaking Expert connects process tracking information from individual plants and integrates this information into a single display to analyze correlations and impacts beyond the individual aggregate borders, allowing for cross-process data mining and sensitivity analyses. Thanks to central data collection, key performance indicators (KPIs) can easily be calculated for the whole ironmaking area. The main feature of this application becomes apparent when trends from different areas are shown at the same time. The system is able to track the genealogy of the material flows, allowing for direct comparison of related trends from different plants. This enables the user to analyze the process conditions and material properties throughout the whole ironmaking production chain.

As an excellent example of an Industry 4.0 solution, Holistic Ironmaking Optimization enhances the performance of ironmaking plants by the consistent, methodical, and comprehensive consideration of the global optimum rather than aiming at local optima for each plant. The resulting traceable production decisions and the increase in transparency allow for thorough process optimization, which leads to reduced conversion costs and more consistent quality, higher efficiency, and increased production.

MAIN FUNCTIONS OF THE VAIRON IRONMAKING EXPERT

- Coordination of steel shop and ironmaking plants
- Material tracking, process analysis, production planning, and control for ironmaking
- Coordination of gas demand and generation
- Automatic calculation of key performance indicators



The Holistic Ironmaking concept from Primetals Technologies aims to optimize the entire process route in ironmaking as a whole rather than to offer piecemeal improvements.

DIGITALIZATION AND PROCESS OPTIMIZATION

WHAT DOES THE FUTURE HOLD FOR IRONMAKING?

Many of today's ironmaking facilities could benefit massively from more thorough digitalization of processes. We sat down with Dieter Bettinger, Product Manager for Ironmaking Automation at Primetals Technologies, to talk about his perspective on the state of digitalization in ironmaking today, the potentials offered by artificial intelligence, and the crucial difference between data and information.

What potential for improvement do you see in ironmaking plants in terms of process optimization systems?
Dieter Bettinger: In many plants, you can still easily identify shift-dependent operation—which is particularly unfavorable for plants with process times in the same range as shift duration. In many cases, it is quite straightforward to calculate the related saving potential.

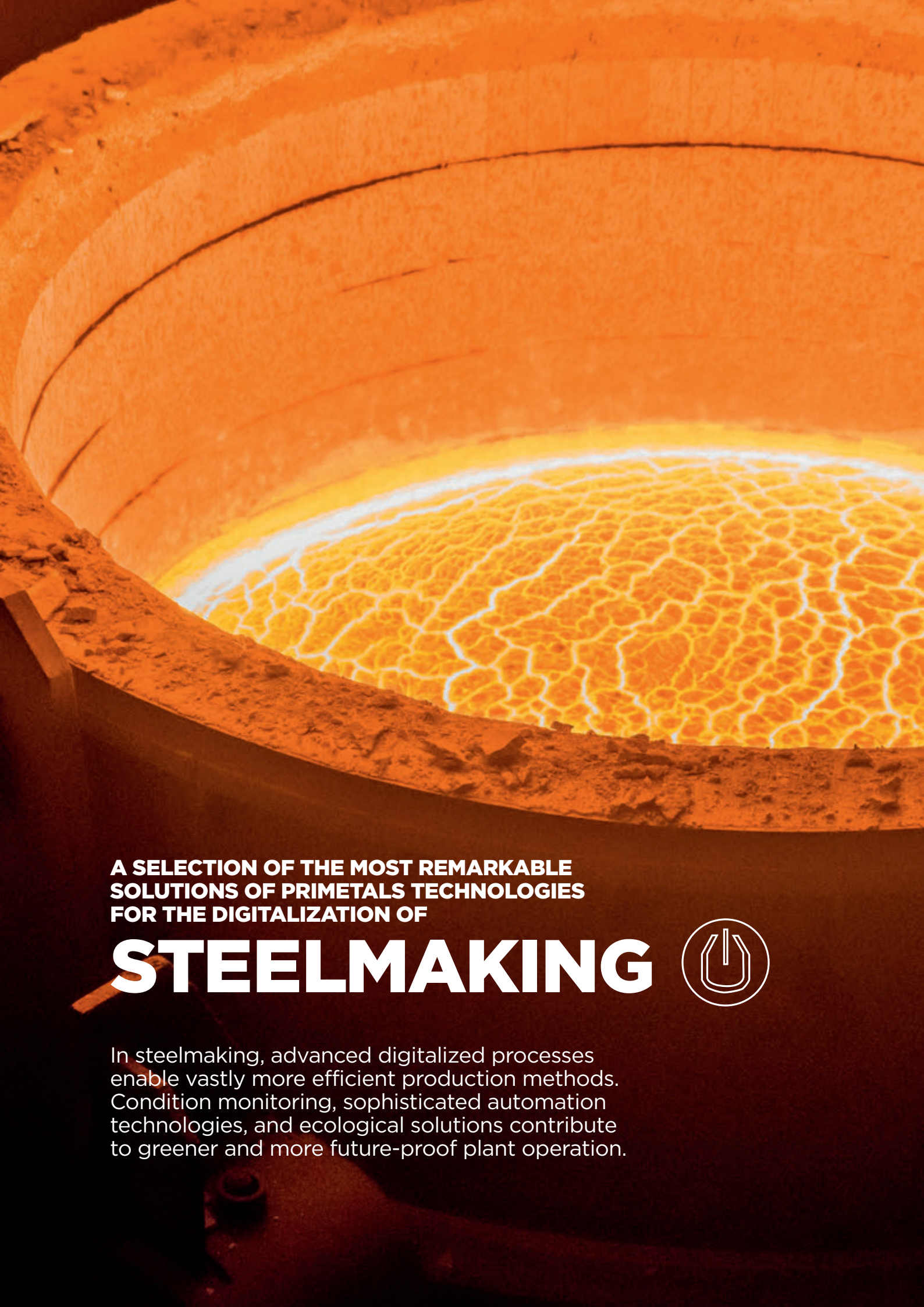
What was the starting point for the development of ironmaking process optimization?
Bettinger: From the very beginning, the main motivation for developing ironmaking process optimization solutions was to reduce conversion costs—in other words, to save money. The basic approach is to develop a standardized operation philosophy, which is then executed by the automation system. The great success of our approach based on an Expert System is the continuous improvement that can be achieved in the process: If the operator or process engineer finds additional room for improving the operation, he or she can easily add new insight to the system—because of the continuous dialog with it. This increases the knowledge base of the system. It took years of close cooperation with our metallurgical partner voestalpine to reach a level of trust in our technology that allowed them to go for closed-loop operation. But in the end, they saw that a well-maintained Expert System is hard to beat in terms of reliability and cost savings.

There are several new measuring systems available—how do you use the related information?
Bettinger: The paradigm of our approach is first to extract information from data—and then to use this information to provide the basis for actions. Data is not relevant as long as no information is generated; information is useless if not used to trigger actions. For this reason, measurement systems that are not fully integrated into the process optimization system are not used at their full potential. Additionally, many plants only use a small fraction of the history data—wasting an important source for operational improvements.

A huge amount of data is created in modern ironmaking plants—how can it be efficiently used?
Bettinger: The important task of data mining is transforming the huge data sets stored in the automation systems into information that is actually valuable. Our automation systems are ready to interface with data mining tools. In addition, we have data scientists—specialists with data preparation knowledge, data analytics skills, and domain know-how—who can provide efficient support services to help the customer get more out of their data.

How do you judge the impact of digitalization?
Bettinger: The merging of classical automation technology with information technology has already started and it offers huge potential. At the same time, connecting local automation to other systems will introduce big challenges to the industry, as it potentially opens doors to hackers and other intruders. It is important to prepare professional security concepts for these challenges.

What is the relevance of artificial intelligence for state-of-the-art process optimization?
Bettinger: There has been a revival of artificial intelligence, most recognizably in applications highly visible to the public, such as autonomous vehicles. Understanding human language, developing faculties in strategic game systems (such as chess and Go), intelligent routing in content delivery networks—these are other applications. There is definitely potential for applications in the iron and steel industries, as long as human intervention is possible to identify impact factors for key performance indicators, to do pattern recognition, to perform data analytics, and to optimize plant operation. However, we are still very selective in incorporating AI solutions directly into control systems, to avoid unforeseen actions.



A SELECTION OF THE MOST REMARKABLE SOLUTIONS OF PRIMETALS TECHNOLOGIES FOR THE DIGITALIZATION OF

STEELMAKING

In steelmaking, advanced digitalized processes enable vastly more efficient production methods. Condition monitoring, sophisticated automation technologies, and ecological solutions contribute to greener and more future-proof plant operation.

MELT EXPERT
ELECTRODE-CONTROL SYSTEM

Melt Expert is a state-of-the-art electrode-control system that Primetals Technologies has designed to ensure optimal operation of electric arc furnaces. It retrieves production data from a variety of furnace-related components and continually analyzes this information in order to obtain a complete picture of the state and history of the melting process. Based on its findings, Melt Expert regulates the activity of the electric arc furnace, and changes set points and controller gains in reaction to the actual process conditions. Operators can inspect the overall melting process on a selection of interfaces—even current-generation smartphones are an option.

Melt Expert's auto-adaptive algorithms make a significant contribution toward a reduction in furnace energy requirements. It increases melting efficiency and productivity with its automatic melting profiles and dynamic adjustment of production-process parameters. Another key benefit is the increase in both furnace reliability and operational safety. Of course, Melt Expert's core objective is to safeguard process quality at the steelmaking stage so that any unexpected fluctuations that would influence the production facility's end products can be ruled out. Since Melt Expert yields substantial energy savings, the system pays for itself within a nine-month time frame.

MAIN BENEFITS

- State-of-the-art furnace control
- Increased furnace reliability
- Reduced energy consumption
- Highly developed safety functions
- Reduced need for maintenance
- Integrated system health checks
- Universally accessible interface
- KPI and benchmark reporting

Melt Expert features a universally accessible furnace control interface.

Download
our Chargeopt
brochure here:

bit.ly/scrapyardpt

AUTOMATED SCRAP MATERIAL FLOW

Primetals Technologies has continually worked on perfecting the automated scrap material flow for steel plants that are based on electric arc furnaces (EAFs). Depending on the customer's requirements and the targeted scope of automation, various configurations are possible. In principle, the automated scrap material flow comprises the automated scrap bucket loading at the scrap yard and the automated charging of scrap into the EAF.

The basis of the fully automated scrap yard is Primetals Technologies' EAF Chargeopt solution. This is a scrap-charging system that can operate largely without human interaction, and comprises patented scrap-bucket detection as well as a charging-crane positioning system, which enables the automation of all processes related to the feeding of scrap into the EAF. The system's precise and perfectly repeatable movement patterns lead to faster EAF charging and reduced maintenance needs.

The EAF Chargeopt technology also vastly increases the safety of the staff and the involved equipment. The execution of all automated routines is monitored by an operator in the control room. EAF Chargeopt can easily be added to existing plants and typically leads to a significant reduction in plant downtime. The mechanism for the unloading of scrap into the EAF supports both a main crane (to lift up the ladle) and an auxiliary crane (to pull the ladle's opening latch at the right time). Power-off times are shortened, and a drop in human-labor requirements and equipment costs can be expected as well. The amortization time for an EAF Chargeopt installation is usually between 9 and 15 months short.

In addition to the EAF Chargeopt, an advanced scrap-yard automation concept has been devised in close cooperation with an Italian partner. Based on a specifiable loading recipe for the ideal scrap composition, the system is capable of loading the scrap buckets, which are typically located on scrap cars, exactly as desired. Once filled, the scrap cars are transported to the melt shop without the need for any human intervention whatsoever, to then be picked up by the charging crane. The rather impressive accuracy for both EAF Chargeopt and scrap-yard automation is at 1 cm horizontally and 0.5 cm vertically. Remarkably, even complex scrap-yard layouts can be accommodated, and multiple yards can be incorporated into one automation setup.

A recent addition to the proven capabilities of the scrap-yard design of Primetals Technologies is the automation of scrap-yard cranes. The development of this aspect of the fully automated scrap yard has reached a progressed stage, and the first implementations in steel plants are expected to start soon, as customers have already shown keen interest in the technology.

FULLY AUTOMATED CONVERTER OPERATION

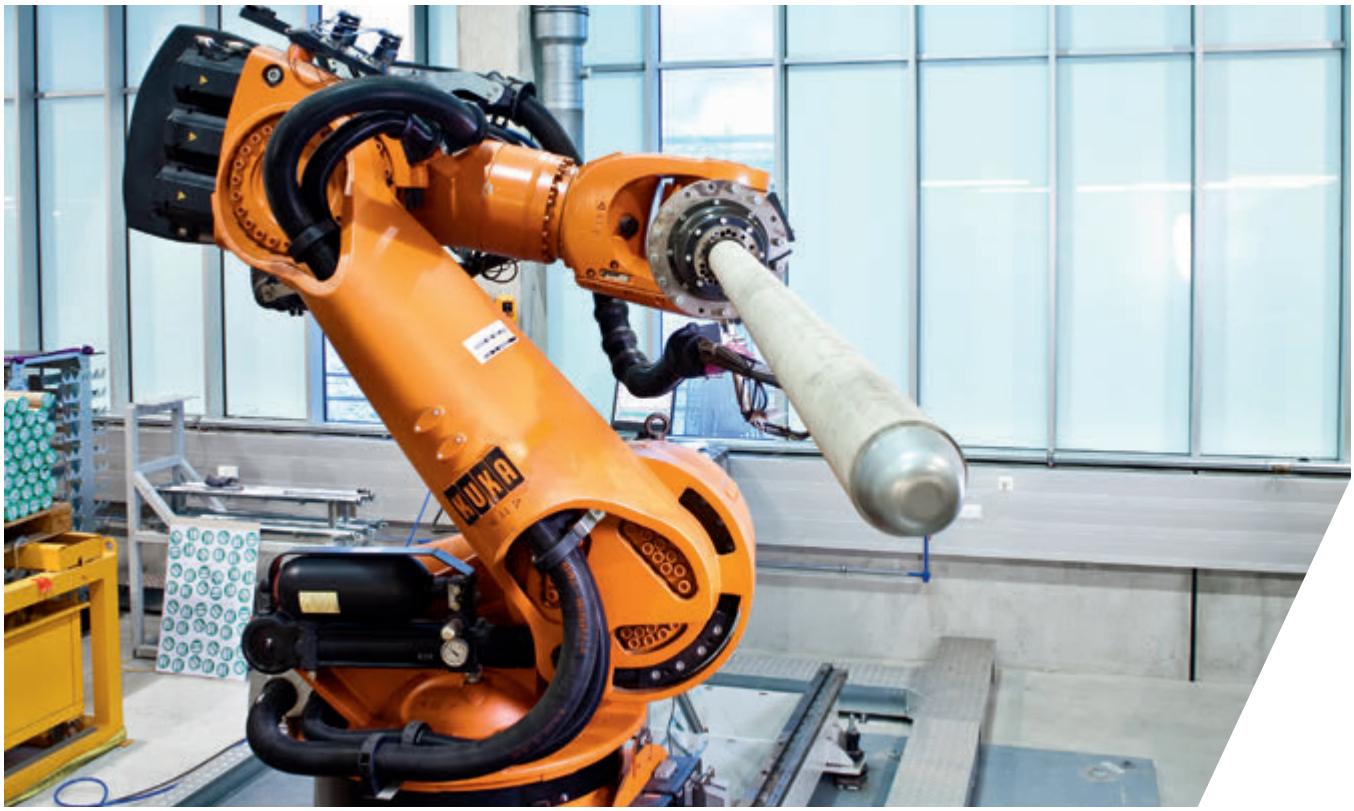
At the steelmaking stage, more and more tasks that used to be done by human operators can today be executed automatically. For a while now, most converter-based measurements have been taken without the involvement of manual labor, yet some of them have proven to be harder to automate. Primetals Technologies has developed solutions to digitalize those trickier yet essential processes. One example of a more challenging task is taking samples at the tilted convertor prior to tapping. Not only is this job potentially dangerous to staff, it also needs to be executed in a well-controlled and precisely reproducible manner. The horizontal measuring manipulator of
Primetals Technologies takes care of exactly that. It can be installed at either the charging or the tapping side of the converter, and respectively takes measurements before tapping.

The manipulator introduces the advantage of precisely determining factors such as the position and the depth at which measurements are taken and the speed of the evaluation process. This allows for extensive customization of the sample-taking operation. In some steel plants, dedicated robots are the method of choice for the handling of probes. At voestalpine's Linz-based plant, for example, Primetals Technologies was commissioned to install robotic solutions on three 180-ton converters, with the goal of automating probe handling at the sublances. The resulting system has now been in successful operation for almost two years and has proven to be capable of maintaining the highest standards in terms of process reproducibility and reliability.

In general, fully automated converter operation covers all process steps from the initial charging of the converter to the blowing control to the final tapping. Depending on a production facility's preexisting equipment, customized modernization packages can propel converter operation into a fully automatic operation mode, improve process consistency and safety, and vastly increase both transparency and efficiency.

MAIN BENEFITS

- The next step in converter steelmaking
- Fully automatic charging and tapping of the converter
- Manipulator for measurements at the tilted converter
- Robots for fully automated handling of probes at the sublance
- Frees up operators to focus on process supervision and process optimization



LiquiRob from Primetals Technologies can perform a variety of work tasks in the metals industry.

LIQUIROB: A TIRELESS WORKER
FOR HIGHER EFFICIENCY, QUALITY, AND SAFETY

The LiquiRob robot system was specifically developed by Primetals Technologies for improving workplace safety and measurement quality under the harsh conditions encountered in the ironmaking and steelmaking industries. It has numerous applications in a wide variety of work activities across the entire production process.

FOR THE HOTTEST APPLICATIONS

LiquiRob is a highly flexible robot system that meets the challenges of a number of tasks that require working with—or close to—liquid metal. The system is installed to support plant equipment such as electric furnaces, converters, secondary metallurgy, and continuous casting machines. Fully automatic measurements and procedures increase process reliability and workplace safety as well as flexibility, productivity and—by extension—product quality. Every work activity performed automatically by the robot can be monitored from the control room, where operating personnel are kept at a safe distance.

IN OPERATION SINCE 2007

LiquiRob is the world's first successful industrial-scale system of its kind on the market. It premiered in 2007 in the Gwangyang steelmaking plant of POSCO in South Korea. The robot system in that facility is responsible for sample taking, measuring steel temperature in the tundish, and feeding casting powder on the casting platform of a two-strand continuous slab caster.

A HIGHLY ADAPTABLE SYSTEM

A standard industrial robot with six axes is used for all activities. An optional, additional axis extends the working area. The robot is equipped with different tools and components that allow it to perform a variety of tasks. This includes equipment such as tool changers, fire-proof protective enclosures, and position detection systems. Using a combination of these components, LiquiRob can be adapted to nearly all plant types and automation systems with a high degree of reliability and flexibility.

MAIN BENEFITS

- Increased workplace safety
- Better reproducibility of measurements
- Higher availability
- Lower maintenance costs

LANCE GUARD—AUTOMATIC DIAGNOSIS FOR MEASUREMENT EQUIPMENT

The precise acquisition of liquid metal parameters such as temperature, oxygen activity, and carbon content, is one of the most important requirements for delivering high-quality results at minimal production cost. However, measurement lances and their wiring are subject to high thermal and mechanical stress, thus requiring frequent testing to prevent unknown deviations. Lance Guard from Primetals Technologies significantly speeds up and fully automates this process at minimal hardware cost. A lance adapter is attached to the lance contact block and Lance Guard starts feeding data to the system, emulating a typical one-way measurement probe. With closed-loop feedback from the automation system, all values are verified and checked for violations of the specified limits. The result is a seamless quality record of all components in the measurement chain. Lance Guard can be used with all lance systems; both with manual lance applications and fully automatic systems such as LiquiRob, which also enables automatic cleaning of the contact block.

A RANGE OF APPLICATIONS

Semi-automatic manipulators are widely used at converters, at electric arc furnaces, and in secondary metallurgy. However, each of them performs only one specific task, and each requires special maintenance. A single LiquiRob can assume the responsibilities of several manipulators. At the converter, for example, the system provides a highly flexible solution for probe handling in combination with a sublance system, including cartridge exchange. With limited space availability in a harsh operational environment, the probes are rapidly taken from the storage rack and placed exactly onto the sublance, which then inserts it into a downspout for taking samples and performing measurements. Not only does this improve workplace safety, but it also increases the reproducibility of measurement results. A newly developed robot tool expands the range of applications to enable measuring and sampling at converters without sublance systems.

At the electric arc furnace, a newly developed LiquiRob feature makes the hazardous task of inspecting the furnace via camera system through the slag door fully automatic. LiquiRob can also open the tap hole, using a lancing tool with an oxygen lance. By means of a tool changer, the same robot can be used for deburring the tap hole.

In continuous casting, the dangers to personnel can be even more acute. LiquiRob can substitute humans and take measurements and samples, charge casting powder, or do ladle preparation, stripping, and lancing. The latest addition to LiquiRob's faculties in continuous casting is fully automatic shroud manipulation.

