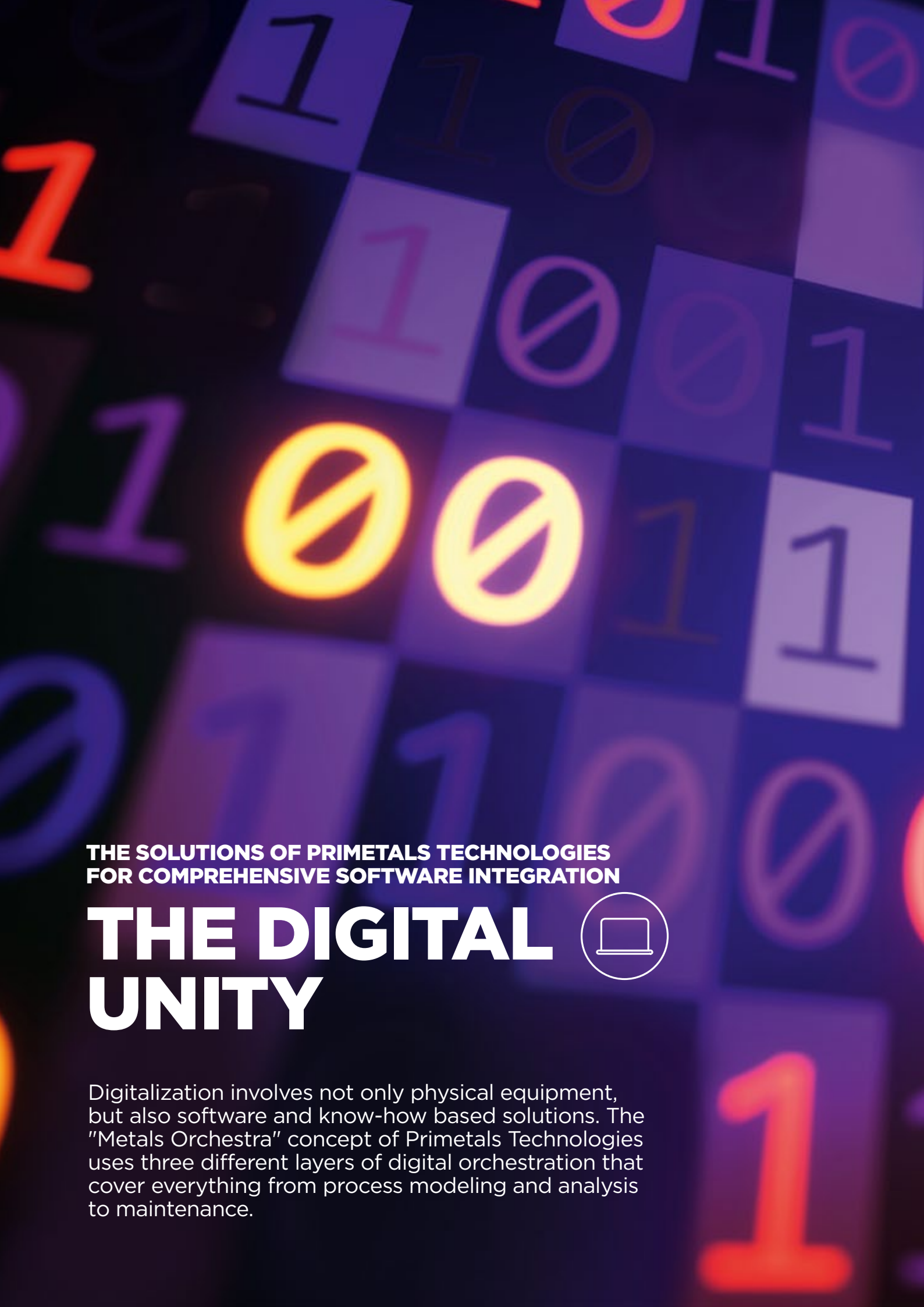


THE SOLUTIONS OF PRIMETALS TECHNOLOGIES FOR COMPREHENSIVE SOFTWARE INTEGRATION

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 trouble-shooting 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 full

