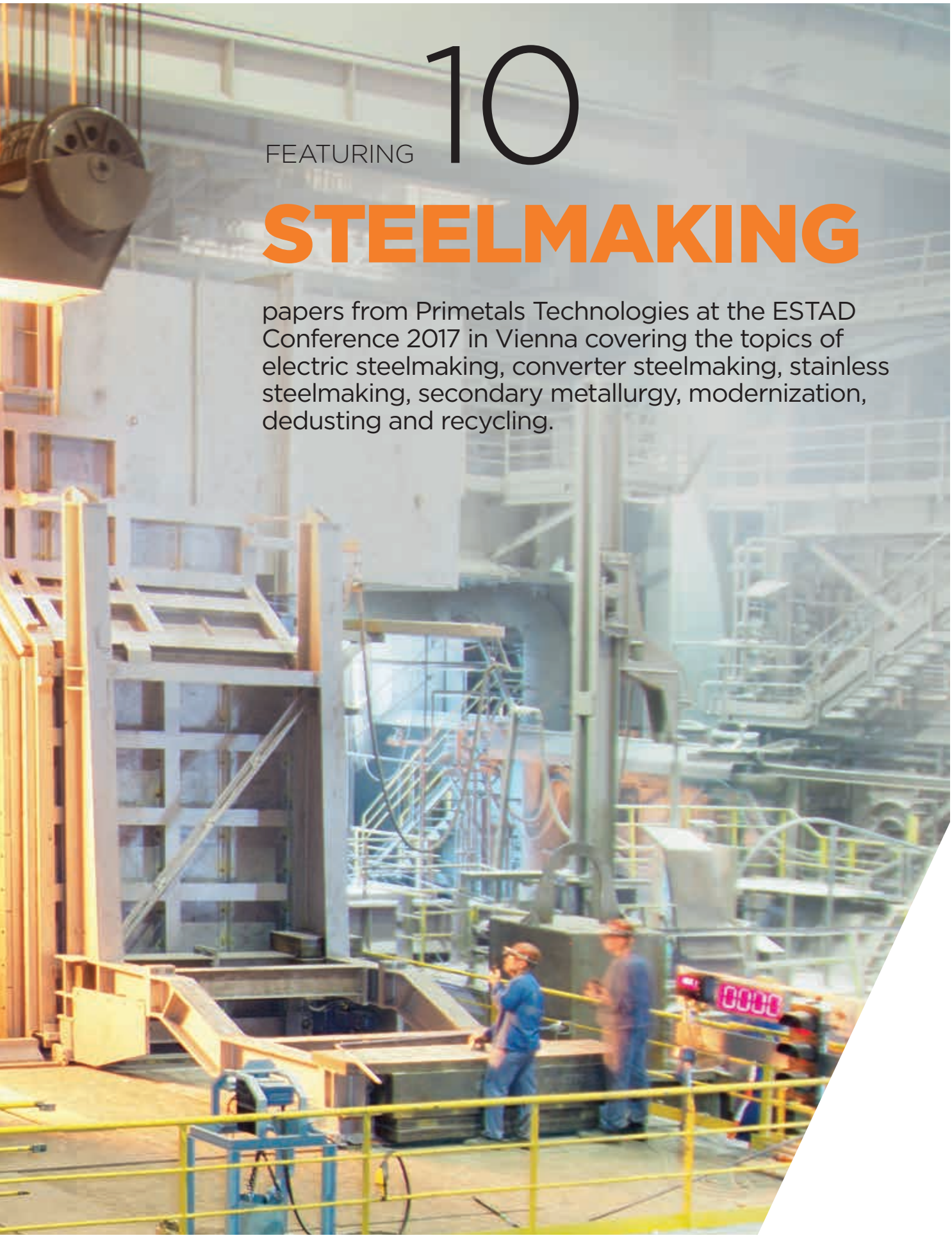

FEATURING 10

STEELMAKING

papers from Primetals Technologies at the ESTAD Conference 2017 in Vienna covering the topics of electric steelmaking, converter steelmaking, stainless steelmaking, secondary metallurgy, modernization, dedusting and recycling.

The design of the Melt Expert electrode control system is based on Industry 4.0 principles.

PRACTICAL USER EXPERIENCE WITH AN INDUSTRY 4.0 ELECTRODE CONTROL SYSTEM

Paper number: 85
Principal author: Christoph Sedivy

Industry 4.0 is slowly but surely making its way to the melt shops. Furnaces are being equipped with more and more sensors, digital models are increasing the degree of automation, and information is being shared between different aggregates within the plant. Because the electrode control system plays a key role in electric steelmaking, it naturally assumes an important position in the Industry 4.0 strategy of the melt shop. In addition to reliable, state-of-the-art core regulation functionality, monitoring and reporting tools as well as the ability to communicate with other equipment are also crucial. The latest generation of the Melt Expert electrode control system has therefore been developed according to Industry 4.0 design principles.