LIQUIROB IN ACTION

Scan the QR code or type in the link below to catch a glimpse of LiquiRob in action.

bit.ly/liquirob

SMART-SENSOR PACKAGES

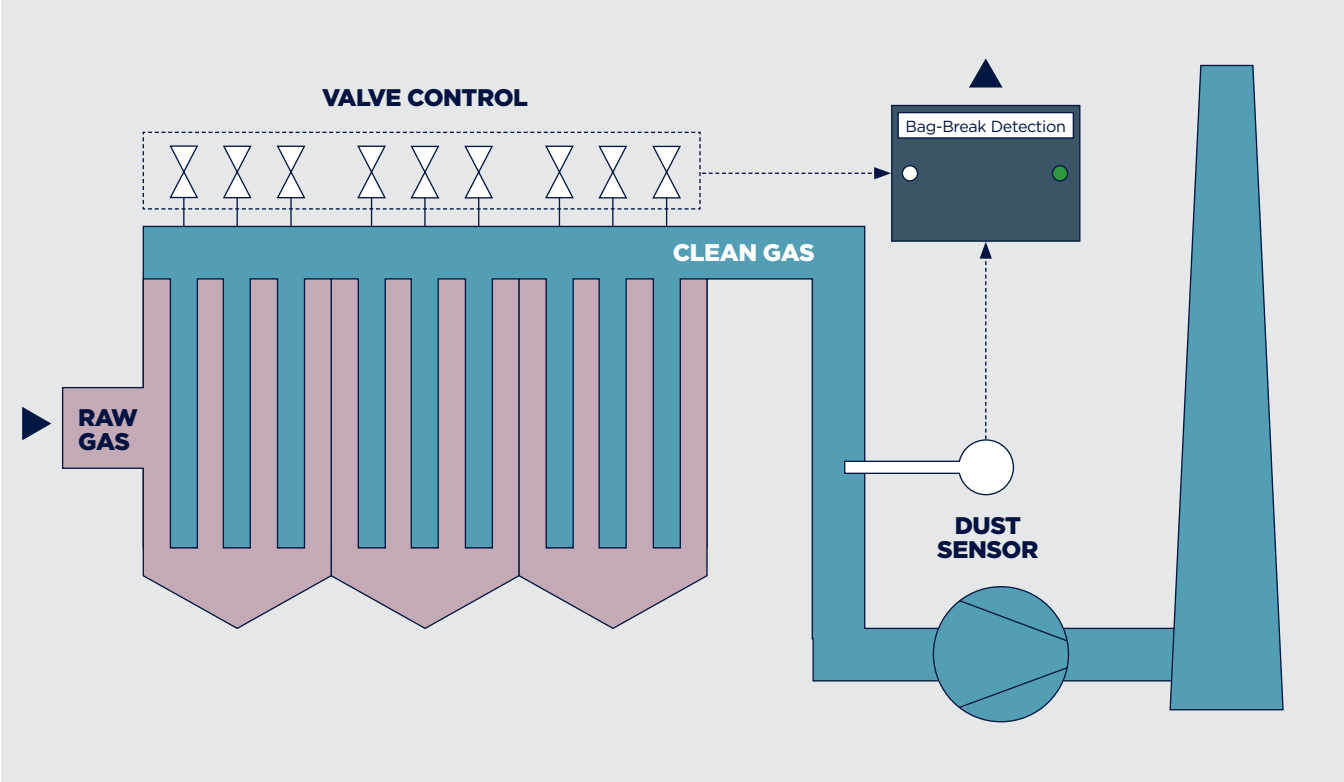
Primetals Technologies has developed a variety of sensor solutions for steelmaking. These sensors generate the data required for condition monitoring, and play an important role in determining necessary maintenance efforts. They contribute to the proactive prevention of standstill times, and improve overall production-process reliability. In this overview, we have selected three sensor packages to illustrate the wider commitment of Primetals Technologies to comprehensively digitalize the steelmaking production stage.

BAG-BREAK DETECTION SYSTEM

The Bag-Break Detection System continuously monitors the status of filter elements in a pulse jet filter. By measuring the dust at the filter exit, damaged filter elements can be detected and localized.

The system also allows for integration with the condition-monitoring system of Primetals Technologies, so that a precise analysis of the state of the filter bags attached to a valve can be conducted.

The system therefore plays a crucial role in terms of ongoing maintenance and improving cleaning efficiency, as it allows damaged filters to be replaced as necessary. Consequently, the time and money spent on identifying damaged filter bags can be significantly reduced.



Basic overview of the working principle of Primetals Technologies' Bag-Break Detection System.

SPARK-DETECTION SYSTEM

Sparks or flames in exhaust gas ducts can cause considerable damage to upstream machinery. For instance, sparks can cause significant damage in pulse-jet bag-filter systems if they are not identified in time, or at all. Damage to the hoses can cause a direct increase in exhaust gas emissions, which means taking the relevant chamber out of commission in the worst-case scenario. This could result in a production stop to allow for the damaged filter bags to be repaired. The Spark-Detection System of Primetals Technologies not only handles spark detection fully automatically; it is also a spark-extinguisher system for all types of exhaust pipes. Because the system takes measurements within the infrared spectrum, reliable detection can be guaranteed even in extreme darkness or where the situation is complicated by the accumulation of dust or very-high-volume flow rates. Integration with a condition monitoring system (such as Primetals Technologies' BOX Concept, see pg. 34) is also possible with this product, thanks to spark counters or spark-extinguisher status signals.

SLOP-OVER PREVENTION SYSTEM

The Slop-Over Prevention System was created for ladle-transfer cars. Given that steel at 1,600°C is as fluid as water, any overly jerky movements will cause slop over, which greatly increases the risk of significant damage and danger. To minimize the risk to staff and equipment, Primetals Technologies has developed a slop-over prevention system for ladle-transfer cars that uses a model-based ruleset for acceleration and deceleration curves, in order to effectively reduce the risk of slop over.

DEVELOPING SENSORS **WITH APPLIED CREATIVITY**

Andreas Rohrhofer is part of the development team at Primetals Technologies for sensor-based products in steelmaking.

How has the recent push for increased digitalization promoted the development of new sensor solutions?
Andreas Rohrhofer: Digitalization has forced us to come up with new sensor strategies and concepts. Virtual sensors, for instance, allow new measurements and calculations to be made by linking existing sensors without having to install new hardware. This new sensor strategy minimizes any disruption to the equipment and keeps design costs low.

What are the challenges in the creation of new sensor solutions for steelmaking?
Rohrhofer: The best sensor is one that we will no longer need in the future, because it will have been superseded by mathematical models and software. Therefore, we have to work hard to properly recognize physical correlations in the process and to derive a mathematical relationship from that.

Is there any one recent sensor-related project that you find particularly intriguing?
Rohrhofer: The measurement of temperature and oxygen content using submersible probes is crucially important in steelmaking. Lance Guard ensures that the associated sensors are monitored and deliver accurate readings for production and process models.

ECO SOLUTIONS
FOR FUTURE-ORIENTED PLANTS

The ECO Solutions of Primetals Technologies have been developed to improve the CO2 footprint of today's steel plants, to save resources, and to achieve environmental compliance even under the most demanding conditions. It is evident that future-oriented steel-production facilities have to rely heavily on technologies that optimize both their ecological compatibility and their overall efficiency. As Primetals Technologies has a large variety of ECO Solutions in its portfolio, only a selection of them can be presented here to serve as examples.

Dynamic Suction Control is an important innovation that significantly reduces the energy consumption of dedusting systems. At its core, it is a sophisticated control algorithm that is based on mathematical models developed over time to reflect the complex processes taking place during dedusting. Dynamic Suction Control calculates the ideal pressure set-point and damper position, which can reduce the energy required for included-draft-fan operation by as much as 20%. The solution is easily adjustable and can be added to all types of dedusting systems.

GreenButton is as conceptually simple as it is effective. It is essentially a power scheduler for dedusting systems that systematically optimizes energy consumption during planned or unplanned plant-standstill periods. Plant engineers can predefine different scenarios in which GreenButton will be active, and can select the appropriate setup momentarily and with ease when indicated. GreenButton can capture even the most complex situations that occur in today's as well as tomorrow's steel plants.

Bag-Filter Control is another huge step forward for dedusting systems. It dynamically sets the cleaning pulse in order to reduce the consumption of pressurized air. Any damaged cleaning valves or filter bags are automatically detected, freeing workers from manual inspection and allowing them to focus on other tasks. The power electronics of the Bag-Filter Control system are maintenance-free. The operator has the option of overriding the automatic selection of advanced cleaning modes. Overall, Bag-Filter Control makes dedusting more cost-effective by reducing the consumption of production-related resources and lowering the need for human labor.

DOWNLOAD OUR ECO SOLUTIONS BROCHURE HERE
This comprehensive pdf-based brochure presents an overview of the ecological solutions of Primetals Technologies.
bit.ly/ecopt

> **“To use a metaphor, the train for minimizing the carbon footprint in steel production is already unstoppable.”**
>
> Dr. Thomas Steinparzer

GREENER TECHNOLOGIES
FOR A CHANGING WORLD

Dr. Thomas Steinparzer is Head of Technology and Innovation for ECO Solutions at Primetals Technologies.

How can ECO Solutions support full-scale digitalization in tomorrow’s steel plants?
Dr. Thomas Steinparzer: The waste-gas system is an integral part of any modern steel plant and has recently become mandatory. Proper waste-gas treatment is an important step toward optimized and energy-efficient production processes. Intelligent control systems can make a significant contribution when it comes to lowering a facility’s maintenance requirements and energy consumption, so that overall compliance with even the most stringent environmental standards can be achieved and kept over time.

Which markets are currently the most relevant, and which carry the most potential?
Steinparzer: Under the current market conditions, our business has largely shifted from greenfield projects to the modernization of existing steel plants and the implementation of specific upgrade packages to conform to the latest environmental guidelines. This has reintroduced Europe as an interesting market. Asia and Russia are also highly relevant, and I see great potential for our ecological innovations in Japan and Southeast Asia. Additionally, steel plants in China are putting much attention on lowering their emissions and increasing energy efficiency.

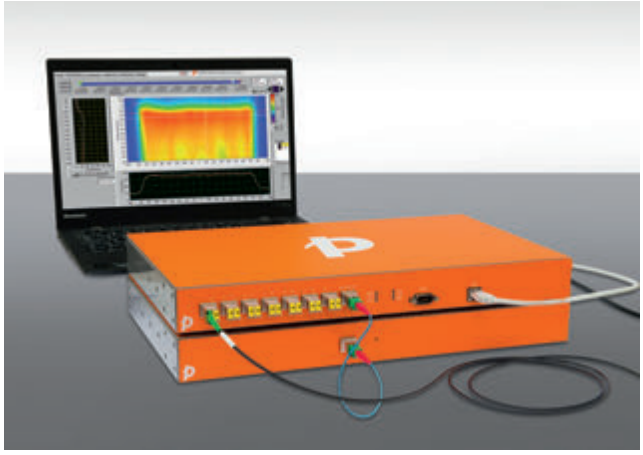
It seems that China is transforming more rapidly than many would have imagined. How would you assess the country’s recent ecological progress?
Steinparzer: China is currently undergoing a huge transformation due to the country’s new, more stringent environmental regulations. Compared to other regions, China’s emission standards are quite rigorous today. For the environment, this certainly is a positive development.

With all the controversy around the Paris climate agreement, do you foresee sufficient progress within our industry in the next four years?
Steinparzer: For many of our customers, CO_2 emissions continue to be a key topic. To use a metaphor, the train for minimizing the carbon footprint in steel production is unstoppable. It is hard to tell what speed this train will travel at due to a variety of political factors, but I am convinced that we will be seeing numerous steel plants with a vastly lower CO_2 footprint over the long term. Our ECO Solutions will make a significant contribution to this trend—particularly as we have many brilliant innovations in our pipeline for the years to come.

A SELECTION OF THE MOST REMARKABLE SOLUTIONS OF PRIMETALS TECHNOLOGIES FOR THE DIGITALIZATION OF

CONTINUOUS CASTING

The vast experience of Primetals Technologies in the field of continuous casting directly leads into the age of digitalization. Expert systems, advanced simulations, and high-end measuring devices are among the new solutions that propel continuous casting to new heights.



Mold Expert Fiber uses thousands of fiber-optic sensors to provide an astonishingly detailed "inside look" into the mold.

Example of a Speed Expert HMI. The green bars represent acceptable speed ranges for different requirements in casting.

MOLD EXPERT & MOLD EXPERT FIBER

Sticker-related breakouts are one of the major reasons for high repair costs and production losses. Product defects can mostly be traced back to processes in the mold, but conventional detection tools do not offer directly accessible information. Disturbances in the solidification process such as poor casting-powder performance, tilted submerged entry nozzles, improper taper settings, or bad steel-flow patterns are frequently overlooked due to the lack of reliable information from the mold. The Mold Expert system from Primetals Technologies collects exactly that information: comprehensive data on temperature, oscillation, primary cooling, mold level, and casting speed is fed into the Mold Expert server and interpreted. This allows for rapid alerts in the event of critical conditions. In addition to breakout prevention, the system provides an ever-increasing number of expert packages that are used to detect possible surface defects and inform operators about other challenging casting conditions. Mold Expert has become the world's leading system for mold monitoring, and Primetals Technologies recently celebrated its 200th installation.

The cutting-edge incarnation of the system—Mold Expert Fiber—takes measurement accuracy and resolution to a whole new level. It builds on the technology of fiber Bragg gratings to integrate fiber-optic sensors into the mold. This dramatically increases the number of measurement points—from a mere 120 in the standard Mold Expert installation up to in excess of 2,000. The massive amount of resulting data allows for an astonishingly detailed, real-time "inside look" into the mold. Among other benefits, the system more precisely detects critical events such as stickers and longitudinal cracks, and it calculates meniscus flow speed. Mold Expert fiber has already been sold and is on track to be deployed in production for the first time.

SPEED EXPERT

Selecting the proper casting speed in continuous casting is critically important for the productivity of a caster and the quality it produces. Many factors and requirements have to be considered when choosing the right casting speed: superheat, steel-grade requirements, quality, safety, machine limits, and other production aspects. In many instances, these requirements are at odds or effectively contradict one another; increasing production, for example, calls for higher casting speeds while safety requirements demand lower speeds.

Speed Expert from Primetals Technologies was engineered to take all of these requirements into account and find the optimum balance between them in any given casting situation. It is based on a set of rules—one for each requirement relating to casting speed. Each rule defines the ranges of speed needed to satisfy the appropriate requirement. Rules can also be assigned priorities—if two rules yield contradictory requirements on casting speed, the rule with the lower priority is ignored. Speed Expert then determines the intersection of suitable speed ranges and makes a selection based on a predefined strategy. Depending on the situation, this strategy may be to maximize speed within the possibilities, to aim for a particular speed, or to avoid any speed changes as long as all requirements are met. In continuous casters that apply soft reduction prior to solidification of the strand, Speed Expert will set the casting speed in such a way that the soft reduction process is completed right at the end of a movable segment. Most remarkably, the system can determine the casting speed necessary to achieve this online during a casting sequence.

Since its introduction in 2015, Primetals Technologies has added eight references for Speed Expert.

QUALITY EXPERT

Quality Expert is a computer-aided quality-control system for all types of continuous casters. It is designed to determine the definitions necessary for quality-related process parameters, to track data during production, and to predict the quality of cast products so that potentially defective products can be separated. It provides plant operators with online quality alerts and a preview of the quality of the casting strands in the machine. Quality Expert comes in two editions with either basic or comprehensive product-quality rating capabilities.

The online quality-control functions are configured in the Maintenance and Simulation System. The flexible rule editor enables end users to adapt or add quality rules without the support of specialized software engineers. Rule systems for predicting the quality of product-defect types (cleanliness, surface quality, inner quality) can be configured. The Quality Expert then evaluates quality rules online and displays the resulting quality rating. The quality previews are available for hot strands currently being cast and for products already cut, along with a root cause explanation of the quality rating. The knowledge-base component means that Quality Expert is easy to configure, enabling process engineers to react quickly to changing quality demands and production requirements. Quality Expert records quality-critical process data at high resolution as it is transmitted from the basic automation system and process computers. All tracked data and calculation results can be transferred from the Quality Expert's production module to a solution called the Discovery system, which is dedicated to the long-term archiving and evaluation of tracked data in accordance with ISO 9001 standards. Quality Expert represents a milestone in improving quality control in continuous casting. Cost savings can be achieved by avoiding product inspection and conditioning activities, thereby minimizing material losses and handling costs.

Visualization of Quality Expert's results

Quality Expert is easy to configure, enabling process engineers to react quickly to changing quality demands and production requirements.

YIELD EXPERT

The aim of the Yield Expert is to minimize scrap and to optimize yield. It considers scrap portions, quality defects, weight restrictions, sample cuts, and width changes while producing the maximum number of scheduled products. Yield Expert optimizes product length or product weight whenever scrap sections need to be taken care of, thanks to advanced algorithms that determine the area that should be allocated as a scrap section. It also handles quality-related defects, and schedules mold-width adjustments to amend the casting process. Yield Expert's optimization algorithms can easily be switched on or off via direct on-line control. One of Yield Expert's strongest features is the ability to replay previously used cut-to-length optimization steps within actual production setups. Yield optimization has never been so easy, straightforward, and transparent.

Yield Expert minimizes scrap during production, optimizes the casting process, and handles quality-related defects.

INTERMIX EXPERT

The Intermix Expert for all types of continuous casting machines calculates the mixed-steel area and incompatible strand portions along the entire strand. The information gathered allows the Yield Expert to cut prime products before and after the incompatible section of the strand, so maximum prime-quality yield is ensured.

Steel mixing takes place not only in the tundish but also in the mold and upper parts of the strand. Mixing in these areas is evaluated by a mix-box-type submodel of the Intermix Expert, which makes it possible to calculate the chemical composition of the steel at any position along the cast strand. Based on the chemical composition of the steel, the Intermix Expert calculates whether the mixed steel zones can be used for the desired product application or if the steel has to be downgraded or even scrapped. Input parameters such as analysis, tundish weight, casting speeds, and dimensions of the strand are taken into account. The computed results are visualized in the human machine interface. Graphs are displayed for single-analysis elements or combinations of multiple elements. Valuable information including volume concentration, mixed steel length, scrap length, and heat ranges on the strand are displayed on the screen. Configuration and simulation of the model are easily carried out in the Maintenance and Simulation System. Metallurgists can choose which chemical elements are used to determine the intermix for any steel grade. At the same time, Intermix Expert will provide them with precise information on the chemical analysis at any position on the cast slabs. The Intermix Expert's powerful simulation environment allows the intermix of different steel grades to be accurately tested.

EQUIPMENT EXPERT

The Equipment Expert is designed to monitor the installed equipment of the caster and provide operators with valuable feedback about any maintenance work required. Equipment could include, for example, an entire segment, individual rolls, a mold, or mold plates. Equipment test reports, manuals, and instruction documents for equipment are viewed in the human machine interface. For every piece of equipment, lifetime or partial-lifetime criteria are defined. Such criteria might include the number of heats, casting time, casting length, tons, durations, or any other factors. The Equipment Expert collects these criteria for each piece of equipment and notifies operators when a lifetime criterion is due to be reached, in order to facilitate preventive maintenance.

A single Equipment Expert can handle several casters at once.

NOZZLE EXPERT

The Nozzle Expert helps to detect clogged nozzles and broken hoses in all types of continuous casting machines, and ensures that the strand is uniformly cooled during the continuous casting process. The steel is cooled by spraying water onto the strand through nozzles. To avoid surface defects and possible product downgrading caused by clogged nozzles or ruptured or jammed hoses, the Nozzle Expert automatically monitors the condition of the nozzles during the casting process.

The Nozzle Expert features online and offline monitoring. In online mode, calculations begin automatically with the "Start Cast" signal, and the condition of the nozzles is monitored throughout the casting process. In offline mode, the secondary cooling system can be tested by manually activating the Nozzle Expert during casting breaks, with the advantage that any problems with the nozzles can be detected and repaired before the casting process is re-started. In idle mode, the Nozzle Expert can perform a more detailed check because proper water-flow rates can be selected. During a manual check, the water-flow rates cover the full range from minimum to maximum flow, and the performance of the controllers can be examined. The results are documented in a report, which shows the states of all cooling zones and contains a detailed section for each zone with the time trends of all relevant zone data. The Nozzle Expert is based on statistical models and indicates the ratio of clogged nozzles in each zone. Therefore, operators only have to inspect zones for which an alarm is generated. This highly efficient setup minimizes maintenance efforts and reduces the hours involved in checking nozzle status.

With the Maintenance and Simulation System, a customer can grant experts access to real-time data for remote advice.

MAINTENANCE AND SIMULATION SYSTEM FOR TESTING PROCESS CHANGES IN CASTING

The steel industry is well on its way toward fully automated continuous casting, which is going to minimize the risk of human error and increase workplace safety considerably. Meanwhile, tried and tested automation products from Primetals Technologies provide sophisticated opportunities for optimizing and monitoring the casting process, while their pioneering component-based architecture offers a high degree of flexibility.

MAINTENANCE AND SIMULATION

Primetals Technologies provides an all-in-one setup, testing, and maintenance tool as an integral part of the Continuous Casting Optimization package. The "Maintenance and Simulation System" (MSS) facilitates the maintenance of parameters and configurations for the automation system, including the process model suite DynaPhase, Dynacs 3D, and DynaGap Soft Reduction, described in more detail on pages 62-63. The MSS thus supports metallurgists in their daily work and enables them to enter the machine geometry, cooling requirements, and formulas describing water distribution and heat removal for each cooling loop, radiation, roll-heat removal, mold-heat removal, and natural convection. It also comprises the following additional functions:

- Software deployment, configuration, start, stop, restart, and the ongoing supervision and troubleshooting of caster optimization processes
- Online checks of basic automation data and an overwrite function for emergencies
- Long-term monitoring of basic automation data consistency during cold testing or parallel runs with legacy systems

A "DIGITAL TWIN" OF REAL-WORLD EQUIPMENT

The simulation part of the MSS provides the functionality necessary for testing parameter changes and training operators in an offline environment in order to achieve smooth system start-ups. It creates a virtual instance of the actual plant facility—a "digital twin" of real-world equipment. This allows engineers to run extensive simulations of new equipment or parameter changes before they are introduced to the actual casting process. It eliminates any disruptions in ongoing production and minimizes the risk of unexpected outcomes. Using predefined script files, it facilitates tests of various casting scenarios and can replay past events. The digital twin also allows for stress tests in order to predict the long-term effects of any modifications.