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

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

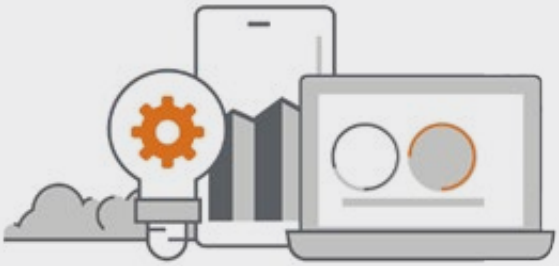
Paulo Marinho is Head of Operations at Primetals Technologies' workshop in Rio de Janeiro, Brazil. The site is located in the vicinity of the facilities of Ternium Brazil (formerly thyssenkrupp CSA). In 2009, the workshop started to provide metals producers with online and offline maintenance for the 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

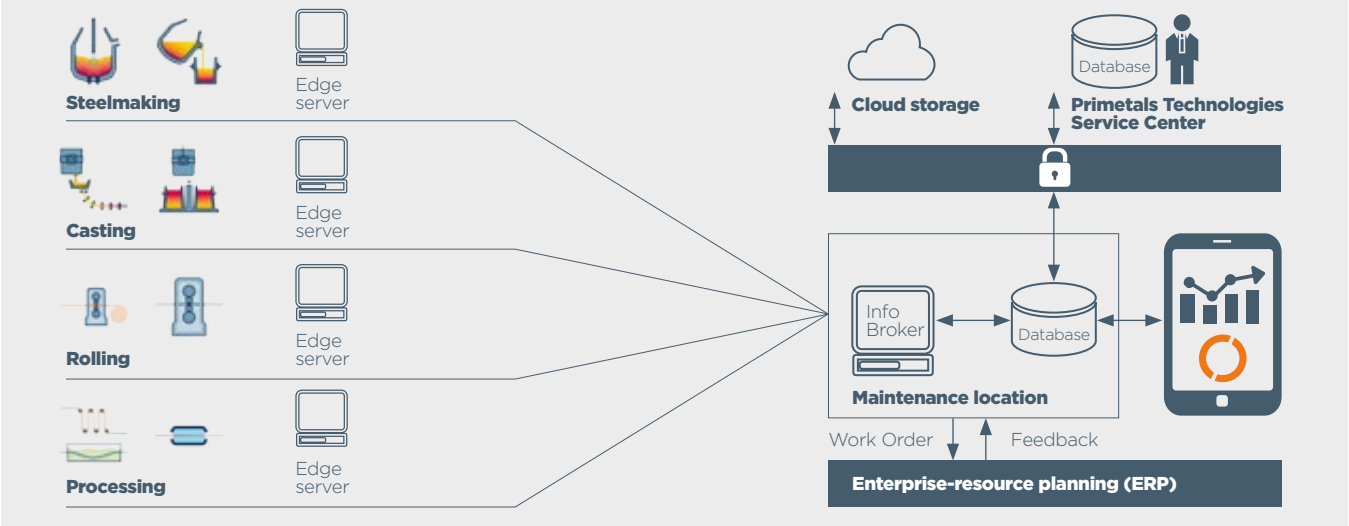
Thanks to the web-based architecture of the BOX Concept, plant managers can easily access the information or reports they desire using a smartphone or a tablet, either via an authorized connection to the plant network or by scanning a dedicated QR code on the respective piece of equipment. Additionally, 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).

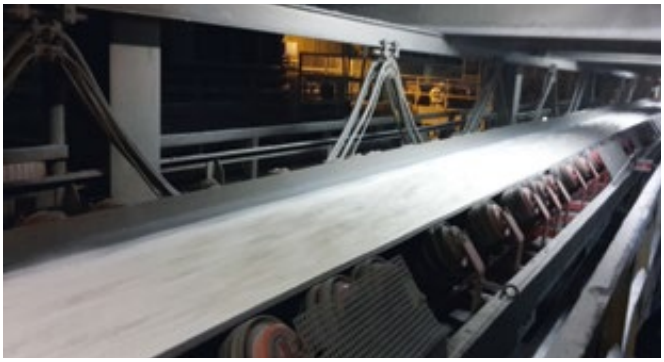


Simplified overview of the BOX Concept's web-based architecture.

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.