Intelligent plant condition diagnostics, performance monitoring and user-defined reporting are essential modules in this new system. Thanks to these functionalities, electrode control systems are becoming the information and control center of the furnace. A newly developed software app forwards the most relevant process information to mobile devices. This feature allows steelmakers to monitor the performance of their equipment any time and anywhere.

This paper describes the new features of the electrode control system and shares operational experiences of customers. Special focus is placed on the practical aspects of plant status monitoring, KPI (key performance indicator) reporting, diagnostic functionality and the resulting improvements.

EXTENDED NEW OVERVIEW OF CHEMICAL INJECTION SYSTEMS AT THE EAF

Paper number: 94
Principal author: Hannes Beile

This paper provides an overview of state-of-the-art chemical injection systems for the EAF and the benefits of modern injection solutions: lower consumption costs, increased productivity and improved safety.

These systems are easily upgradable for any EAF. With only a short downtime period, the installation of modern combined injection systems can lead to huge productivity gains and process improvements. The chemical injection portfolio of Primetals Technologies includes solutions for every steelmaking process route.

The following topics are addressed in this paper:
- History of chemical injection into the EAF
- Overview of state-of-the-art injection systems for all electric arc furnace types
- Detailed description of the new RCB (Refining Combined Burner) 3.0 system
- Preview of the future RCB Move technology

The Refining Combined Burner for enhanced electric arc furnace performance

LATEST MODERNIZATION DEVELOPMENTS FOR ELECTRIC ARC FURNACES

Paper number: 96
Principal author: Patrik Zipp

Electric arc furnaces (EAF) can achieve high performance and productivity rates through maximum utilization of equipment and products and by applying an optimized process know-how. Producers also benefit from a more uniform and safe operation. The furnace components and supporting products have to be designed for maximum power input, utilization and operational safety. Power-on and power-off cycle times can be reduced toward achieving a faster and safer process.

This paper discusses the latest EAF modernization solutions from Primetals Technologies, which lead to the following benefits:

- Increased productivity
- Lower conversion costs
- Operation with a symmetrical power input
- Reduced refractory wear
- Improved plant availability and lifetime with the use of heavy-duty components
- Improved operational safety thanks to the application of fully automatic systems

100-ton FAST DRI electric arc furnace installed by Primetals Technologies at Qatar Steel Company, Mesaieed Industrial City, Qatar

ROBOTIC-GUIDED TAPHOLE MAINTANENCE ON ELECTRIC ARC FURNACES – A MAJOR INCREASE OF WORKER SAFETY

Paper number: 221; Principal author: Mario Hirth

There are many areas within metallurgical plants where dust, smoke, gases and liquid steel can pose a danger for site personnel. Carrying out manual work in these unsafe environments should therefore be avoided whenever possible. Today, an increasing number of manipulators and robotic solutions are being used to perform tasks in hazardous working areas, such as for taphole opening of electric arc furnaces. This is usually done with an oxygen lance burner held to the taphole, which requires the operator to stand right next to the dangerous taphole area. Owing to the weight of the lance, two people are often required to work in this exposed area.

This paper describes the highly versatile LiquiRob system of Primetals Technologies and its newly developed feature "taphole-opening for EAF." The robot functions as an extension of the operator's hand. Heavier lances can be manipulated since there are no work safety restrictions for the robot. More energy is therefore available for the burning process, and the taphole-opening rate can be significantly increased. Standing at a safe distance, the operator can guide the burning lance with the robot to the taphole with the greatest precision. Using a closed-circuit television (CCTV) system, this task can even be performed from the control room. The first operational results using robot-guided oxygen lances in dangerous working areas are presented.

The robot system for fully automated handling of probes for the converter sublance (voestalpine Stahl, Linz, Austria)

FULLY AUTOMATIC CONVERTER STEELMAKING

Paper number: 51; **Principal author: Dr. Gerald Wimmer**

The intensive use of automation solutions, process models and expert systems is well established in converter steelmaking, and it is widely recognized that automated procedures have a positive influence on productivity, product quality and operational safety. The combination of existing technologies, new support systems and the efficient use of information management tools supports plant operators to run their plant almost fully automatically, allowing them to focus on the supervision and optimization of the process.