OFFLINE SIMULATIONS **FOR SUPERIOR SLAB QUALITY**

At its plant in Duisburg-Beeckerwerth, Germany, thyssenkrupp Steel Europe (TKSE) operates two slab casters that were upgraded with the advanced process models from Primetals Technologies. The upgrade also included an installation of the Maintenance and Simulation System (MSS). This allowed experts from Primetals Technologies to perform offline casting simulations by means of a remote connection, minimizing the impact on ongoing production and limiting the team's presence on site. This led to remarkable results as early as during the commissioning phase: Working offline, the Dynacs 3D secondary cooling model was able to identify uneven spray-water distribution in two cooling zones of the strand. Simulations with new nozzle types performed in the MSS promised significant improvements—which fully materialized in the form of superior slab-surface quality shortly afterward, when the changes were actually introduced in production.

"Digital twin" offline simulations avoid disruptions in ongoing production when changing parameters or introducing new equipment.

CASTING-PROCESS OPTIMIZATION **WITH MACHINE LEARNING**

Daniel Fuchshuber is Head of Process Optimization, Continuous Casting at Primetals Technologies.

Which types of plants benefit the most from the kinds of "digital twin" offline simulations that the MSS makes possible?
Fuchshuber: I think plants that are trying to extend their product range to special alloyed steel grades and need to invest in new or upgraded equipment benefit the most. It is invaluable to be able to simulate the outcome of these modifications in detail beforehand and plan investments accordingly.

Where do you see the most potential for future developments in the digitalization of casting?
Fuchshuber: Currently, I see two trends: autonomous casting and data analytics. Modern casting machines incorporate very complex systems that require vast knowledge to operate correctly. To achieve the best quality, an automation system needs to assess the current casting situation and take the correct actions autonomously. Long-term data analytics based on collected production data gives steel producers the foundation to identify areas for improvement.

Do you see artificial intelligence and machine learning playing a big role in the mid-term?
Fuchshuber: Long-term data analytics will become very important, but these analyses are very complex and time-consuming, and require extensive know-how. By incorporating machine learning into analytical methods, we are creating tools for the plant operators to interpret their data in a feasible way.

PIONEERING THE FUTURE OF CONTINUOUS CASTING

As one of the pioneers of continuous casting technology—a legacy extending back to the 1960s—Primetals Technologies has always been the leader in the development and implementation of sophisticated process models geared toward maximizing operational efficiency and the quality of the cast products. As far back as the 1970s, Voest-Alpine Industrieanlagenbau (VAI), a predecessor company of Primetals Technologies, introduced complex nonlinear models for evaluating strand mechanics such as bulging and material creep at high temperatures. Results of these investigations led to the application of many of the process and machine design features that Primetals Technologies still incorporates into its casting machines today.

The use of advanced process models in continuous casting remains indispensable today to meet new challenges arising from changing and increasingly difficult market requirements. The models also help to satisfy the need for new and special steel grades for ever-demanding downstream applications. Primetals Technologies therefore continues to drive innovation in this area, especially by offering a complete range of expert technological packages and models that cover all aspects of the casting process—from the casting platform to the strand run-out area.

This capability is impressively demonstrated by recent advancements in caster-automation solutions with the introduction of the DynaPhase, Dynacs 3D, and DynaGap Soft Reduction 3D models. This suite of dynamic secondary cooling and soft-reduction packages takes into account thermodynamic effects such as steel shrinkage and phase transitions, thereby significantly contributing to impressive quality improvements during the strand-solidification phase.

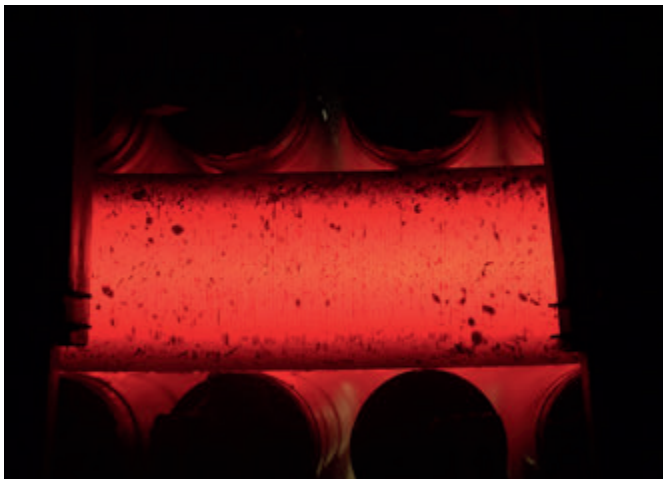
All process models from Primetals Technologies are being increasingly integrated with each other to take operating efficiency and product quality to the maximum level. This not only eases the work of the operator but also ensures that customers will have at their disposal the tools and capabilities to thrive and excel in their respective markets.

DYNAPHASE

Calculation of the 3D temperature profile of the strand requires accurate knowledge of the thermodynamic properties of steel, which includes enthalpy, solid fraction, density, and conductivity as a function of the steel temperature. However, in most cases the metallurgist does not know these thermophysical properties in advance. In order to obtain an approximation of these values, steel grades are normally grouped together and an average chemical analysis is made of each steel group. The various material properties of the respective steel groups are then experimentally determined. The resulting data is then manually entered into the Maintenance and Simulation System (MSS) tool by the metallurgist, which is a time-consuming procedure. However, casting operations show that there can be a difference in the point of final strand solidification of half a meter and more when different steel grades are cast within a particular steel group. This fact underlines the need for a process tool capable of performing online calculations of the actual steel-grade properties.

With the DynaPhase software model, the thermodynamic properties of each steel grade are calculated online on the basis of the relative proportions of coexisting steel phases at a particular temperature. This information is entered into the Dynacs 3D system, which then maps a 3D temperature profile of the strand. The combination of the DynaPhase and Dynacs 3D process models is unparalleled in the industry.

Number of references: 14 since the introduction of this process model in 2013; 14 additional projects will be implemented in 2018 and 2019.



Steel-grade properties can be calculated by the DynaPhase process model on the basis of the actual steel-melt composition.

DYNACS 3D

Thanks to continuous improvements in computer performance, it is now possible to calculate the temperature at any point within a continuously cast strand in real time. Using this information, the Dynacs 3D process model generates detailed 3D temperature profiles that serve as the basis for totally optimized secondary cooling. The model solves the heat-transfer equation and takes into account temperature-dependent steel density as well as slab thickness and width at a specific position. Heat transfer from surface radiation and natural convection, and heat transfer to the rolls and the spray water is accurately calculated by Dynacs 3D. The model is applicable for both spray-water cooling and air-mist cooling. It also considers the spray-distribution pattern of the nozzles and the actual spray-water temperature.

Thanks to the precise temperature calculations, individual control of water-flow rates and precise positioning of each cooling nozzle with movable 3D spray nozzles are possible. In this way, the targeted strand-surface temperature values are obtained for homogeneous surface cooling and excellent surface quality.

Knowledge of the temperature distribution along and throughout the strand during casting enables the point of final strand solidification to be accurately determined. Optimized soft-reduction can then be performed beforehand to eliminate center-strand porosity. The combination of the Dynacs 3D and DynaPhase process models also serves as a powerful off-line simulation tool for defining the cooling strategies required for the development of new steel grades.

Number of references: installed in more than 60 casters since the introduction of this process model in 2011; 17 additional projects will be implemented in 2018 and 2019.

Calculated temperature profile of strand surface (top and side views)

Calculated temperature of strand center (top and side views)

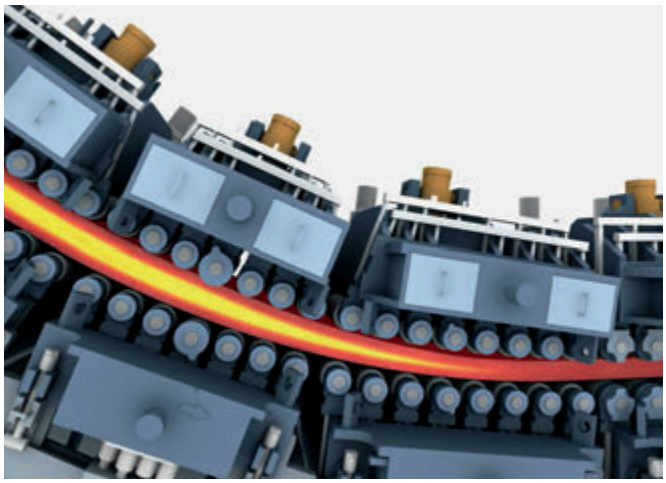
DYNAGAP 3D

DynaGap Soft Reduction 3D (DynaGap 3D) is a sophisticated process model that allows for dynamic roll-gap changes in slab and bloom casters. Working in combination with remote adjustable segment types such as Smart, Single Roll DynaGap (SRD), and Withdrawal Straightening Unit (WSU), roller gaps can be adjusted to perform strand-thickness changes, eliminate centerline segregation, and reduce porosity for substantially improved internal strand quality.

On the basis of detailed online information provided by the Dynacs 3D thermal-tracking model that includes steel shrinkage, DynaGap 3D dynamically calculates the required set points of the roll gap. Supervision of roll engagement, depending on the state of strand solidification and the calculated strand-thickness profile, is decisive for ensuring precise roll adjustments and outstanding product quality. Optimized roll engagement also prevents excessive forces from being exerted on the strand and reduces unnecessary roll wear.

Highly accurate control of the roller gaps also allows additional casting strategies to be implemented that include liquid-core reduction for high-speed casting, extended soft reduction, and also hard reduction to further reduce porosity for additional product quality improvements. Thanks to its modular setup and design, this process model can be used on existing casters with basic automation systems supplied by third parties.

Number of references: installed in more than 50 casters since the introduction of this process model in 2011; 11 additional projects will be implemented in 2018 and 2019.



Precise adjustment of the roll-gap profiles based on DynaGap Soft Reduction 3D contributes to superior product quality.

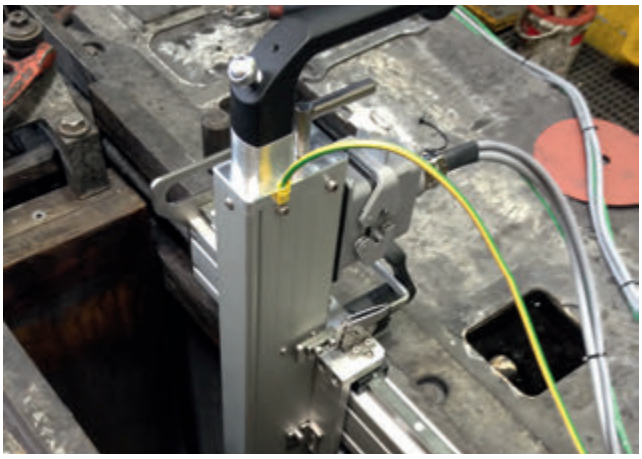
OsciChecker Wireless analyzes oscillator behavior and helps to minimize strand breakouts and improve surface quality.

OSCICHECKER WIRELESS

OsciChecker Wireless is designed to analyze the behavior of oscillators on continuous casting machines and accordingly optimizes maintenance time, reduces downtime, minimizes strand breakouts, and improves surface quality through optimized lubrication conditions at the mold. The device enables plant operators to measure mold stroke and oscillation frequency, as well as sinusoidal and non-sinusoidal movements. It can be used for straight and curved oscillations, and is suitable for slab, bloom, and billet casting machines.

OsciChecker Wireless comprises up to four measuring sensors, a calibration plate, a measurement unit, a data acquisition and evaluation program, and a measuring box in a heavy-duty protection case. It picks up mold movement spatially using capacitive acceleration sensors placed on the mold, pointing horizontally in casting direction and vertically in stroke direction. The sensors, which can be charged via standard USB or mini-USB cable, feature magnetic fixings to ensure stable measurements and a high level of accuracy. Once placed on the mold or the oscillator, the measurement sequence can be started. Movement in and perpendicular to the casting direction can be detected, as well as negative strip time and percentage. OsciChecker Wireless is also able to spot total harmonic distortion of the oscillation frequency.

The compact yet powerful OsciChecker Wireless is suitable for the measurement of oscillator movement in all three directions and for the storage and visualization of measurement data in 3D. A wireless data connection ensures maximum user comfort and flexibility, entirely eliminating the need for cumbersome cables. The system is transportable, which means it can be carried easily between strands, and predictive maintenance means that shutdowns and breakouts can be avoided.



The Automatic Thermocouple Checker is suitable for all types of thermocouples and is geared toward optimum performance.

AUTOMATIC THERMO-COUPLE CHECKER

The Automatic Thermocouple Checker is a computer-aided tool designed to test the quality of a thermocouple installation. The test involves heating the copper plate in the same position and with exactly the same intensity each time so that it is impossible to damage the copper plate.

The device delivers highly accurate temperature measurements with deviations within a range of only 0.1°C. Any bad contact between the thermocouple and the copper plate can also be detected. The automatic, repeatable heating of thermocouples allows the quality of thermocouple installations to be markedly improved, while keeping the exchange of molds from bad thermocouples to a minimum.

The Automatic Thermocouple Checker is delivered as a transportable unit that is connected to standard thermocouple connectors. It is suitable for testing the integrity of narrow faces as well as broad faces and can be used to measure either single-mold plates (maintenance area) or mold plates at the assembled mold (in the machine). The measuring arm is positioned manually by the operator to a predefined (lockable) thermocouple column requested by the software. In a fully automatic procedure, the thermocouples in a column are heated one after another, and the temperature reaction is evaluated. Once an entire copper plate has been checked, any thermocouples with bad contacts are flagged and a report is generated.

The Automatic Thermocouple Checker eliminates measurement errors as a result of incorrect heating positions and guarantees the optimum performance of thermocouples. Consequently, maintenance work can also be kept to a minimum and quality management improved based on the recorded data.

The high-precision, robustly designed taper measuring system can be applied in any conventional slab caster.

TAPER CHECKER WIRELESS

The Taper Checker Wireless is a taper-measuring system designed to check and adjust the mold within the required tolerances before casting begins. The taper of the lateral mold surfaces is precisely measured with long-term stable inclinometers, a critical procedure given that correct tapers of mold narrow faces can minimize the number of breakouts and improve the surface quality of cast slabs.

The Taper Checker Wireless eliminates virtually all human error, such as entering incorrect calibration values. The operator's only job is to measure both narrow faces, and by pressing the transmit button, the measured correction value is sent to the automation system wirelessly.

A small display on top of the measuring device shows the correction values, enabling the user to check the plausibility of the measured taper. The Taper Checker Wireless can also be used in the maintenance area, where no Wi-Fi calibration is done.

The Taper Checker Wireless is designed to be extremely stable, which means that under normal circumstances accuracy and usage are not affected by the actual measuring process. The robustly designed system makes taper measuring a quick and easy process. As such, it can be applied in any conventional slab caster. Thanks to its modular block design, the measuring system can also be cost-effectively tailored and configured to meet individual customer needs.

Learn more about the "Industry 4.0" measuring devices of Primetals Technologies by downloading our product brochures at **bit.ly/checkerspt**

OBTAINING MEASUREMENTS **THE INTUITIVE WAY**

Nicole Oberschmidleitner is Head of Mechatronic Products at Primetals Technologies, and has been with the company for 16 years.

What are the most important objectives for current-generation measurement devices?
Nicole Oberschmidleitner: The main objectives are to ensure optimal operation of all involved production equipment, streamline maintenance efforts, enable seamless documentation, and allow for product analyses.

Have measuring devices changed due to the trend toward digitalization?
Oberschmidleitner: Certainly. In general, there has been a push toward more software-led devices that make the operators' lives easier. You can compare this development to that of recent smartphone cameras. They take great photos thanks to their software even if you don't know much about the internal workings. Also, measurement data is now automatically fed into automation systems for calibration to avoid human error.

In the future, will less human labor be required in taking measurements?
Oberschmidleitner: The process of taking measurements has clearly become more efficient. Multiple readings can now be obtained at the same time. The main benefit of today's technologies is that operators don't have to be experts, because the measuring process is largely self-explanatory.

A SELECTION OF THE MOST REMARKABLE SOLUTIONS OF PRIMETALS TECHNOLOGIES FOR THE DIGITALIZATION OF

ROLLING

In the steel plant of the future, the complexity of hot and cold rolling becomes more easily manageable. Smart sensors, a new generation of digital process models, and better cooling technologies all contribute to a higher and more consistent end-product quality.

Hot rolling | Cold rolling | Long rolling | Aluminum

CYBER-PHYSICAL MODEL FOR COOLING

In 2010, a brand new idea for a novel type of cooling model triggered a wealth of activities geared toward an implementation in the years to follow. In its current form, the model is designed to use a comprehensive thermodynamic approach, starting at the roughing mill and calculating strip temperature, phase content, and microstructure in real time from the roughing stand to the coiler.

The process model not only controls cooling units but also allows for the control of the booster pumps for Power Cooling and the water-management pumps. The fact that the cooling model always knows in advance how much water is going to be needed has two major benefits: Large amounts of water can be controlled with unequalled dynamics, and efficient control of pumps and water can lower production costs.

Another highlight is the comprehensive temperature control for the transfer bar, final strip, and coiler. Based on measurements of pre-strip temperature after the roughing mill, the cooling model predicts subsequent rolling temperatures and controls the speed of the finishing mill with an optimized speed diagram. Since the future rolling speed is thus a known factor, it can improve the accuracy of the values for the final rolling and coiler temperatures—above all for thick strip, where dead times are especially long.

Together with the mechanical equipment from Primetals Technologies—cooling aggregates are fitted with continuous-control valves and pumps with vector control—the new cooling model forms a cyber-physical system. It lowers production costs by reducing the need for alloying elements and energy, increases throughput as well as quality, and opens up new possibilities for the production of advanced steel grades.

The cyber-physical cooling model increases throughput and lowers productions costs (photo courtesy of thyssenkrupp).

MODEL-BASED STRIP-WIDTH CONTROL

Hot rolling

The main challenges facing today's basic and process automation systems for hot-strip mills are the reduction of strip-width deviations and the avoidance of below-minimum widths after the finishing mill, which is why Primetals Technologies has developed model-based strip-width control. Recognizing that tension can be used to manipulate the strip width in the finishing mill, model-based width control compensates for width deviations.

Width deviations are measured in front of and after the finishing mill. Entry-width deviation and width deviation due to inhomogeneous temperature distribution along the strip are reduced by a feed-forward width control (FFWC). The residual exit width deviation is reduced by a feedback-width control (FBWC). Moreover, the model-based feed-forward width control takes account of the effects of width spread in the roll bite as well as creep deformation between the stands. Effective width-deviation compensation using tension control is limited to low-frequency width deviations.

By default, the strip width in a hot-strip mill is determined by edging and rolling the strip in the roughing mill. The width deviation after the finishing mill arises from the width deviation in front of the finishing mill and from width-spread anomaly occurring inside the finishing mill. The behavior of width spread in a finishing mill depends on effects in roll bite and on the creep deformation between the stands, whereby the width spread in roll bite is influenced, for example, by thickness reduction, front and back tension, and the change-of-strip-crown ratio. The creep deformation between the stands depends on factors such as yield stress, strip temperature, specific tension, distance between stands, and strip speed.

Essential measuring instruments for FFWC and FBWC are standard width measurements located respectively after the roughing mill and finishing mill. In the case of a large product mix with different entry-strip temperatures to the finishing mill, a temperature measurement in front of the finishing mill improves the performance of the FFWC. The signal processing of the exit width of the roughing mill is an important component of the FFWC. It tracks the actual filtered exit width and the reference exit width of the roughing mill at the entry of the finishing mill for the FFWC.

The model-based approach ensures better strip quality and therefore improved productivity due to the decrease of overwidth. There is less off-gauge, with decreased areas close to minimum width through the reduction of reference tensions in the finishing mill, and the overall result is increased product tonnage.

WEDGE AND CAMBER CONTROL

Hot rolling

Rolled strip is ideally both straight (i.e. without camber) and left-right-symmetrical with respect to thickness (i.e. without wedge). Unfortunately, if wedge within a slab is removed through swiveling of the roll stack without further countermeasures, the result is camber, which—from a quality point of view—is even worse than wedge. The wedge and camber control solution from Primetals Technologies combines a number of technologies to tackle the problem: it uses cameras to obtain reliable readings of the strip's position, measures thickness across the width of the strip, uses precise process modeling for both the roughing mill and the finishing mill, and utilizes the edger as a straightening machine. As a result, wedge is reduced to a minimum, and camber formation is avoided altogether—as are cobbles while threading and tailing out.

In order to control both wedge and camber, several components of the solution are ingeniously interlinked. First, the model-aided slab-to-slab swiveling in the roughing train reduces wedge at a point where there is still enough lateral material flow. Any camber that might result from this is straightened by the edger on the reversing pass. Second, a camber-measuring device placed after the roughing mill not only delivers data on camber, but also on the possible formation of hooks on the head or tail. Third, cameras monitoring lateral strip position in the finishing train support two functions of the "steering expert" from Primetals Technologies: threading control to compensate for camber effects on steering in the first stands, and strip-guidance control to react to steering issues and settle the strip's run.

The full functionality of the solution was installed and tested at thyssenkrupp Steel Europe with very positive results. But even in cases where only a selection of the complete functionality is implemented, wedge formation and strip guidance are still notably improved.

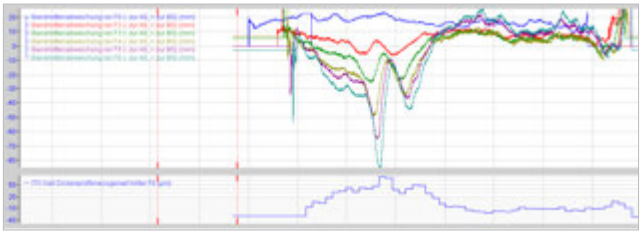
A package of intertwined technologies rises to the challenge of reducing wedge formation in rolling without causing camber.

VISION-BASED STRIP-STEERING CONTROL

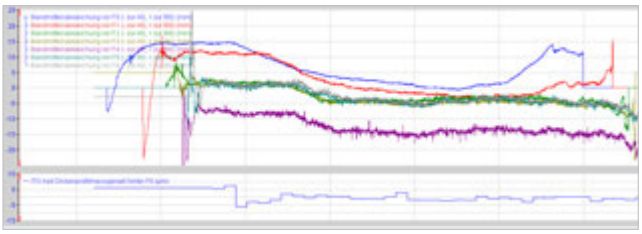
Hot rolling

The Electrics & Automation experts at Primetals Technologies, together with thyssenkrupp Steel Europe, have devised a new vision-based strip-steering control system for hot-strip mills. From the start of the development phase, the solution was intended to further improve strip quality by enabling even tighter tolerance levels for the strip profile and for strip flatness. Also, the buildup of camber was to be counteracted. The finalized solution met all expectations. During the pilot phase, nearly 18,000 coils were produced to statistically validate the effectiveness of the strip-steering control system. Results showed that with the steering control system turned on, the lateral displacement of the strip was dramatically reduced, whereas with the system switched off, the displacement strongly correlated with the evolved thickness wedge after the finishing mill (see comparison below for a visualization of the effect). Improvements were achieved for all products rolled in the testing mill, and for all material grades usually targeted.

While the complete strip-steering control system is complex and involves sophisticated control mechanisms, it could not function without a reliable sensor. Since operating conditions in a hot-strip mill are demanding (significant amounts of dust and splashes of cooling water), the sensor had to be able to withstand the challenges of its environment. The technology experts chose a custom-made optical sensor called the "ShapeMon" sensor—a combined camber and centerline measurement device with the ability to also measure the width of the strip. thyssenkrupp decided to keep the vision-based strip-steering system in regular use at its Duisburg plant, based on the excellent results delivered by the solution.



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



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

SMARTER PLANTS **THROUGH ARTIFICIAL INTELLIGENCE**

Günther Winter has been with Primetals Technologies for 38 years and currently holds the position of Technology Officer and Head of Innovation Electrics & Automation. Winter has led and participated in the creation of numerous innovative automation solutions. He views process automation from a holistic standpoint and strives to see the big picture of how steel producers can optimally set up their operations for maximum efficiency and profitability.

What do you consider to be the core challenge in the push toward digitalization?
Günther Winter: First and foremost, digitalization is going to increase the creation of added value along the full metals-production chain. This can be done, for instance, to increase productivity, flexibility of operations and product quality. However, a core challenge that steel producers are facing is the transfer of application knowledge from their seasoned operators to the next generation of employees. In many cases, new employees arrive with far less experience than their predecessors. This will increasingly become a widespread problem over the coming years. Digital assistants and the digitalization of know-how will be supporting our customers in their agenda. Our Through-Process Optimization and Maintenance and Asset Technology are examples of superposed systems for intelligent production capable of implementing existing operational and maintenance know-how and providing a high-quality database for the training of software systems based on artificial intelligence —such as digital assistants. Last but not least, cyber-physical systems, i.e. our implementation of the next generation of process automation, will optimally collaborate with our digital assistants and our superposed systems for intelligent production. They will make process control even more autonomous and robust.

Digitalization aims to connect all process steps within a plant in order to control and optimize overall efficiency. This is a big undertaking, so how far along are we?
Winter: Compared to other industries, the steel business in general—and Primetals Technologies in particular—has been ahead in terms of the level of process automation for a long time. This is a fact. But it is also true that most automation systems have been limited to specific parts of the production chain, and are based on heterogeneous systems that are difficult to connect with one another, which would be an essential prerequisite for a technology to participate in the Internet of Things. Many steel producers still have to upgrade their equipment in order to properly mirror and interconnect their processes through software. This will take place in successive steps, for instance, within the scope of modernization projects, and Primetals Technologies will provide its customers with scalable modernization packages.

Is there any one country that you think is moving toward digitalized steel production more forcefully than others?
Winter: The Chinese government has issued the so-called "Made in China 2025" program, which is without parallel in its ambition. However, we are also seeing impressive progress in our customer projects in the EU, USA, Japan, and other countries.

Will artificial intelligence play a role in the steel plant of tomorrow?
Winter: Yes. I am glad to state that Primetals Technologies is a pioneer in the field of artificial intelligence. We introduced machine learning and neural networks to the steel industry in the mid of the 90s. Since then, we have accumulated many references for the enhancement of process models with artificial intelligence. Let me give you some concrete examples: our Acoustic Expert, a technology that relies on smart analysis of recorded sounds, is an excellent tool for condition monitoring. Also, the interlinked data history of our Through-Process Optimization system is an excellent basis for data analytics and for the creation of expert systems, which enables comprehensive fine-tuning of the full steel-production chain. Recently, machine-learning technology has made further vast advancements, especially in the area of imaging, autonomous systems, and digital assistants. I think that machine learning in metals will continue to play an important role, especially in complementing our advanced cyber-physical systems with digital assistants. Overall, Primetals Technologies is continuously enhancing its portfolio of solutions that incorporate artificial intelligence in all the fields that I just mentioned, and many more!

Peter Hunt, Development Manager at Primetals Technologies, demonstrates the capabilities of the Transformation Monitor.

The Air Bearing ShapeMeter is precision technology, assembled in the U.K. by experienced Christchurch technicians.

TRANSFORMATION MONITOR

The Transformation Monitor directly measures the transformation of iron from austenite to ferrite through a real-time, online measurement of the ferrite concentration within the steel as it cools. It uses EMspec technology under license from The University of Manchester, U.K.

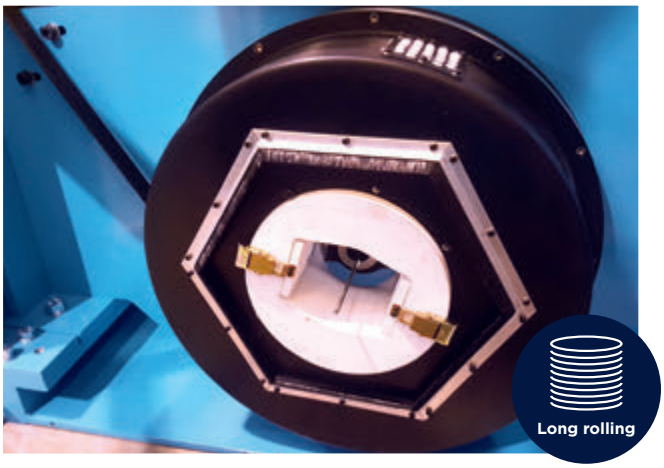
The Transformation Monitor breaks with the traditional approach of measuring the surface temperature of the steel on the runout table, a method which is open to error as the temperature reading can be affected—for instance, scale or water on the steel surface will produce a lower reading. In this case, however, the sensor head is constantly washed with water to prevent false signals caused by material on the surface. One or more sensor heads are located under the passline on the runout table. Each water-cooled head is in close proximity to the hot steel and generates a primary magnetic field which interacts with the hot steel, producing a secondary magnetic field that is detected by the sensor head. Austenite has a low magnetic permeability while ferrite has a high magnetic permeability, so the Transformation Monitor exploits this difference to measure the percentage of transformation that has occurred.

The Transformation Monitor measures transformation directly, making it superior to the common approach where modeling is still used to determine the microstructure of the final product by controlling rolling and cooling. This model often relies on parameters that are not exclusively related to microstructure. Given that certain steel grades do not fully transform to ferrite, a more useful measurement is the Transformation Index, a material-dependent measure of the ratio of austenite to ferrite in the final product. The Transformation Monitor can be installed into new and existing mills.

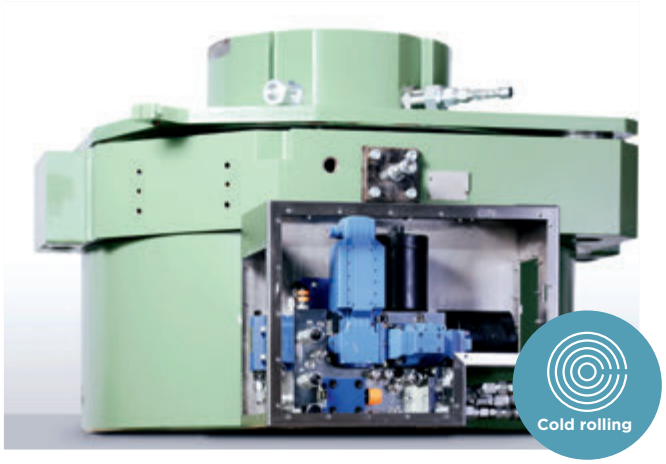
AIR-BEARING SHAPEMETER

The Air-Bearing ShapeMeter of Primetals Technologies accurately measures the shape of rolled metal sheet and foil material (Aluminum and other metals). It provides continuous, high-accuracy readings with fast signal-response rates even at low rolling speeds. Thanks to its modular construction, the Air-Bearing ShapeMeter can be adapted to almost any application without compromising its full operating capability. The core of the instrument is a roll comprised of hardened, precision-ground rotors, which are supported by an air film on a stationary, stainless-steel arbor. Each rotor is supplied with air by an array of jets that are connected to a common plenum chamber in the arbor's center. This design results in low-inertia rotating elements that exhibit the minimal frictional resistance typical of air bearings. The need for helper drives is eliminated.

The operating principle of the Air-Bearing ShapeMeter is straightforward: the pressure differential between the top and bottom of the inside of each bearing is proportional to the load applied to the rotor. It is therefore possible to calculate the tension at each rotor position across the width of the rolled metal sheet. As a result, the Air-Bearing ShapeMeter can accumulate enough data to determine a profile of the stress distribution—a "shape"—of the sheet. Every differential-pressure output is measured by a high-integrity pneumatic transducer, which is located remotely in the transducer housing attached to the end of the arbor through an armored signal cord. With more than 600 installations worldwide, the Air-Bearing ShapeMeter has a track record of excellence going back 40 years. Its high accuracy, robust construction, modular design, low maintenance needs, and strikingly positive impact on end-product quality have convinced many customers of Primetals Technologies to trust its readings for optimal rolling operation.



The Orbis+ can handle more profiles per meter than other technologies while guaranteeing high online accuracy.



The ChatterBlock solution is a unique anti-chatter system that fully eliminates third-octave gauge chatter in cold-rolling mills.

ORBIS+ ROTATING GAUGE

The Orbis+ is a rotating gauge designed to continually measure properties of hot steel in rod and bar rolling mills such as the diameter, and to pass on this information to the automation system. The system includes an in-line gauge head capable of withstanding the harsh environment of a rolling mill, as well as an operator workstation where the product dimensions and profile are displayed on a user-configurable screen in numeric or graphical form.

Fully rotating optics enable the gauge to measure and display the dimensions of round and non-round shapes regardless of product orientation. The optical system is mounted on a rotating assembly comprising a collimated light source and a dual- or single-line scan camera, and is sealed from the mill environment. The back light is a collimated source which utilizes an LED and lens assembly to produce a collimated beam across the field of view. As the product passes through the gauge, it obscures the light path, causing a shadow to be seen by the line-scan camera, and this is converted into an absolute measurement by a simple calibration algorithm. An optional pyrometer can be used to provide the product temperature; this input is used to convert the hot dimensions into cold-corrected measurements before they are displayed on the operator screen, allowing rapid judgments to be made about any necessary mill adjustments.

The graphical area is in the form of a polar plot, meaning that any bar defects (overfill, underfill, roll cross, etc.) are magnified to enable the operator to immediately identify potential problems in the rolling process. With 200 references installed to date, the Orbis+ has evolved to keep pace with technological advances in computing power and optical equipment while maintaining backward compatibility to ensure a long service life.

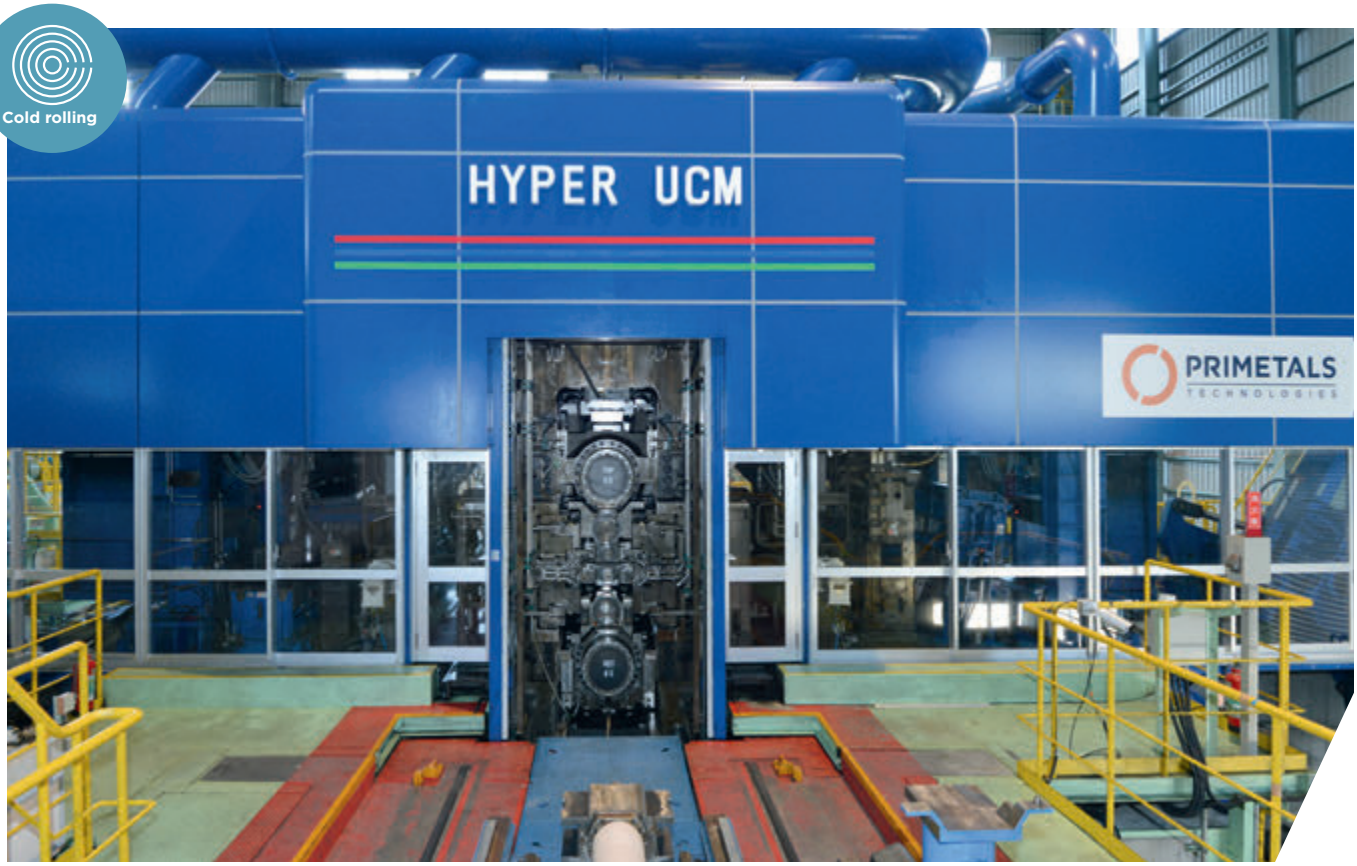
CHATTERBLOCK MILL-VIBRATION CONTROL

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

The ChatterBlock solution is a unique anti-chatter system that fully eliminates third-octave gauge chatter in cold-rolling mills. It is based on an in-depth root-cause analysis of the chatter phenomenon. During this analysis, the Primetals Technologies specialists found that mill chatter represents a process parameter-excited instability generated in the roll gap. The solution thus required a stabilizing system that would bring the rolling mill back into a stable and controllable state. The core function needed was the exertion of a damping effect on the powerful roll-force cylinders that would not hamper the mill's automatic gauge-control system. Primetals Technologies therefore developed customized controller algorithms, completely new and highly dynamic servovalves, and hydraulic design solutions to control vibration frequencies between 90 and 150 Hz.

Results show that a 10% increase in maximum mill speed is possible, which translates into an impressive increase in plant productivity. ChatterBlock Control is available as an autonomous technology package that can be modified to meet the individual vibration-solution requirements of both new and existing mills. Through the suppression of unwanted mill vibration, producers also benefit from prolonged equipment lifetime, improved product quality and higher profit margins.

Cold rolling



UCM Flat optimizes strip-flatness quality with the Universal Crown Control Mill of Primetals Technologies.

UCM FLAT—THE NEW FLATNESS CONTROL FOR 6-HIGH UNIVERSAL CROWN CONTROL MILLS

Mechatronics know-how from Japan, combined with German expertise in Electrics & Automation: the international team of Primetals Technologies has developed an advanced flatness-control system for the production of cold-rolled strip. The system has been designed to complement the 6-high Universal Crown Control Mill (UCM) technology and enables earlier prevention of nonconformities at optimal actuator use. It is based on commonly used flatness-control approaches but adds significant improvements:

- Model-based actuator-efficiency calculation
- Model-based flatness-error optimizer
- Model-based control principle

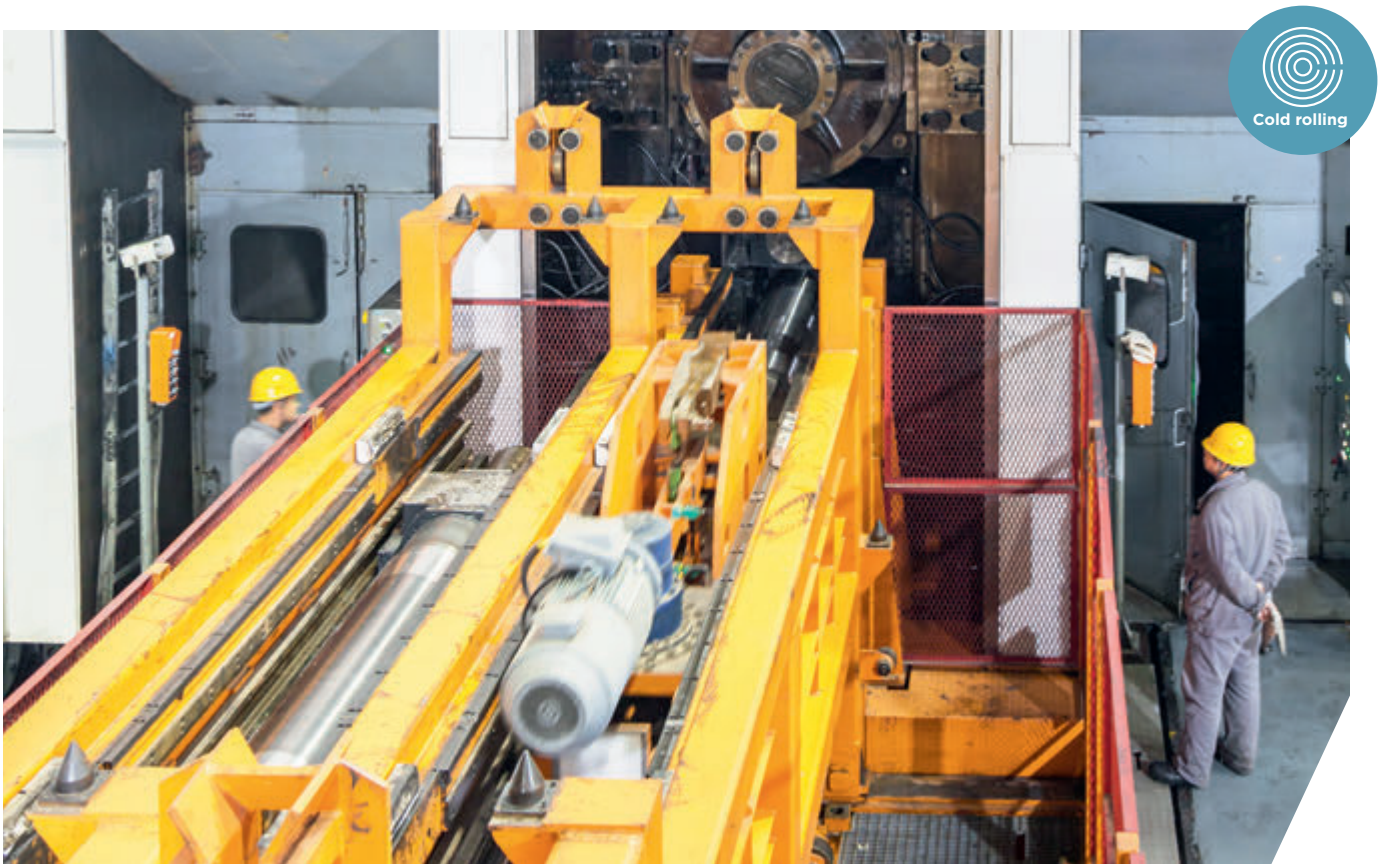
The UCM Flat encompasses a newly structured control software that makes operation extremely straightforward. The UCM Flat software's general advantage is its high degree of reliability stemming from the decades-long experience of Primetals Technologies in strip-flatness control. Primetals Technologies has developed an application called "ChartConverter," which automatically transfers the UCM Flat software to different types of automation platforms and will ensure optimal implementation of UCM Flat far beyond its current reach.

MAIN BENEFITS OF UCM FLAT

- Higher strip-flatness quality
- Shorter start-up time with mill revamps
- Reliable production planning
- Lower risk for producers' customers

When used stand-alone in conjunction with a measurement system, the flatness control is an ideal upgrade for existing automation systems. Alternatively, it can be integrated into the larger automation system of Primetals Technologies.

The new control system was successfully tested on a 6-high UCM in the Hiroshima testing facilities of Primetals Technologies. During the pilot phase, the control system and the mechatronics were optimized and further aligned. Early rolling tests showed significant improvements with fewer nonconformities and a reduction of off-gauge material at the head and the tail of the strip.



With the patented Flying Roll Change (FRC) from Primetals Technologies, work rolls can be changed without stopping the mill.