This paper takes a bottom-up approach and includes reference examples of how an LD (BOF) steelmaking plant can be upgraded to maximize automatic operation. This approach comprises several steps: it begins with basic-automation requirements such as totally automated transfer cars and reliable measurement systems; it then proceeds to more advanced automation solutions such as robotics for probe handling or crane logistics for automated charging; and concludes with completely coupled data management systems for through-process quality control.

The paper presents early practical references such as ICE Tag technology – a high-temperature RFID (radio-frequency identification)-based identification technology for tracking of ladles and slag pots; converter monitoring; Lance Guard for closed-loop diagnosis of sublance measurement systems; and Fluid Guard for leakage detection in safety-critical applications. Fully automatic converter steelmaking also requires the installation of additional condition-monitoring systems to ensure maximum plant availability and reliability at lowest maintenance costs. Finally, solutions for the automation of critical maintenance tasks in converter steelmaking, such as lining maintenance or converter relining, are discussed.

UPGRADE OF STAINLESS SPECIAL STEEL PRODUCTION BY IMPLEMENTATION OF AOD PROCESS AT ACRONI

Paper number: 54; **Principal author: Bernhard Voraberger**

In mid-2015, Acroni, a Slovenian steel producer and part of the Slovenian Steel Group (SIJ), commissioned Primetals Technologies to supply a new 95-ton AOD (argon oxygen decarburization) converter and dedusting system for its steelworks in Jesenice. Less than two years later, in April 2017, the new process route was put into operation, which allowed the annual liquid steel output to be increased by 35% up to 530,000 tons. With an additional electric arc furnace (EAF) upgrade and the installation of an AOD top lance, a maximum annual liquid steel capacity of 650,000 tons can be expected. Stainless steel scrap had been previously melted in an EAF and decarburized in two VOD (vacuum oxygen decarburization) treatment stations with a capacity of 90 tons each. Because the treatment of stainless steel in a VOD requires more time than for carbon steels, the existing plant configuration meant that there was a bottleneck in stainless steel production. This was eliminated by the installation of an AOD converter, which not only increased the production capacity but also the flexibility of the steelworks. Heat-processing times for stainless steel were reduced significantly. For example, tap-to-tap times at the EAF were shortened by 55 minutes, and more than two hours are saved by switching treatment at the VOD station to the new AOD converter for the production of duplex and ferritic stainless steel grades.

Additional advantages of an AOD converter are the higher yield of alloying elements, such as chromium, and the use of less expensive ferrochromium grades with a higher carbon content as an alloying addition. Acroni was therefore able to significantly reduce its production costs and can look forward to a short return on investment for its AOD converter investment.

Numerous other sophisticated technologies and systems were installed by Primetals Technologies at the Acroni melt shop that included a new material-handling system and Level 2 process automation specifically designed for AOD converters. This ensures that raw materials are used efficiently and that treatment times are minimized. The converter is equipped with a patented drive damper system to reduce vibrations caused by injection processes. This reduces wear and maintenance costs and additionally lengthens the service life of the plant. A dedusting system was also installed at the same time as the AOD converter. Not only can emissions be kept well below current limits, but also energy efficiency and occupational safety are greatly increased in the production area.

The paper summarizes the technical highlights and execution of the project, as well as the achieved steelmaking results.

Charging of the 95-ton AOD stainless steelmaking converter at SIJ Acroni, Slovenia

BOOSTING THE VALUE OF YOUR STEELMAKING SLAG AND DUST

Paper number: 53
Principal author: Dr. Gerald Wimmer

Considerable amounts of slag and dust are produced in integrated iron-ore-based steelmaking plants as well as in EAF scrap-based steel mills. These by-products still contain considerable amounts of metals in metallic and oxide form, which are only partly processed and recycled. The rest is used for landfill purposes or, after mechanical processing, is suitable for low-value external applications such as in road construction or as filler materials. Internal recycling of slags and dust in a steelmaking plant is typically via the sinter plant and the blast furnace, or by means of briquetting and subsequent charging to the blast furnace, LD (BOF) converter or electric arc furnace.

Primetals Technologies has developed an innovative process that reduces all metallic oxides in the slag or dust, extracts the metallic portion, and returns all metals to the primary process. The basicity of the remaining mineral fraction can be modified, if necessary, to allow its usage as a high-value material for binding purposes or in the cement industry. For example, slags from converter steelmaking processed in this way can be directly used as a cement clinker substitute. Recovered metals are first dephosphorized and can then be recycled as a hot metal or scrap substitute in the converter. The process itself takes place in a modified electric arc furnace with coal injection and quasi-continuous liquid slag charging. The process principles and different ways of utilizing the mineral fraction are presented in the paper, together with business cases for an integrated steel plant for carbon steel production, and for EAF steelmaking based mainly on the use of direct-reduced iron.