NON-STOP FLYING ROLL CHANGE
TO ACHIEVE HIGHER MILL PRODUCTIVITY

Stopping a continuous rolling mill will result in strip defects as well as production losses. Strip-surface marks and thickness deviations may exceed quality control limits and the strip section may have to be cut out.

Depending on strip-surface quality targets (e.g., when producing in high-end stainless-steel mills), roll changes may be called for after two or three strips. In today's plants, this means the line has to be stopped and restarted.

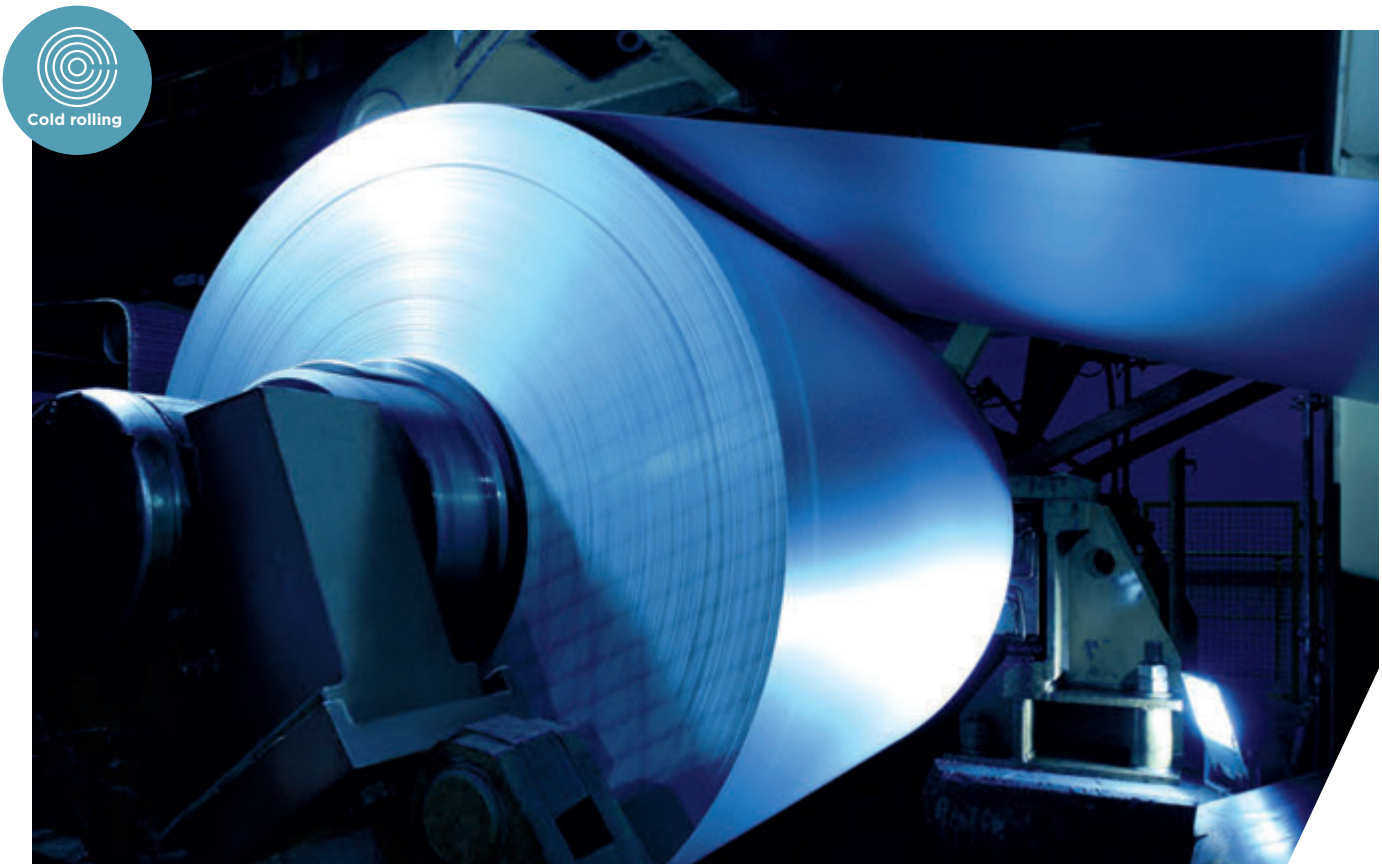
With the patented Flying Roll Change (FRC) from Primetals Technologies, work rolls can be changed on the fly without stopping the mill. The technology works as follows: one stand, e.g., a hypothetical inactive stand No. 4, is prepared with new rolls during the line run with the roll gap being open at that time. At the stand with the worn rolls, e.g., an active stand No. 3, the roll gap will be set to open when the weld seam passes so that rolls can be changed. As long as stand No. 3 is not operating, the thickness reduction it usually performs will be automatically taken over by the stand that is already equipped with new rolls—stand No. 4 in our example. Production can therefore continue without interruption.

MAIN BENEFITS

- Higher production stability
- Higher output due to longer production time
- Higher output due to shorter off-gauge length
- Hot (active) spare parts in case of failure

Introducing the FRC to a rolling mill can increase its production by of up to 8% per year depending on production speed, frequency of roll changes, and type of material. As an example: at a production capacity of 1 million tons per year and $60 of added value for stainless steel, this could mean an additional $4.8 million in profit per year.

If a mill works with materials that require all stands to be permanently active for maximum strip thickness reduction, the solution may be to add an additional stand to the setup. The investment typically pays for itself within one or two years of production.



Even minimal coil eccentricities can cause tension oscillations in the strip and lead to errors in strip thickness and surface defects.

COIL-ECCENTRICITY COMPENSATION
TO TACKLE TENSION DISTURBANCES

When cold strip is wound onto a mandrel, the coil is never perfectly round but slightly eccentric. These eccentricities have a number of different causes:

- A bump resulting from the strip head being wrapped on the coiler mandrel by a belt wrapper, which is propagated with each revolution
- A bump caused by the strip head coming out of the gripper slot (being used instead of a belt wrapper)
- In reversing mills, a difference in thickness emerging after a few passes between the head and tail on the one hand, and the strip body on the other
- An imbalance in the coiler mandrel mechanism

This coiler eccentricity causes tension oscillations in the strip, which in turn can lead to strip-thickness errors and strip-surface defects.

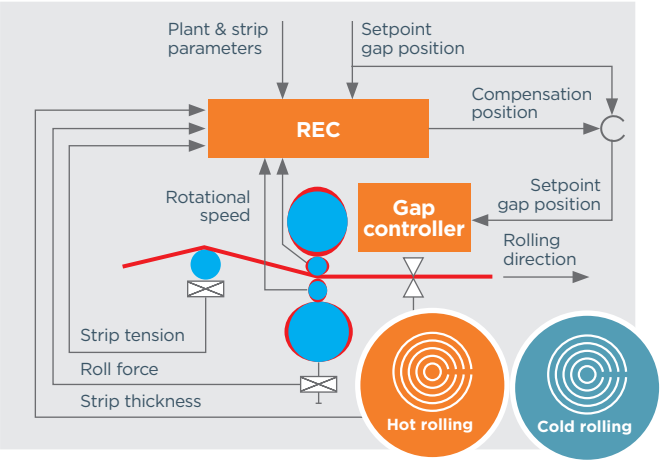
Since tension disturbances are repeated with each revolution of the coiler, their frequency depends on the rotational speed. At high rolling speeds, these periodic changes are much too fast to be compensated by the closed-loop tension controller. Moreover, the behavior of the system to be controlled changes dramatically with speed, coil diameter, strip geometry, and pass reduction.

MAIN BENEFITS OF CECO

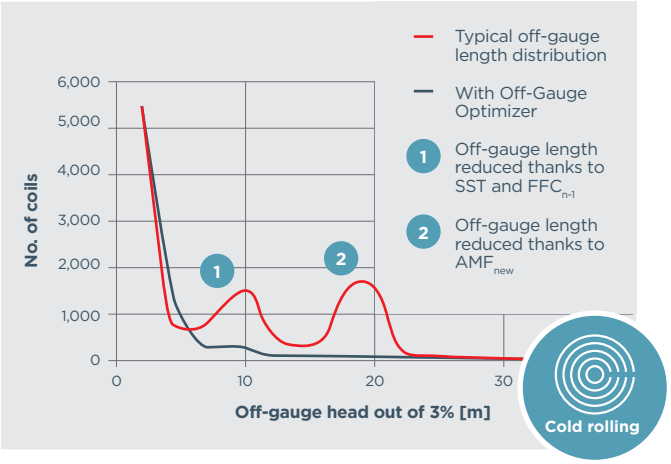
- Better strip quality
- Easy to implement in existing systems
- Fast realization of ROI
- Maintenance-friendly

As a solution to this problem, Primetals Technologies has introduced Coil Eccentricity Compensation (CECO), which can be used for all strip types and coil diameters. It is a model-based control that makes use of the fact that the shape of the eccentricity remains relatively constant during coiling. CECO can therefore create a model of the eccentricity over several revolutions. Using an inverted plant model, the eccentricity is translated into a compensation torque for the coiler drive (pre-control).

As a result, strip quality improves: stable strip tension leads to better strip-thickness tolerances and higher strip-surface quality.



Roll-Eccentricity Compensation (REC) eliminates the influence of roll eccentricity on strip thickness or tension.



OGO significantly reduces the average off-gauge lengths—to approximately 8 m, as verified at several reference plants.

ROLL-ECCENTRICITY COMPENSATION

Rolls in rolling mills are never perfectly round but have a certain eccentricity, which has a range of different causes, such as:

- Inaccuracies in grinding
- Non-uniform thermal expansion
- Asymmetrical adjustment of bearing rolls shell via drive-spindle head

When the roll is rotating, the eccentricity moves at a base frequency, which is the rotary frequency of the roll and a number of harmonic frequencies. Every roll of each roll stack can have eccentricities that result in thickness and tension errors. These errors then lead to disturbances in neighboring stands. The result is a mixture of many cyclic disturbances in the exit thickness that in most plants add up to a significant percentage of the total thickness deviation.

Compensating roll eccentricity is no small feat—due to the large number of different eccentricity frequencies and difficulties in obtaining the right measurement signals and filtering them.

Roll-Eccentricity Compensation (REC) from Primetals Technologies rises to these challenges. It is a fully digital model-based control that models the shape of the eccentricity during rolling. As input, depending on availability, it uses a combination of data on the exit thickness, entry strip tension, and roll force to extract any eccentricities. The output is translated into a compensation set point for the gap control (pre-control), adjusting the gap in a way that effectively eliminates the influence of the eccentricity on strip thickness or tension.

As a result, the plant owner can expect higher strip quality, fewer roll changes and thus fast ROI.

OFF-GAUGE OPTIMIZER

Head- and tail-end off-gauge length is defined as the length of strip from the weld to the point from which the final thickness deviation reliably stays within a tolerance band of approximately ±3%. Reprocessing costs of downgraded, off-gauge material can have a considerable impact on the final cost figure in rolling.

Moreover, high off-gauge lengths decrease the annual yield in quality product. To unlock this "hidden potential" of rolling-mill equipment, Primetals Technologies has developed a very cost-effective technology package called the Off-Gauge Optimizer (OGO).

Based on the perfect combination of technology, process control, and instrumentation, the OGO features a smart implementation of the control algorithms of a tandem cold mill based on the mass-flow principle.

The architecture of OGO is modular and consists of three parts: First, Advanced Mass Flow (AMFnew) controls the mass flow from the mill entry to the mill exit and ensures stable rolling conditions to keep thickness errors at a minimum. Second, Soft-Sensor for Strip Thickness (SST), a soft-sensor-based roll-gap-thickness estimator, perfects the performance of OGO during weld-seam-transition rolling. Interstand rollgap thicknesses are modeled based on strip speed data and one initial strip-thickness measurement. Third, Feed-Forward Control (FFCn-1) minimizes thickness errors that occur for reasons such as tension disturbances during weld-seam rolling on the next-to-last stand.

In the end, OGO significantly reduces the average off-gauge lengths—to approximately 8 m, as verified at several reference plants. For a plant with a production of 1.6 million tons per year, this corresponds to an annual increase in yield of approximately 6,400 tons.

MQL spray bar with optimized quick-change nozzles

MINIMUM QUANTITY LUBRICATION

Cold rolling

Minimum Quantity Lubrication (MQL) is Primetals Technologies' next generation roll-gap lubrication system for cold-rolling mills, applying neat rolling oil atomized with air directly onto the surfaces of the work rolls. This is especially relevant in light of recent trends toward increasing production of advanced high-strength steel grades (AHSS) for the automotive industries or silicon steels for electrical appliances.

MQL allows for intelligent control of the oil-film thickness depending on the rolling process. Based on actual process and product parameters, the digital solution can determine and control the optimum amount of oil to maximize rolling efficiency and secure rolling stability (intelligent forward-slip control). MQL not only ensures optimum product-specific lubrication, but the effortless and rapid change of lubrication settings offers a much higher degree of flexibility than has been previously possible with classical emulsion systems. Comprehensive tests at three different European steel producers proved the industry strength, and also showed conclusively that MQL permits the application of considerably lower rolling forces and motor torques, as it maximizes the level of oil concentration in the roll bite. These savings can be converted into more reduction or a wider strip. Another major advantage of the system is better strip-surface cleanliness, which is achieved via improved lubrication leading to less strip wear and hence less iron fines on the strip surface after cold rolling.

MQL is a pre-tested technology package now available to customers and consists of spray bars with quick-change nozzles (as illustrated above), an oil-supply unit, and a process unit with a defined interface to the mill automation system. The system can be easily installed on existing mills either as an additional lubrication system, or to replace an existing emulsion recirculation or direct application system.

After several successful prototype tests, MQL was installed permanently in the batch tandem cold mill of a major European steel producer. It has been in operation for more than a year, delivering outstanding results.

Static Non-Contact Bar Counter, in operation in a long-rolling mill.

STATIC NON-CONTACT BAR COUNTER

Long rolling

The advantages of a high-speed bar mill are lost if bottlenecks develop during production. One of the final post-production steps prior to delivery is bar bundling and counting. An engineer from the Primetals Technologies operation in Worcester, Massachusetts, U.S.A., has invented a static non-contact bar-counting system to provide the precision expected by end customers.

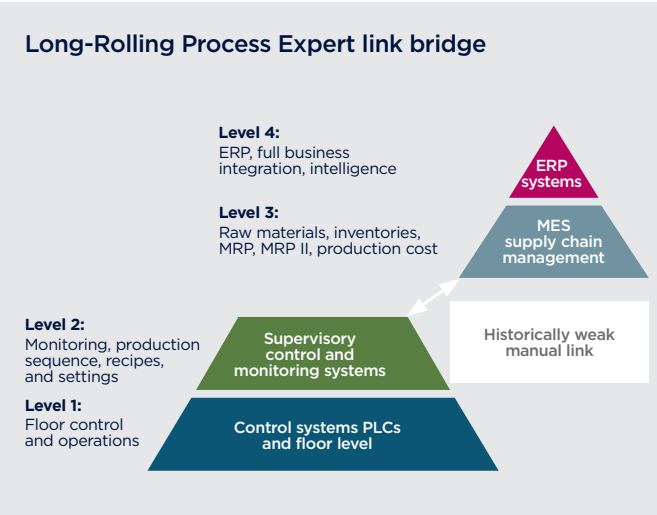
"Before now, the number of bars per bundle was often estimated, based on weight and the known lengths of the bars," says Ruth Kirkwood-Azmat, a senior engineer in the Electrical & Automation group in Worcester. "The old system generated some considerable errors. This was particularly problematic as bundles can range in size up to 500 bars."

In the new, low-cost, highly accurate solution, Kirkwood-Azmat incorporated an intelligent camera to take an image of the end of a bundle for high-speed optical analysis. The system provides visible evidence of the count—a vast improvement over the previously necessary, labor-intensive manual checks. Kirkwood-Azmat's innovation is part of the broader, patented, Industry 4.0 bar-counting systems that have been installed at several customer sites.

Senior engineer Ruth Kirkwood-Azmat with Apostolos Ntaoukas (left) and Steve Morgan from the Primetals Technologies Worcester team

LONG-ROLLING PROCESS EXPERT

The Long-Rolling Process Expert excels at quality management.



The Long-Rolling Process Expert is a cost-effective modular process-automation system for continuous and reversing rolling mills, and for monoblocks as well as flat blocks. Similar Expert Systems also exist for other types of rolling mills—from hot-strip to plate mills and Arvedi Endless-Strip Production lines to all types of cold mills.

The Process Expert monitors and collects data, from the input-material stage through to the finished product. Its domain extends from enterprise-resource planning (ERP), through manufacturing-execution systems (MES), to control systems and down to the plant device level. The system performs a wide range of tasks, from suggesting pass schedules to calculating and downloading mill settings according to the availability of rolls. The Long-Rolling Process Expert also helps manage and track material yards and orders, and helps plant operators maintain a competitive edge in today's aggressive global market by delivering mill reports so that plant performance can be assessed and production optimized.

The Long-Rolling Process Expert is geared toward quality management. Online quality monitoring allows for the results of product inspections to be accessed at any time, while interface modules to manufacturing execution and plant-automation systems ensure secure communication. There are also analysis and reporting modules, a report editor, and a label editor, with archiving capabilities so that all data can be archived and production history accessed, even years down the line. Comprehensive and accurate reporting on the mill, production efficiency, equipment utilization, downtimes, energy and media consumption, tool stand times, and much more can be used as the basis for increasing the competitiveness and ultimately the profitability of a plant.

The Long-Rolling Process Expert also helps to increase customer satisfaction, making it easier to respond quickly and flexibly to inquiries from new customers or to demand for new products. Checking production availability, calculating the time needed for product changes, tracking the route from raw material to finished product, creating customer labels, or producing quality reports are all challenges that can be met with the Long-Rolling Process Expert.

EXTENDABLE FUNCTIONALITY

The Long-Rolling Process Expert provides a modular range of basic functions for managing orders, assets, and qualities, enabling plant operators to pick and choose between functions. For instance, the yard-inventory modules for incoming and outgoing materials provide a real-time status of stock materials; the production-sequence module provides up-to-date information about production schedules, line status, and material position, and increases flexibility in the fulfillment of production orders; the tracking module records data on all material flows from the yard to the charging grid to the outgoing yard—including processing, compacting, weighing, and tagging.

ROLL AND GUIDE MANAGEMENT

Roll and guide management helps monitor and manage the rolling mill. Tools such as rolls, calibers, and guides are located in the roll shop stock, and plant, tonnage, and rolling time are tracked. Then, based on production requirements, tool-change lists are created to shorten product change time while also maximizing tool-utilization time.

The Long-Rolling Process Expert is part of the comprehensive Electrics & Automation solution portfolio of Primetals Technologies for the long-rolling industry. It can either be supplied as a stand-alone installation or seamlessly integrated into other long-rolling automation concepts.

LONG-ROLLING ROLL MASTER

Long rolling

The Long-Rolling Roll Master is a powerful and easy-to-use tool geared toward increasing plant flexibility and performance by providing advanced pass scheduling for continuous and reversing mills, and for both monoblocks and flat blocks. With plant operators under increasing pressure to boost productivity in response to aggressive competition on the steel market, the Long-Rolling Roll Master is the ideal solution for precise management of the rolling mill.

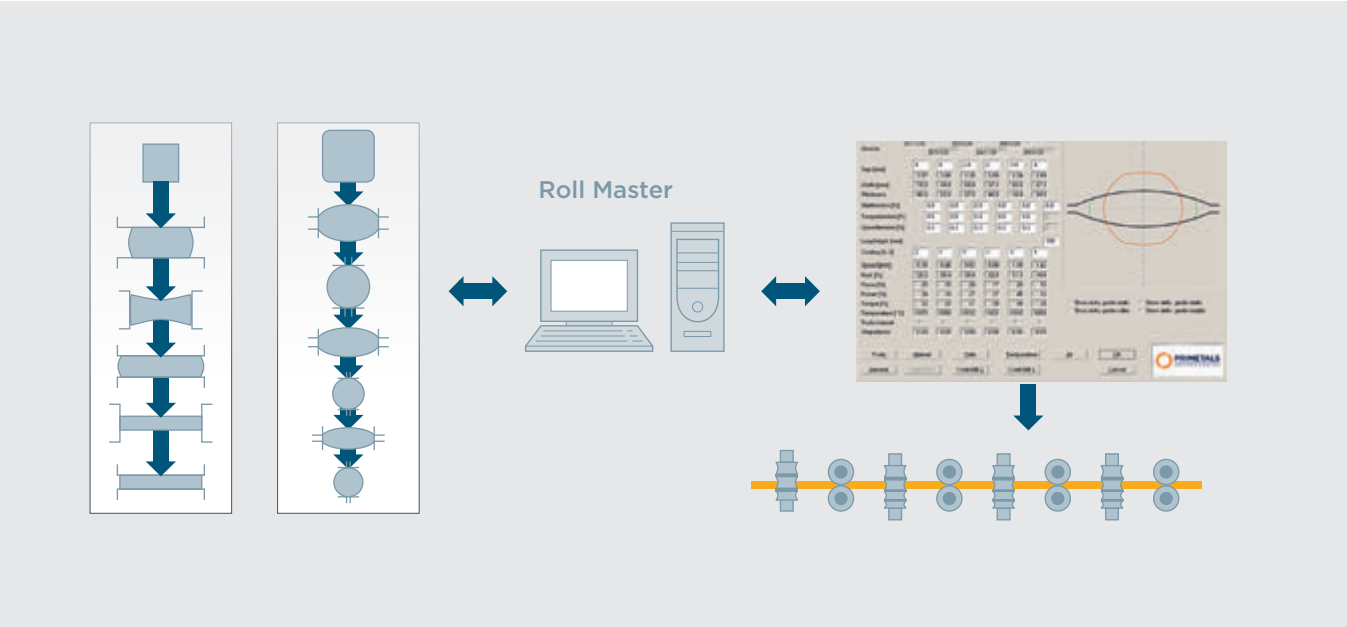
The Long-Rolling Roll Master allows for the easy creation of pass schedules for grooves and guides as well as setup data for smooth mill start and restart based on material database, specific mill design, mill-load conditions, and available rolls. For switching to new steel grades or dimensions, the Long-Rolling Roll Master features a database of more than 200 steel grades and special alloys. Another database for rolls, grooves, guides, and other components contains a plant's own mill-specific data. The system constantly tracks current tool and mill conditions during operation and takes them into account when providing pass schedules, thereby making the most of plant availability and supporting maintenance routines.

Plant operators are faced with multiple challenges that can be addressed with the use of the Long-Rolling Roll Master. When changing dimensions or steel grades, high productivity can only be maintained with a fast and secure production restart. In order to reduce the cobble rate, mill settings need to be accurate right from the start. And because of groove wear, it can also be challenging to repeat rolling schedules. In general, it is difficult to make precise calculations for the implementation of new dimensions and steel grades. Tests are time-consuming and require in-depth knowledge of the rolling process. Grooveless flat rolling offers high flexibility, but pass-schedule creation and the calculation of mill setup data are difficult to calculate and confirm.

Because the challenges are so complex and wide-ranging, Primetals Technologies is committed to carrying out a thorough analysis of mill layout, design limits, and drive systems. Primetals Technologies also handles integration of all available tools (rolls, grooves, and guides) into the database as well as adaptation of the Long-Rolling Roll Master to specific mill design and production targets. Calculations and models are tailored to a plant's own processes and interfaces engineered accordingly.

The advantages of the Long-Rolling Roll Master are that it offers greater flexibility and optimized production thanks to computer-based pass scheduling, while smooth scheduling is guaranteed by the material database of steel grades.

The Long-Rolling Roll Master can be seamlessly integrated into long-rolling automation concepts, but is also available as a stand-alone product, making it ideal for retrofits and upgrades. Due to its modular design, it can easily be adapted to meet the specific requirements of any plant. The Long-Rolling Roll Master is a proven solution and has so far been installed at over 25 mills worldwide.



The Long-Rolling Roll Master allows for the simple management of all key data related to mill grooves, guides, and rolls.

EMPOWERING TECHNOLOGY WITH KNOW-HOW

Hans-Jürgen Zeiher is not only one of Primetals Technologies' most trusted managers but also a skilled and experienced technician. As an automation and drives expert particularly in the downstream area, he has personally participated in the start-up of numerous projects and led the efforts behind many more. Zeiher has been serving as Global Head of the Business Segment Electrics & Automation, since the start of Primetals Technologies in 2015. Metals Magazine sat down with him to discuss the impact of digitalization on the metals industry.

What in your view are the main targets for digitalization in the steel industry?
Hans-Jürgen Zeiher: For me, digitalization has some very clear objectives: it will make the steel-production process more flexible, raise end-product quality, and increase overall plant efficiency. At the same time, it will help to minimize raw-material costs and energy consumption. Also, a fully digitalized production facility requires a far lower operations and maintenance effort.

How many years will it take for digitalization to fully "arrive" in the steel industry?
Zeiher: There is no one answer to this question. Some of our customers already own highly advanced plants, and many of the processes taking place in their facilities are led and captured by sophisticated software. Other customers still rely on Excel sheets to plan their production. How long it will take for these customers to have their plants fully upgraded varies greatly. What is true for almost every steel producer is that the pressure to modernize has increased. Europeans and East Asians probably feel the urgency the most.

At Metals Magazine, we have found that there is still substantial insecurity about the impact of digitalization—even among seasoned technologists. Have you discovered any popular misconceptions about what digitalization will change?
Zeiher: I think that Industry 4.0 as a concept was never properly fleshed out by those who created it, and therefore has remained somewhat vague. Our interpretation of it is this: In a typical steel-production plant, many processes are already highly automated, but largely they are still operating on their own. The challenge is to end this isolation and integrate everything into one comprehensive network by a holistic approach towards digitalization. On the basis of such a system, steel producers can serve their end customers in completely new ways, with higher degrees of customization regarding product specifications and lot sizes. Recent developments in hardware, software, and especially data analysis have made all of this possible.

Is it true that when it comes to advanced automation, the steel industry has been ahead of discrete manufacturing and other areas for a long time?
Zeiher: Definitely. I think that our industry is about 25 years ahead of almost everyone else.

Is the linking of existing technologies for an increasingly digitalized production the main challenge?
Zeiher: Yes, this will be the key to a successful digitalization strategy in our field. Steel-production equipment is simply so expensive that no company will be willing to replace everything they have been using successfully up to now. Our job then is to determine which upgrade packages a customer needs to sufficiently improve the existing plant in order to reach compatibility with today's technologies and market requirements. We often have to enable old equipment to communicate with newer solutions, so that all plant activity can be monitored and controlled in a unified manner. At Primetals Technologies, we have built a unique competence profile that is widely recognized within the industry: we combine classic automation skills with deep knowledge about the metallurgical process. We are using these capabilities to support

MAKING IT WORK
Hans-Jürgen Zeiher, demoing the capabilities of his team's automation solutions.

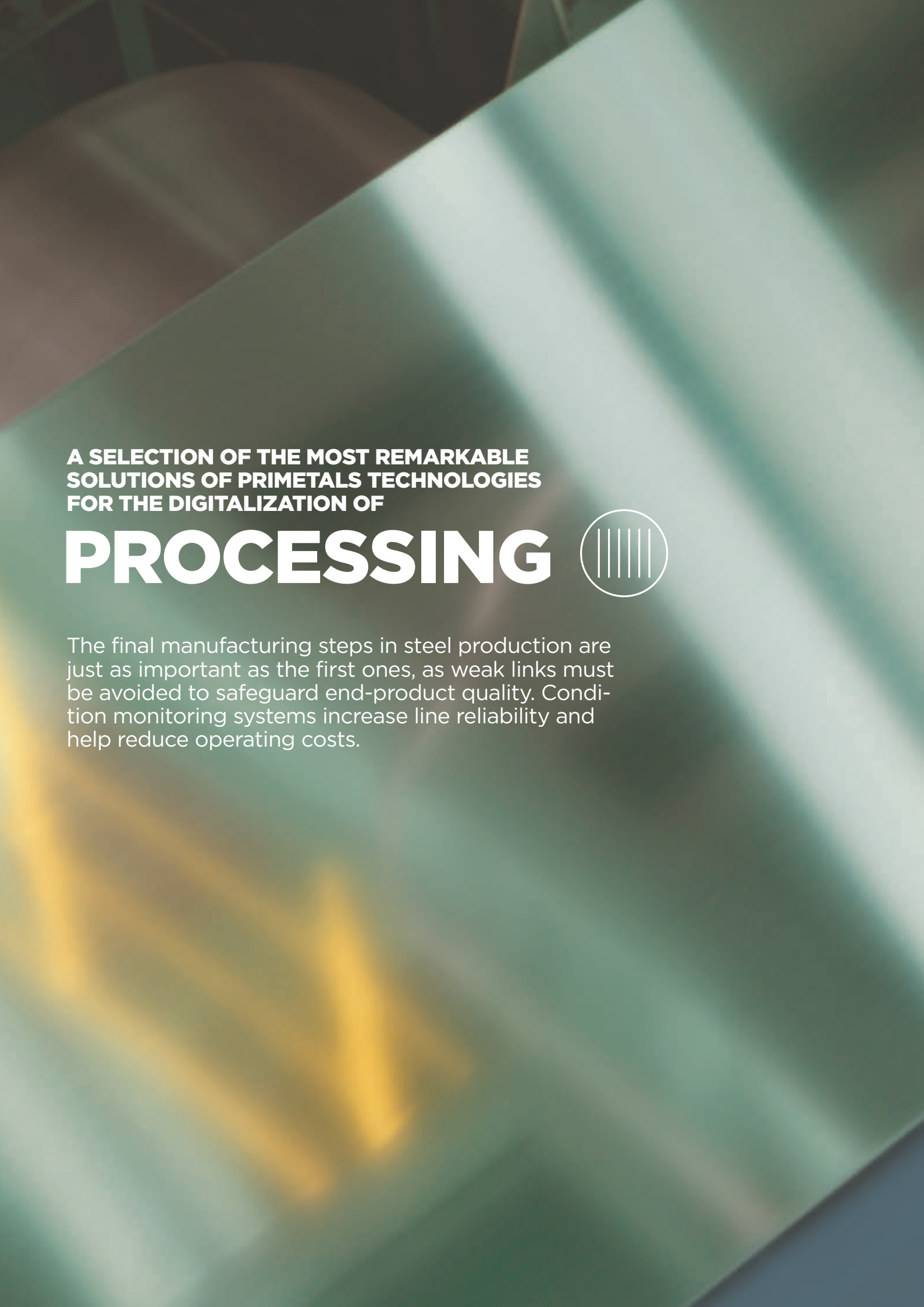
our customers in developing the right digitalization strategies based on their current equipment. And we are regularly approached about entering new partnerships to create completely new automation solutions.

Artificial intelligence is a much-discussed if somewhat vague subject matter these days. Will artificial intelligence be a cornerstone of the steel plant of the future, and if so how?
Zeiher: For me, the key question is to what degree self-learning algorithms might at some point replace our traditional physics-based approach. Theoretically, we could see some major technological shifts or disruptions in the future. Therefore, we are actively conducting company-wide research to stay ahead of everyone else. Of course, I don't believe that our tried-and-tested methods will become obsolete any time soon. But there might be disruptive changes from big-data analytics that could speed up certain parts of our work in the future.

Should steel producers be worried about falling behind? What should they focus on?
Zeiher: I think that those steel producers who are currently leading the industry will have to work even harder on pushing the envelope in order to maintain their position. Companies from the Far East are beginning to catch up technologically, and faster than many expected. It is very important to be realistic about this development—but it is also essential not to overreact and throw in the towel. Many high-end producers are addressing this issue sensibly, for instance, by approaching us about partnerships to create new solutions that will further improve their plants' efficiency and end-product quality.

What are the top three measures that steel producers should take in order to meet the trend toward more computer-controlled processes?
Zeiher: Our holistic take on steel production—and in particular on the future of steel production—implies that software systems which can integrate all production-related processes are arguably the most crucial factor. We are talking about a "Digital Unity" of three systems: a computer-backed maintenance system that is based on expert knowledge but can be used by regular workers, a quality-management system such as our Through-Process Optimization, and a state-of-the-art production-management system. Importantly, these three systems need to harmoniously interact with one another.

Which solution of the "Industry 4.0" portfolio that Primetals Technologies has established do you consider particularly remarkable, and why?
Zeiher: We have just recently seen remarkable success with big-data analytics from our technology experts. For a Chinese customer, we were able to isolate the source of hardness deviations that occurred at the rolling stage. Initially, the reasons were completely unknown. The Primetals Technologies team was able to pinpoint the origin of the problem by use of our Through-Process Quality Control software in combination with advanced data analytics. In other words, we combined our deep process know-how with the power of big data to narrow down the relevant process parameters. Our customer is now able to reliably reproduce the improved end-product quality levels. I consider that an impressive achievement, and I am intrigued by the technology that made it possible.



A SELECTION OF THE MOST REMARKABLE SOLUTIONS OF PRIMETALS TECHNOLOGIES FOR THE DIGITALIZATION OF

PROCESSING

The final manufacturing steps in steel production are just as important as the first ones, as weak links must be avoided to safeguard end-product quality. Condition monitoring systems increase line reliability and help reduce operating costs.

SIAS AUTOMATED SURFACE INSPECTION FOR FLAT PRODUCTS

Producers of flat-rolled steel are facing a growing trend toward zero-defect tolerances for surface quality. This trend, initiated by customers in the automotive industry, is increasingly becoming the norm in other sectors—namely in packaging, "white goods" (appliances), and others. From a quality management (ISO) perspective, it is necessary to standardize surface quality like any other product characteristic.

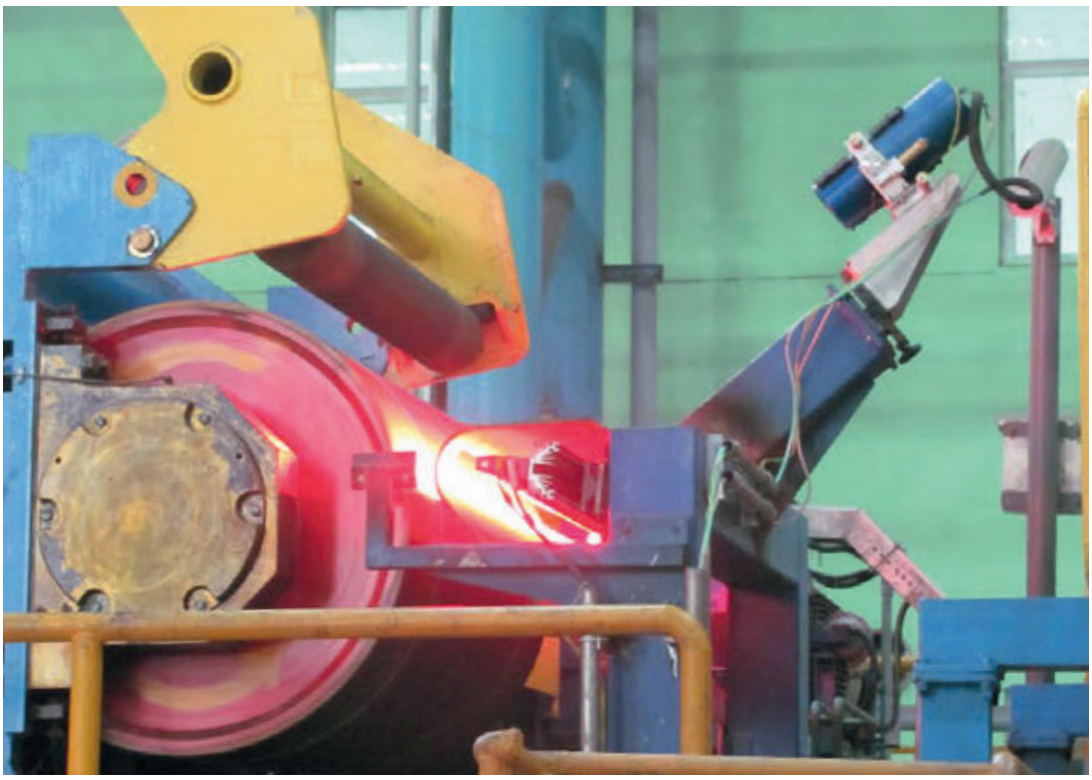
The Automatic Surface-Inspection System (SIAS) from Primetals Technologies is an online surface-quality control solution that helps address this challenge by detecting and automatically classifying all surface defects visible on the strip: inclusions, mechanical damage, scales, repeating defects such as roll marks and dents, as well as coating defects and other imperfections.

The system uses high-end cameras, optics, and lighting to provide a sharp, fine-resolution image of the strip surface. Recent developments in the next-generation platform include high-resolution and near-infrared vision techniques. The obtained image data is software-processed for defect identification: flaws are detected, automatically classified, and graded for severity. The results are displayed to the operator, and stored in the form of coil reports mapping the defects on every coil. They comprise defect data (size, position, type, and severity), defect images, and context information such as mill/line speed and product texture. All information is stored in an open and SQL-compatible database structure, which allows for easy compilation into studies at a later stage e.g., to determine trends on groups of coils by grades or by dates.

The results are also available to the operator in real time, allowing immediate reaction. Through the SIAS coil-grading software, the quality department can determine instantly whether the coil surface quality matches the requirements of the customer—and what action to take if this is not the case.

SIAS is available for all flat-product rolling and processing applications: hot mills, pickling lines, cold mills, continuous annealing lines, metallic coating lines, hot-dip galvanizing lines, electrolytic galvanizing and tinning lines, color-coating lines, and stainless steel lines.

In recent times, advances in digitalization have made it possible to perform analyses remotely and help customers more quickly whenever support is required. Remote-access services for SIAS, as offered by Primetals Technologies in combination with a customer-support hotline, have the advantage of including prompt hardware diagnosis, providing support over a longer time span, and facilitating remote defect-detection analysis.



Light bar and camera of a SIAS installation for one side of the strip.

Side trimmer, equipped with a condition-monitoring system from Primetals Technologies

Learn more about BOX Concept, the condition-monitoring solution from Primetals Technologies on page 34.

CONDITION-MONITORING SYSTEM FOR PROCESSING LINES

Primetals Technologies' condition-monitoring system for processing lines uses predictive-maintenance algorithms to pinpoint incidents before they occur.

The condition monitoring system (CMS) is part of the newly developed Through-Process Optimization solution (TPO) of Primetals Technologies, which encompasses the intelligent Through-Process Quality Control (one of the company's "Industry 4.0" IT systems), Through-Process Know-How (the vast application knowledge that optimally tunes the IT system to customer requirements), and the Total Condition Optimizer (Expert System for processing lines). Each of these tools is designed to enable customers of Primetals Technologies to tackle new market challenges: to develop new products, improve product quality, and increase the overall competitiveness of their production lines. The CMS focuses on predictive and proactive maintenance with the aim of increasing line reliability while decreasing operating costs. Without the CMS, maintenance has to be either corrective (reactive maintenance) or systematic (preventive maintenance). The downside to reactive maintenance is that it requires an unscheduled stop of the line, resulting in a drop in line availability and production losses. On the other hand, preventive maintenance can sometimes be carried out too early and therefore involves unnecessary costs. The CMS, meanwhile, is the ultimate approach for predictive conditional maintenance; maintenance is performed "on time," thereby optimizing the lifetime of each component by avoiding any unscheduled stoppage and anticipating component end–of-life.

For the processing-line equipment built by Primetals Technologies, the company's French-based Mechatronics team is responsible for developing, configuring, and commissioning the CMS. The team comprises mechanical, electrical, automation, IT, and process specialists whose expertise can be called upon remotely via the "CMS Remote Hotline." Customers can use the hotline to help them better diagnose a problem through "proactive maintenance," but Primetals Technologies experts can also train customers and help them to develop new rules in the CMS installed on their production lines.

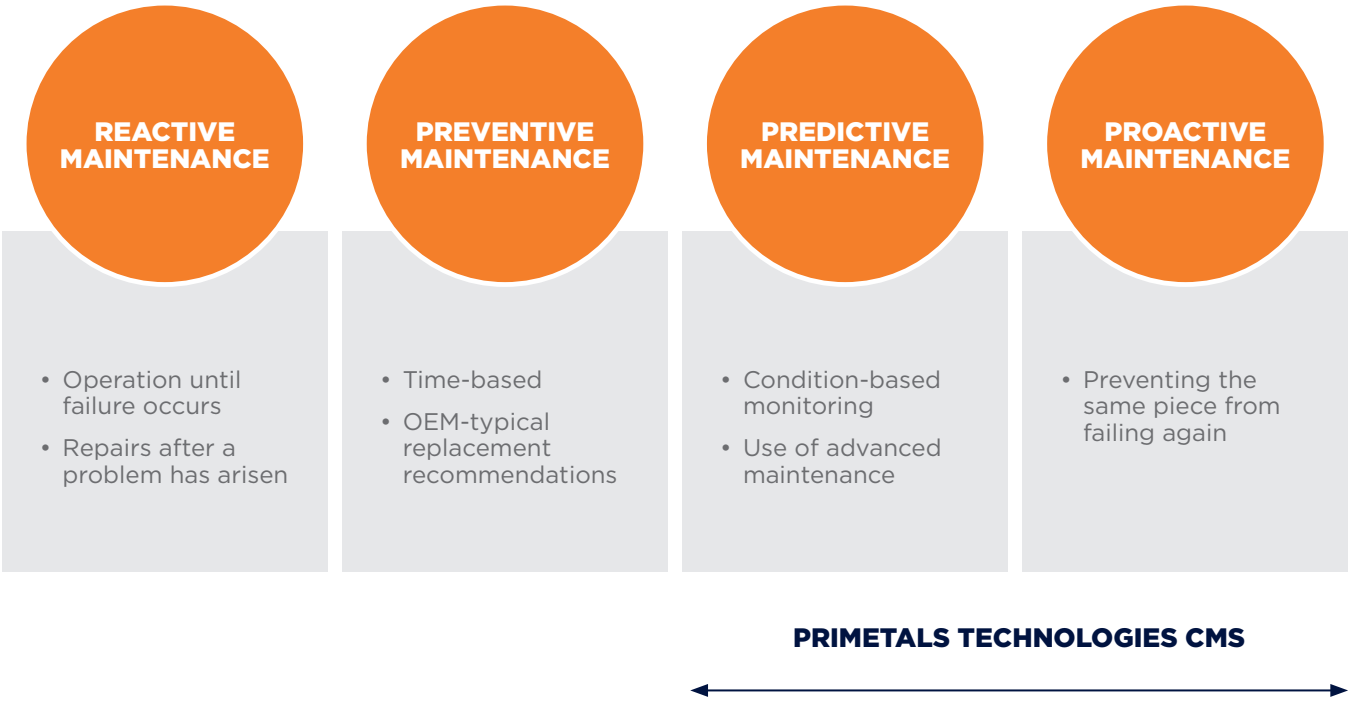
CMS FOR THE SIDE TRIMMER

These days, most of the equipment supplied by Primetals Technologies includes a CMS module. This also applies to the side trimmer, which comprises several key components—hydraulic, pneumatic, servo motors, and knives—all individually monitored by the CMS.

There is particular emphasis on the condition of the knives, which directly affects the edge quality of the sheet and, indirectly, other areas such as the operating speed of the motors and the consumption of electrical energy. In the worst case, the sub-optimal condition of the knives could even damage downstream equipment. With previous maintenance strategies, knives have to be changed according to the length of strip cut in kilometers. This presented two main drawbacks: knives were often changed too early (while still operational and in good condition) or too late (after product deviations occurred). Now, however, the CMS uses specific cameras to inspect the edges and analyze the picture obtained in order to qualify edge quality, detect any wear or breakout, and also swiftly warn operators that a change of the knife is necessary.

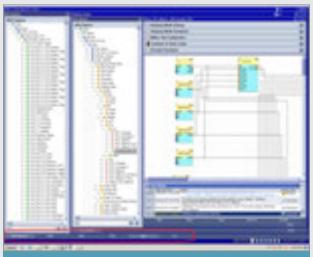
VIBRATION-ANALYSIS BASED MONITORING

Any machine in operation produces a degree of vibration generated by its movements, which can be rotary or linear. Small levels of ambient vibration are perfectly acceptable, whereas high and increasing levels of vibration are symptomatic of an anomaly and have to be prevented. Vibrations are largely a result of the centrifugal forces acting on rotating machine parts, and can come from a misalignment of machine-drive trains, bearing damage, gear defect, imbalance, and other causes. The CMS analyzes vibrations using feedback from special piezoelectric sensors installed on certain parts of the equipment. These sensors look for vibrations on different axes. By correlating the dominant frequencies with different elements of the equipment, the CMS is able to determine the origin of the vibration. »



MECHANICAL EQUIPMENT

Signals from sensors are sent from the equipment via programmable logic controllers



CMS

- Monitoring signals
- Decision-making engine
- Database
- Human-machine interface

Assistance by secure remote connection from Primetals Technologies' Mechatronics Laboratory

Real-time information about the status of the equipment gathering data for analysis and decision to repair

PROACTIVE MAINTENANCE

PREDICTIVE MAINTENANCE

Overview of the principal signal flow and computation implemented by the CMS

EDGE MONITORING SYSTEM

The EdgeMon edge monitoring system typically consists of four cameras mounted on the rotating turrets of the side trimmer to the left and right of the steel strip. In this setup, two cameras are installed on each side of the side trimmer. One of them is actively used while the other remains in maintenance position. The sensors of EdgeMon are directly mounted on the shear block. Triggering of the camera for knife breakout detection is done with either a rotary encoder on the shaft of the knives or with the plant-speed signal. This trigger has to be provided by the supplier of the side trimmer. EdgeMon monitors and visualizes the trimmed edges, and evaluates the cut-to-break ratio—a typical quality parameter for trimmed edges. Furthermore, knife breakouts can be detected automatically based on periodic analysis. Typical detection reliability, based on figures from different plants, is about 90%. For other more unusual defects that are not detected automatically, visualization helps the operator to recognize them immediately.

PROPERTYMON MEASURING SYSTEM

PropertyMon is a quality-monitoring system for the online detection of mechanical and magnetic properties of the steel strip for various types of processing lines. Measurable steel grades are hot- and cold-rolled ferromagnetic steel strips including micro-alloyed, interstitial-free, dual-phase, and transformation-induced plasticity steels. The system performs continuous and contact-free inspection over the entire strip length based on an electromagnetic measurement principle. All values are immediately available and stored in PropertyMon's internal database.

THE MECHATRONICS LAB IN MONTBRISON

Process or maintenance optimization does not happen overnight; as every steel producer knows, improvements

The CMS analyzes vibrations with special piezoelectric sensors installed on certain parts of the equipment.

EDGE MONITORING SYSTEM

The EdgeMon system monitors and visualizes the trimmed edges of the steel strip. It evaluates the cut-to-break ratio and conducts regular analyses to detect any knife breakouts. The detection rate achieved by EdgeMon is high, with about 90% of all identified problems found automatically.

- **Good:** The cut-to-break ratio is stable and at a correct level; the edge shape is correct.
- **Knife worn:** The cut-to-break ratio is stable but not at a correct level. Adjust the gap, knife shows partial wear and has to be changed.
- **Breakout:** Strip edge is damaged; check knife.
- **Inhomogeneous:** The cut-to-break ratio is not stable; knife shows partial wear and has to be changed.

Primetals Technologies has chosen to thoroughly embrace digitalization, with advanced solutions and remote-access functions for quick and easy-to-obtain customer support from a specialist.

are usually time-consuming. It takes significant and relentless effort to be a market leader that continually improves equipment quality, develops new products, and minimizes production downtime. Primetals Technologies is fully aware of this fact and supports its customers for the entire lifecycle of their equipment. For this purpose, the company has installed a multi-disciplinary, highly skilled team in a brand new Mechatronics laboratory at its French facility. The team is involved in the design, development, commissioning, and optimization of processing line equipment, and is always available to swiftly assist customers around the world.

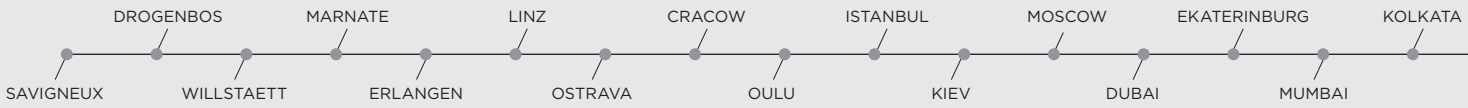
CUSTOMER-ORIENTED SOLUTIONS

Customers will often benefit greatly from a quick yet highly professional analysis of their equipment and a solution-oriented discussion with an experienced Primetals Technologies specialist. This is why remote access for fast and easy-to-obtain support is now available for all solutions supplied by Primetals Technologies. This has become possible thanks to the recent forays in digitalization and "Industry 4.0"-type technologies, which Primetals Technologies has chosen to thoroughly embrace to optimally serve its customers.

Laser welders supplied by Primetals Technologies France are tested and fine-tuned at the Montbrison Mechatronics Lab prior to installation to ensure optimal operation at the customer's site.

SHAPING THE WORLD OF TOMORROW

CHRISTCHURCH IS THE SPOTLIGHTED COMPANY LOCATION IN THIS ISSUE OF METALS MAGAZINE



The Christchurch location of Primetals Technologies, which goes by the name of ShapeTech, may not be the company's largest, but it is certainly among its most remarkable. With a staff of 37 based on the site, it brings together experts in the fields of hardware and software engineering, as well as technical sales and procurement, to deliver advanced sensor products for the metals industry. Dr. Tom Widter visits the location to find out more about the place, the people, and the products.

I have a confession to make: I have always loved driving on the "wrong" side of the road. For years now, I have spent much of my free time exploring the United Kingdom, steadily keeping my rental cars to the left in order to stay in line with everyone else. I have taken a liking to the many roundabouts that the U.K. is home to, and I greatly enjoy the ever-changing weather conditions that can make even the most monotonous motorway drive an adventure. Add to all this the beautiful scenery of, say, the Lake District or the Surrey Hills, and you've got yourself a trip that you'll never forget.

As you can probably tell, the chances of me enjoying my visit to the Christchurch location of Primetals Technologies were fairly good to begin with. I knew that getting there would be marvelous (it was), that staying at a hotel close to the beach would turn out to be quite an experience (it did), and that exploring the nearby Stonehenge site would allow me to tick off one long-standing item on my bucket list. But while all of these expectations were realized, the most extraordinary thing I encountered was something completely different: the truly unique—and uniquely sociable—ShapeTech staff.

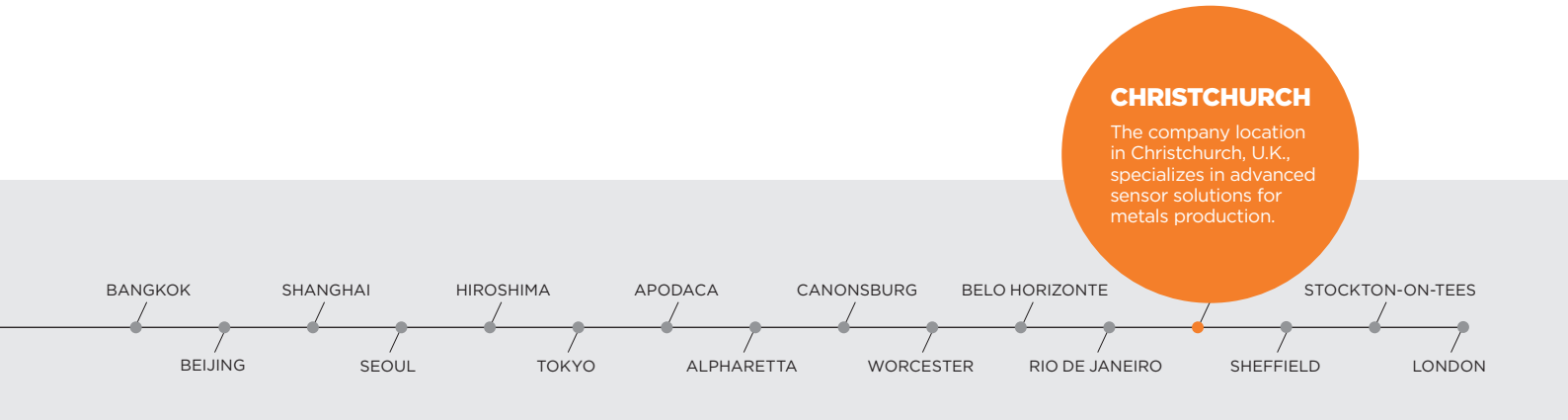
Arriving at ShapeTech, I was immediately welcomed by Susan Viljoen, whose job is to "check in" visitors and staff members alike. Originally from Zimbabwe via South Africa, Viljoen has a demeanor that is both direct and disarming and immediately makes you smile. "We are like a big family here," she says, referring to the warm-hearted camaraderie at the company location. Everyone is allowed to be themselves, bring something to the table that is genuinely their own, and in doing so contribute to results that are distinguished by dedication and passion.

A FAMILY-LIKE WORKPLACE

Let me introduce you to some of ShapeTech's finest: there's Roy Tubman, who instills his determination to succeed in both his work as a product manager and his private pursuit of running marathons. In 2017 alone, he ran three. His running shoes have conquered France, Germany, and some of the most remote areas of the U.K.

Then there's Trevor Card, who at the time of my visit had just won a sailing contest. He had also just been crowned "Sales Manager of the Month" the day before, with the respective trophy proudly sitting on his desk. After scoring his most recent sale, Trevor Card stopped by a grocery store the next morning and brought two large boxes of donuts to the office. In reference to the corporate-design colors of Primetals Technologies, the donuts were orange with chocolate crumbles on top. The entire team relished both Card's achievement in general and the delicious confectionery in particular. Unsurprisingly, the donuts quickly disappeared, and as the next day arrived only one of each sort was left. This is a wonderful, typical case of British courtesy: no staff member dared to take the last donut, feeling that someone else might just need it more. The staff at ShapeTech look out for one another, and it shows in many respects.

If there's an occasional rivalry, it is always a playful one. While the sales staff are in constant competition for the monthly award, engineers Steve Course and Mark Davey have established their own way of enriching the workplace with a bit of good-humored banter, which is usually centered around football. If you listen to Course, you will learn why the Southampton Saints are the team destined for glory; if you ask Davey about his convictions, he will »



tell you why the Bournemouth Cherries are the only squad that really deserves your attention. In the U.K., an affinity for any particular club is usually something you "inherit": Both Davey and Course were introduced to their respective clubs through their fathers, and it is considered a family tradition that the youngsters root for the same team. Thanks to football, there is always something to talk about, making the sport part of the glue that keeps generations together.

BRITISH ENGINEERING

Many of the team members of Primetals Technologies Christchurch are engineers, and that includes Andy Ricketts. "Engineers are wired differently," he says, referring to his deep fascination with cutting-edge gear that is common among his breed. Ricketts is a problem solver, someone who applies his sense of order to complex technical challenges and appreciates a well-executed technological concept. Ask him for a textbook example of remarkable engineering, and he will unquestionably point you to the Lotus sports car he owns. Ricketts was kind enough to give me a test ride, and it was an experience I will never forget. British engineering, at its best, is based on a daring idea and the relentless search for its optimal realization, leading to exceptional products that have been rigorously tested for long-term reliability.

ShapeTech's products also very much belong to this category. The ShapeTech staff are justifiably proud of the fact that their creations are highly sought after by metals producers all around the world. If pressed to describe their products in a nutshell, the label "smart sensors" would not be inappropriate. During my stay at Christchurch, development manager Peter Hunt led me through the company workshop and shared with me his excitement for the products whose inception, development, and implementation he oversaw. His deep fascination with ShapeTech's technologies, particularly with the Transformation Monitor, could not be more evident in his presentation.

"This device can tell metals producers exactly what happens inside their hot-strip mill," Hunt says, turning on the Transformation Monitor demo unit. "Up until now, engineers had to rely on models to determine the amount of cooling they should use. Transformation Monitor enables

THE WORLD IN **TWENTY YEARS**

Which technological advancement do you expect to change the world we live in the most dramatically within the next 20 years? The team of Primetals Technologies Christchurch peers into their crystal ball.

"The move toward electric cars will certainly have tremendous impact. I think that it is unavoidable to abandon fuel-based vehicles in the future. In many ways, it is a positive development. But it will also take away some of the enjoyment you get when driving."

Steve Course, Senior Design Engineer

"I expect the biggest changes to occur in power management. Chemical batteries are conceptually flawed and outdated. Nuclear waste could be made into portable energy, even if that sounds impossible today. This would solve a lot of the world's problems."

Mark Davey, Senior Engineer

much more precise cooling strategies. It uses an electromagnetic field to assess the properties of the steel as it cools. You see, in hot steel, the ferrite concentration is low, so the Transformation Monitor's readings won't be impacted very much. But as steel cools, its composition changes from austenite to ferrite, and ferrite will interfere with the sensor's electromagnetic field. We can monitor the transformation with great accuracy. For metals producers, this is a huge step forward, because the production process becomes so much more transparent." Hunt adds that he is especially pleased with the team's close collaboration with the University of Manchester, which brought the Transformation Monitor to fruition.

PRECISION AND ELEGANCE

The sensors made by ShapeTech are precision technology. The Orbis+, which measures thickness deviations in rod- and bar-production lines, relies on a sophisticated, always-online camera system. All of the necessary electronics are part of the core device, and the resulting data is then transferred via Wi-Fi to a computer that serves as a graphical user interface. The one product that impressed me most, however, was the Air-Bearing ShapeMeter. Its design is as simple as it is elegant, and its purpose is to provide high-accuracy information on the flatness parameters of rolled strip or foil. The ShapeMeter is carefully manufactured by the ShapeTech staff, and to date has been sold over 600 times. Having laid my hands on one, I can tell you that it almost feels other-worldly: it is made of steel rings that rotate around an arbor, relying solely on air pressure to keep them afloat. The diameter of these rings has to be exact, down to a twentieth of the thickness of a human hair for the ShapeMeter to work. I found it truly amazing.

On each Air-Bearing ShapeMeter, you will find a plaque bearing a technician's name. "Assembled by Dan Parker," it might read, depending on who built it. The plaque not only serves as an indicator of the ShapeMeter's high quality but also illustrates just how much the workshop staff identify with their products. General manager Paul Sherman recalls the time Dan Parker felt so compelled to help a ShapeMeter customer on short notice that he boarded a plane a mere two hours after having received the phone call. "Dan wanted to ensure that our customer could keep up production, even if the malfunction had »

"The way we work and collaborate as a society will change dramatically. Teleworking will likely become much more prominent. Also, it might get even harder to travel to certain countries, and this again would reinforce working from afar and lead to new communication methods."

Stephen Fowler, Development Engineer

"Self-driving cars will definitely become market-ready soon. Also, face recognition will see great advancements. Both of these forays will be fueled by optical sensors, which have seen significant improvements lately. In general, automation will impact our lives in more areas than we can imagine."

Peter Hunt, Development Manager

"So many areas will be impacted by automation technologies. This is even true in cases where you might not expect it. I like to fish, and I was surprised to discover that drones had been developed that specialize in automated fishing. They rely on cameras and sonar—quite remarkable."

Mark Dolby, Product Development Engineer

nothing to do with his assembly work. He went the extra mile—or really, he went a few hundred. You can't ask any more of your team when they rise to the occasion like that."

ShapeTech's sensors are not only well renowned within the metals industry. Her Majesty Queen Elizabeth II honored the team's accomplishments by presenting them with the Queen's Awards in 2006 and 2012. While the Queen might not be an expert in metals production, I am convinced that she singled out the right company—to illustrate what British engineering excellence can accomplish, using decades of accumulated experience to pave the way for an even more exciting future.

To learn more about ShapeTech's smart-sensor technologies, read pages 70-71 of this magazine issue. You can also download a comprehensive collection of brochures here:

bit.ly/shapePDF

THE QUEEN'S AWARDS

The Queen's Awards are the U.K.'s highest official awards for British businesses. They were originally known as "The Queen's Awards to Industry" and instituted by a royal warrant in 1966 following the recommendations of a committee chaired by the Duke of Edinburgh. It is a great honor for any British enterprise to be among the recipients. Only the most outstanding achievements in regard to international trade, innovation, and sustainable business practices are considered. The Queen makes her choice based on the advice of the Prime Minister, who is assisted by an advisory committee that includes representatives of the U.K. government, industry, commerce, and the trade unions. The finalists are announced annually on April 21, Queen Elizabeth II's birthday. The Christchurch location of Primetals Technologies has so far won this award twice—in 2006 and 2012. This great honor was bestowed upon the team in recognition of advances made for the international metals industry.

SHAPETECH'S FOUNDER

The history of ShapeTech, the Christchurch location of Primetals Technologies, dates back to Ludwig Loewy, who founded the London-based Loewy Engineering Company in the 1930s. Loewy was born in Bohemia, which at the time was part of the Austro-Hungarian empire and later became the Republic of Czechoslovakia. As a young man, Loewy began work for a German shipbuilding company in Berlin, from where he moved to Düsseldorf. As the Nazis' rise to power became more evident, Loewy, of Jewish descent, fled to England. When the Second World War broke out, Loewy moved his offices to Bournemouth, which he considered a safer place than the city of London. Loewy died in 1942, but his company continued. The Primetals Technologies location of today is only a few miles away from where Loewy lived and worked, and some believe that Loewy's innovative and inspiring spirit can still be felt when walking the rooms and corridors of the ShapeTech building.

A DAY IN THE LIFE OF PAUL DURRANT

Metals Magazine asked workshop supervisor Paul Durrant to share what his typical work day looks like. Paul is responsible for ensuring smooth production as well as health and safety at the Christchurch workshop. He also participates in the actual assembly of his location's products.

PAUL DURRANT

We asked workshop supervisor Paul Durrant to tell us what his typical work day looks like.

DAY START

05:45

I wake up when the alarm rings on my phone. My first task of the day is to take my dog for a walk. This gives me time to think about what my work day will bring. Afterwards, I have breakfast.

07:00

I arrive at work by car, motorbike, or bicycle. After getting myself a cup of tea, I will turn on my computer and check emails.

07:50

I take a walk around in the workshop to ensure that health and safety guidelines are kept and nothing was left in an unsafe condition the evening before. For certain workshop equipment, we have established clear processes to ensure safe operation. Everything needs to be set up optimally.

08:00

I step into the workshop and continue with the project I am currently working on. We usually try to complete dedicated steps during a work day so that on the next morning we can progress to the next one.

09:00

When I am assembling a precision-technology Air Bearing ShapeMeter, I will make sure to take scheduled breaks in which I have discussions with colleagues. This helps me concentrate on the more repetitive aspects of the construction process. Over the course of the morning, staff members will typically come up to me to address any issues they might have, for instance regarding spare parts.

11:00

In case my line manager is away on site, it is my responsibility to fill in for him and participate in a weekly progress meeting. After that, I resume production in the workshop.

12:30

I step outside to get a change of scenery. I often go to a park bench that I like to have a small refreshment there.

13:00

If someone has noticed a shortage of any component, tool, or consumable, I will make the necessary purchase requisitions. Should any subcontractor arrive, I will check their work plan, safety assessment, and certification.

14:00

My tasks in the workshop require me to record various kinds of production data for traceability. This helps to ensure that we continually reach our established quality levels.

15:00

I regularly attend engineering and design-review meetings. My colleagues use these meetings to introduce new design ideas, and I will give some input with regard to production as well as maintenance and on-site repair.

17:00

I finish what I had set out to get done for the day and leave for home. Due to traffic conditions, it will take me some time to get home.

18:00

I exchange with my wife the events of the day. We know each other's colleagues quite well and understand each other's profession. I might catch up with world news and take my dog for another walk.

21:00

I go to sleep sometime after nine.

DAY END

THE HISTORY AND MYSTERY OF STONEHENGE

The Christchurch location of Primetals Technologies is only a 38-mile drive from the world-famous Stonehenge site, which dates back as far as 3000 BC. We know today that, over time, Stonehenge was altered and rebuilt more than once. Even before the first stones were erected, the place seems to have carried a special significance for the people living in the area. In 2500 BC, timbers were used as the main construction material, making up what is now referred to as "Woodhenge." In 2200 BC, so-called bluestones were transported to the site all the way from the Preseli Hills in Wales, where folk tales spoke of the special healing powers of these stones. It must have been a huge effort for the ancient people to move the heavy pieces across a distance of almost 200 miles. The bluestones were complemented by white sarsens, a different kind of stone, in remembrance of the ancestors buried at the location. Despite hundreds of years of research, some of Stonehenge's mysteries still remain unsolved: There is even dispute as to why the site was built in the first place, as it had no obvious practical purpose. The most likely explanation is that the farmers of the time, who made up most of the population, believed that the site had spiritual relevance. They dreaded the darker months of the year in which their crops wouldn't grow and their cattle wouldn't thrive, and focused on the warmth and light that spring would return to them. Stonehenge, it appears, was built and aligned to mark the changing of the seasons and the sun's annual journey around the sky. By visiting the site, the ancient farmers could find the reassurance they so desperately needed—that the wait would eventually be over, that the days would soon become longer, and that nature would again breathe life into their existence, which was undoubtedly full of mysteries small and large.

NAVIGATING TOWARD A TRANSFORMATIONAL **FUTURE FOR METALS**

Paul Sherman is general manager of ShapeTech, the Christchurch location of Primetals Technologies, which specializes in sensor technology. Sherman has worked in the metals industry for almost four decades and has gained deep knowledge in product development and design, technical sales, installation, commissioning, and lifecycle services. We spoke with him about his role—and about the fully digitalized future of metals production.

The Christchurch location of Primetals Technologies has a unique role within the larger company. Can you tell our readers what sets it apart?
Paul Sherman: ShapeTech is a special location in many respects. We are a "cradle to grave" kind of business, meaning that we cover all aspects of creating a product—from the initial conceptual phase to the manufacture of the final industrial version. It also indicates that we accompany our customers all the way from their first project ideas to the implementation of their new equipment.

Which of the products you are responsible for do you like the best? We know that picking just one must be as hard as choosing your favorite child ...
Sherman: It is our Transformation Monitor, and let me tell you why. Every once in a while, you come across a technology that you know will change the industry. Transformation Monitor is such a rare case of a product. It makes the rolling of a diverse group of steel grades much more controlled, more consistent, and less of a calculated guess as currently is often the case. It might just set a new standard in terms of transparency of production, much like a certificate. If a producer can tell their customers that Transformation Monitor has tested their end products and that the highest quality standards were confirmed, the specified characteristics of the products can absolutely be trusted.

Sensor technology is essential for digitalization-related technological advancements to work. If fully automated metals production is the ultimate goal, are today's sensors good enough to support the progress made in software, or do they need to be significantly improved?
Sherman: It really depends. Our ShapeTech sensors are already at a stage where they can be a dependable part of the digital world. They use updateable software. However, there are sensors out there that can't be easily integrated into larger automation systems. These will eventually be superseded and will have to be replaced.

If you were to ask your crystal ball what the most far-reaching technological shift would be over the next 20 years—beyond the boundaries of the metals industry—what would it tell you?
Sherman: I think that at some point we will be seeing the introduction of extremely tiny sensors that are implanted in our bodies. They will be an "on-board body-management system with remote access" [laughs]. These devices will monitor our physical condition in detail and support us in extending our lifetime. They will also track our location and store various kinds of information that is relevant in a societal context. With an implant like this, you could, for instance, clock in and out at work. I know of a Silicon Valley company that is already doing this. As our population gets increasingly older, technologies like this will be more and more important.

You have been active in the metals industry for 38 years now, and one feels the unabated passion you bring to your role. What is it that fuels this passion?
Sherman: It is to make a difference, to have a positive impact. What drives me is wanting to make a contribution—not only to Primetals Technologies, though that is clearly important to me, but also to humanity at large. We have so much ahead of us, and I would like to see everybody use their talent the best-possible way. It would be a lost opportunity if someone's skill never got used. My mission as a manager is to encourage people to use what they've got, and the beautiful thing is just how much I get back from that every single day. ●

A new AOD converter at SIJ Acroni speeds up processing and increases production capacity.

OVERCOMING THE BOTTLENECK

BOOSTING PRODUCTIVITY AND QUALITY IN STAINLESS STEELMAKING WITH AN AOD CONVERTER FROM PRIMETALS TECHNOLOGIES

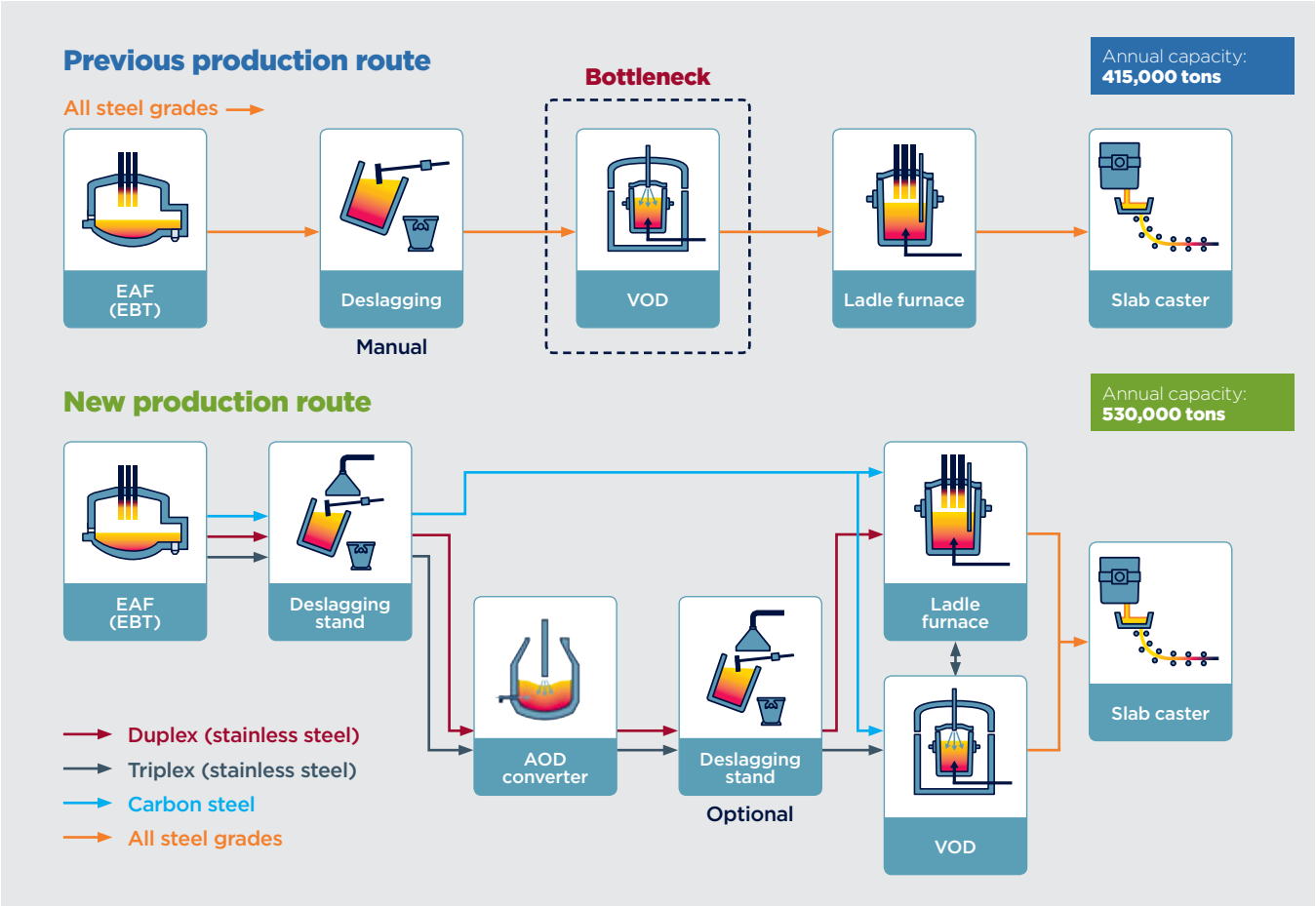
Charging SIJ Acroni's new 95-ton AOD converter from Primetals Technologies for the first time

In mid-2015, SIJ Acroni, Slovenia, placed an order with Primetals Technologies to supply a new 95-ton AOD converter and a new dedusting system to its steel works in Jesenice. The new equipment was started up in April 2017, increasing annual liquid-steel production capacity by roughly 35% to 530,000 tons per year while at the same time lowering production costs and reducing emissions.

SIJ Acroni, d.o.o., is a part of Slovenian Steel Group (SIJ) and one of the largest Slovenian steel producers. It is Europe's leading producer of stainless quarto plates and also specializes in electrical and special steels, which it sells in the form of hot- and cold-rolled coils, heavy plates, and cold-formed profiles. The SIJ Acroni works is situated in Jesenice, about 60 kilometers northwest of the capital, Ljubljana. The existing meltshop was built in the late 1980s and is designed for a yearly production capacity of approximately 396,000 tons of liquid product. Both carbon and stainless-steel production routes are based on melting scrap in an electric arc furnace (EAF), decarburization in a vacuum oxygen decarburization (VOD) plant, and final adjustment on the ladle furnace, before the heat is cast in a one-strand continuous casting machine (CCM). The slab caster at the Jesenice plant was successfully upgraded by Primetals Technologies in 2009 and was fitted with a new head- and strand-guiding system as well as the latest technological packages for dynamic width adjustment and quality. In addition to the meltshop, there is a hot-rolling mill and a heat-treatment line on site.

A VOD BOTTLENECK FOR STAINLESS STEELMAKING

Although the secondary metallurgical area of the meltshop consists not just one but two VOD treatment stations, this part of the plant configuration is a bottleneck for stainless steel production: VOD treatment takes significantly longer for stainless steel than it does for carbon steels, slowing down the entire production chain. To support SIJ Acroni's strategic decision to expand »



Old and new production routes of the SIJ Acroni meltshop in Jesenice

high-profit stainless-steel production and reducing production costs, an investment decision was made in 2015. The installation of an argon oxygen decarburization (AOD) converter would eliminate the bottleneck by offering a quicker decarburization route for most stainless steel grades. In addition, this would shift refining along with the main part of the metallurgical work from the EAF to the AOD, reducing processing time and thus increasing capacity even further. Finally, the change would allow for longer casting sequences and therefore reduce start-up and setting times at the CCM.

With the AOD process upgrade, Primetals Technologies projected an increase in annual capacity of liquid product of roughly 35%, which for the plant means a total liquid output of 530,000 tons. Additional upgrades to the EAF and the installation of an AOD top lance would open up even higher capacities—in the range of a remarkable 650,000 tons.

Capacity increases of about 15% could also have been reached with the installation of a third VOD treatment station instead. However, SIJ Acroni opted for the AOD investment because of its potential to reduce operational expenses (OPEX). The main advantages of the AOD converter in this regard are:

- Potential for using less expensive charging materials without compromising quality. For example, AOD treatment allows for the use of high-carbon ferrochrome (charge chrome) instead of high-quality refined ferrochrome.
- Lower refractory consumption at EAF, VOD and CCM due to shorter contact with liquid steel
- Lower electrical energy and electrode consumption at EAF
- Higher yield due to reduced slagging of alloying elements such as chromium
- Higher yield on CCM due to longer casting sequences

THE AOD VERSUS VOD STAINLESS-STEELMAKING ROUTE

The upper part of the schematic above shows the previous production route at the facility with a total annual liquid production capacity up to 415,000 tons. All aggregates have a heat size of 90 tons. The typical VOD processing times for stainless-steel grades are more than four hours, which is why the two VOD treatment stations constitute a bottleneck in the old production route. With the AOD converter implementation, the VOD bottleneck for stainless-steel production is eliminated and the EAF and AOD processes are balanced. Due to the significantly

The new 95-ton AOD converter at the SIJ Acroni meltshop

The new dedusting system lowers emission levels.

lower processing times for the EAF and the AOD compared to the previous production route, total production capacity increases. Possible further EAF and AOD improvements would open additional growth potential.

In the early stages of the project, Primetals Technologies conducted a study of the logistics involved in increasing production capacity, investigating the utilization of the main charging crane and possible casting sequences for stainless duplex and triplex processes. The results of the study showed that the utilization of the 170-ton charging crane would be high at maximum production capacity, but could be balanced with the second crane installed at the facility. For most stainless-steel grades, production will take a duplex route where no VOD treatment is necessary. The outcome of the production sequence planning was that for the typical duplex route (e.g., standard stainless austenitic grades), the new plant setup allows for a casting sequence of at least three heats. For the typical triplex route (e.g., titanium-stabilized stainless austenitic grades), it enables a casting sequence of two heats.

AOD METALLURGY AND PROJECTION OF COST SAVINGS

The AOD converter is part of most common stainless-steel production routes—mainly because of its high decarburization rates with minimized metal (i.e. chromium) oxidation. To reach the metallurgical targets, it employs a side-blowing process with submerged sidewall nozzles (tuyeres). With decreasing carbon content, it injects an increasing amount of inert gas through the side nozzles to reduce the partial pressure of carbon monoxide and therefore limit the oxidation of chromium into the slag. To achieve maximum chromium recovery in the melt, decarburization is followed by a reduction phase with pure inert gas stirring through the side nozzles only. Additional metallurgical targets are: simultaneous desulfurization in the reduction phase, nitrogen-content adjustment, and minimizing process times as well as minimizing media and material consumption. All of these are also part of the performance guarantees of the project.

Primetals Technologies has in its portfolio a full set of metallurgical process calculation tools for all aggregates in the steelmaking process. All refining processes are guided and monitored by the Level 2 process models to guarantee highest quality, maximized production stability, and lowest processing costs. Offline versions of these tools were used to perform a comprehensive comparison of the existing and the new process route, using confirmed input data for media and material costs as well as production volume and product mix. The result of the process comparison presented a clear picture of the cost savings to be achieved with the AOD, giving SIJ Acroni additional confidence in the ROI to be expected.

EXECUTING THE UPGRADE

In July 2015, Primetals Technologies received the order as the main supplier for engineering, fabrication and delivery of the meltshop upgrade with an AOD converter, including all the auxiliary aggregates such as the deslagging stand, material handling, converter heating, relining and wrecking stands, as well as the transfer car, a dedusting system, and the complete Level 1 and Level 2 automation. Primetals Technologies was also tasked with devising the new layout of the meltshop, and performing the start-up after completing the upgrade. The entire project was handled by a consortium with the Slovenian company Esotech d.d., Velenje. Esotech was responsible for the structural steel work, plant construction, and for supplying the water-treatment plant. Delivery by Primetals Technologies and Esotech started in September 2016 with the main parts of heavy equipment and was completed in February 2017 with the final pieces of electrical equipment. All parts of the upgrade were completed according to the agreed project schedule, which was achieved by strictly monitoring and expediting all supply processes. Daily site coordination meetings and planning on an hourly basis ensured rapid progress with minimal production stops. Less than two years after SIJ Acroni had signed the contract, the first heat was tapped on the AOD in April 2017. The plant has been in full operation since August 2017, following a short ramp-up phase. Even though the converter is operating with side-tuyeres only, the processing times at the AOD could be stabilized to an average of less than 80 minutes. »

NEW EQUIPMENT FEATURES IN DETAIL: THE AOD CONVERTER

The new AOD converter from Primetals Technologies has a tapping weight of 95 tons. Five bottom tuyeres inject the process gases into the liquid bath. In order to achieve even faster processing, an optional top lance can be installed. A rotary joint connects the bottom tuyeres to the valve station with single-shroud control, allowing for independent and optimized control of the gas flow for each shroud, which considerably prolongs the lifetime of the tuyeres and the lining. The vessel itself is designed for optimized flat-bath operation, which guarantees highest carbon removal efficiency (CRE). Therefore, the bath geometry is a compromise between low bath depth for reduced ferrostatic pressure and sufficient bath depth for ensured mixing and chemical reaction of injected process gases. A robust tilting drive with two asynchronous motors ensures fast and precise tilting of the AOD converter.

To reduce AOD-typical vibration, the converter was fitted with the patented Vaicon Drive Damper. Feedback from several reference installations proves that this damping system reduces dynamic load and converter displacement, which entails a range of benefits: reduced fatigue and wear on equipment (especially on gear wheels and bearings), increased equipment lifetime, less maintenance effort, and increased operational safety.

In order to facilitate fast vessel exchange, the setup utilizes the Vaicon Quick suspension. First, an exchange device is placed on the empty ladle-transfer car. This device then lifts out the worn AOD vessel and transports it into the crane bay, where it is transferred into the maintenance area. This newly established part of the plant mainly consists of a converter-wrecking stand where the old lining is removed, and a combined converter relining and heating stand where the new lining is installed and the AOD vessel is heated up before going into production again.

Charging of the main additions is handled by a newly installed additive-feeding system above the AOD converter, while scrap is charged into the AOD by means of a scrap chute. The new alloy and additive feeding system is operating out of three storage areas, which combine pre-existing with new storage facilities. Three new 60 m^3 high-level bins offer the ample storage required for slag builder, lime, and dolomite. For charging of standard alloys (mainly charge chrome), parts of the pre-existing 8 and 15 m^3 high-level bins were reused. Finally, a small (but expandable) 4 m^3 weighing-bin system for special alloys was installed in the furnace bay, which is connected to the AOD by a vertical belt conveyor.

THE NEW DEDUSTING AREA

In order to achieve the lowest-possible emission levels, advanced primary and secondary dedusting systems featuring pulse-jet filter technology were installed for the new AOD process aggregates. As a result, a dust load of less than 10mg/Nm^3 could be achieved during performance tests. Moreover, to improve the dust situation inside the steel plant, the new dedusting system is also equipped with several suction points for the existing EAF material handling system, the ladle furnace, the treatment stand, and the torch-cutting machine. The cooling system necessary for primary AOD off-gas cleaning builds on new, patent-pending technology, which is more effective, requires fewer fans and less space, minimizes dilution air and heat flow to the filter, and thus significantly reduces operating and maintenance costs.

The installation features a new Level 2 automation system.

ADVANCED AUTOMATION

A crucial factor for accurate and efficient process execution is the process-optimization and control software, also referred to as Level 2 and Level 1 automation. The Level 2 system directly communicates with SIJ Acroni's existing production-planning system (MES). The patented dynamic process model employed at the SIJ Acroni plant comprises a number of metallurgical sub-models, which are combined to perform online calculations and offline simulations of the state of the bath and the chemical reactions occurring inside the vessel. As a result, for most grades the process model allows parameters to be predicted at the end of the process, with an accuracy of ± 50 ppm for carbon and ± 15°C for temperature.

An additional automation highlight is the new "Acoustic Expert" system, which monitors the bag-filter cleaning procedure in the pulse-jet filter. The system analyzes the spectrum of sound emitted during the cleaning of the bag filter to detect deviations and initiate condition-based maintenance activities. ●

Bernhard Voraberger, Head of Technology & Innovation, Converter Steelmaking, Primetals Technologies
Dr. Gerald Wimmer, Vice President, Converter Steelmaking, Primetals Technologies
Roman Robič, Technical Director, SIJ Acroni

TAKING A NEW ROUTE

Only two years after signing the contract, the crew at the SJI Acroni Jesenice plant was able to tap the first heat from the new AOD converter supplied by Primetals Technologies. The installation had been performed while regular production at the facility was ongoing—shutdown times were kept to a minimum.

In the weeks and months following the first tap, almost 20 different stainless and special grades were successfully produced with the new setup. Slovenian President Borut Pahor, who attended the ceremonial opening in September 2017, stressed the significance of SIJ Group's investment for the Slovenian economy.

The AOD vessel being lifted into place. All work on the new installation was done with production in the plant ongoing.

At the opening ceremony, Josef Lanschützer of Primetals Technologies thanked the team at SIJ Acroni for their smooth cooperation.

The AOD process significantly increases the capacity of the SIJ Acroni meltshop and reduces operating costs at the same time.

PROJECT VIDEO

Scan the QR code or type in the link below to watch the SIJ Acroni meltshop upgrade unfold in a short video.

bit.ly/aodacroni

ASK DR. HIRAI

YOUR QUESTIONS FOR THE CTO OF PRIMETALS TECHNOLOGIES

In this section, Dr. Etsuro Hirai, CTO of Primetals Technologies, exclusively answers your questions. Should there be an issue that you would like him to address, please send us an email containing your question, your job function, and your location.

Email address for questions:
ask-the-expert@primetals.com

WHY IS INDUSTRY 4.0 SO IMPORTANT TO THE FUTURE OF STEEL PRODUCTION?

Asked by a customer from India

Dr. Hirai: To me, at the heart of the concept of Industry 4.0 is knowledge management. One of the central challenges in metals production has always been that there was just so much know-how at work—too much for any one expert to master. Since even more data is generated today, the value of this information has not fully been digested and transferred from generation to generation. This is where knowledge management comes in, which can make production processes far more reliable and improve the consistency of the end-product quality.

HOW SERIOUSLY SHOULD I TAKE RECENT ADVANCEMENTS IN ARTIFICIAL INTELLIGENCE?

Asked by a customer from Germany

Dr. Hirai: I think that artificial intelligence needs to be taken quite seriously, even if we are still far away from what Ray Kurzweil calls the "singularity"—the point in time when computers will be advanced enough to host the complexity of human consciousness. But even for today's steel industry, artificial intelligence is important. Computer networks have become more powerful, and techniques called "machine learning" and "deep learning" can tackle new kinds of problems. We are already employing these methods in some of our technologies, for instance in our Through-Process Quality Control solution. An important topic that needs to be addressed in conjunction with both artificial intelligence and cloud computing is data security, which we handle with great care. In general, if I look far into the future, I see steel plants operating fully automatically—with very little need for traditional human labor. But it will be a step-by-step process to get there, and it will take several decades.

WHAT ARE THE MAIN TRENDS YOU SEE IN THE CHINESE STEEL INDUSTRY?

Asked by a customer from China

Dr. Hirai: The steel industry in China is now re-adjusting itself. It is following a three-stage plan in alignment with the Chinese government. The first stage is about a reduction in overall production capacity. Much of this downsizing has already taken place. The second stage is about increasing end-product quality. This is a crucial step but will take a while to unfold comprehensively. China is home to numerous steel producers, and there is no "one size fits all" type of formula for how production facilities should best be upgraded. The third stage is about changing the structure of the Chinese steel industry: in the years ahead, many producers will move from the blast furnace to the EAF-based manufacturing route, and toward a larger scrap percentage in their raw materials.

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THE SMART PLANT OF THE FUTURE

THE IMPACT OF DIGITALIZATION

The metals-production plant of the future will be "smarter" than the facilities of today, thanks to recent advancements in the fields of information technology and process modeling. While it is clear that the steel industry will experience some disruption, the path toward the fully automated plant still needs to be sketched out. This issue of Metals Magazine looks at where the industry is going, and what digital orchestration can achieve.

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