INNOVATIVE SOLUTIONS FOR BOF DEDUSTING SYSTEMS – ACHIEVING MINIMUM EMISSION LEVELS

Paper number: 64
Principal author: Herbert Pasteiner

The importance of environmental protection has greatly increased in the iron- and steelmaking industry over the previous decades. Environmental protection measures must now comply with increasingly stricter regulations set by government agencies. Dry-dedusting systems (DDS) represent the latest technology for cleaning the primary offgas of LD (BOF) basic oxygen furnaces. However, due to their relatively high investment costs in revamping projects, this type of dedusting system may not be as feasible as other dedusting solutions.

Primetals Technologies therefore offers alternative cost-efficient dedusting systems to the DDS, in particular, in connection with revamping solutions for existing wet-dedusting systems (WDS). A new application is the wet electrostatic precipitator (WESP). Installed downstream of a WDS, the WESP treats the particulates typically contained in the water-saturated WDS offgas to further reduce dust emissions. After construction of the WESP is completed, it is then connected to the WDS offgas duct by means of a bypass system. This considerably shortens the shutdown period required for installation work and also allows independent maintenance of the WESP when necessary.

Another innovation is a new scrubber design for increasing the gas-cleaning efficiency of a venturi-type WDS. Separation efficiency is improved by injecting water into the gas flow at a 45° angle. Implemented innovations and improvements are presented in detail in the paper, and the results are discussed.

DEVELOPMENT OF HIGH-QUALITY-STEEL PRODUCTION TECHNIQUES USING A VOD PLANT AT VOESTALPINE GIESSEREI

Paper number: 142; Principal author: Andrea Pezza

Research, development as well as plant and production route optimization are some of the ways to drive the steel business forward. This paper describes a new operating concept from Primetals Technologies for a VOD (vacuum oxygen decarburization) plant that was developed on the basis of plant-design experience and customer feedback. Joint and close collaboration with the customer voestalpine Giesserei Linz GmbH was crucial for the new improvement measures. All possible vacuum-degassing solutions were investigated and assessed toward developing a new approach for the use of tank degassers in the production of high-quality steel.

Joint investigation of new vacuum-degassing techniques for the production of high-quality steel grades together with voestalpine Giesserei Linz at the producer's VOD plant in Austria

OPTIMIZATION OF CONVERTER DESIGN WITH CFD – PRACTICAL APPLICATION FOR CONVERTER REVAMPS

Paper number: 52; **Principal author: Dr. Erich Wimmer**

Computational fluid dynamics (CFD) has continuously evolved over recent decades and has come to play an important role in the development of modern LD (BOF) steelmaking converters. Flow inside the converter is highly complex and comprises several physical phenomena such as supersonic flow, chemical reactions, heat transfer and the flow of gas bubbles in the liquid melt. For numerical reasons, not all flow processes can be taken into account, but it is possible to describe major effects, show tendencies and gain valuable insight on multi-phase flow processes. The results of these analyses can subsequently be used in the design of new converters.

Primetals Technologies is committed to developing an efficient approach to modeling flow and mixing inside the converter during the refining process within a reasonable time. Investigations were carried out on a 110-ton converter in connection with steel bath mixing, which led to the development of a generally applicable method for modeling the flow and quantification of the mixing intensity. It became clear that two kinds of vortices are generated inside the flow, which are of significant importance for mixing and overall flow. On the one hand, vortices are created near the bubble columns at the stirring elements and, on the other hand, much larger vortices are formed that strongly influence the total flow in a molten steel bath. Furthermore, it could be shown that the arrangement and type of bottom-purging elements are crucial factors for mixing intensity. An asymmetric alignment of purging elements can result in critical zones inside the converter that are characterized by very low local flow velocities.

Primetals Technologies has drawn on its extensive numerical simulation competence to investigate the influence of varying process parameters in order to optimize the overall design of the converter and blowing lance equipment.

Primetals Technologies is committed to developing an efficient approach to modeling flow and mixing inside the converter.

STEELMAKING HIGHLIGHTS OF PRIMETALS TECHNOLOGIES

Electric steelmaking
- 500 electrode control systems installed during past 35 years
- 20% reduction in electrical energy required for melting with scrap preheating in the shaft-type EAF Quantum furnace
- Anode lifetime of more than 1,500 heats with the DC-EAF fin-type anode
- Two dollar conversion cost savings per ton of liquid steel with the EAF Heatopt holistic process-optimization system
- 50% reduced space requirements with the combined vessel and ladle lifting system (RH CVL)

Converter steelmaking
- Up to 50% scrap or HBI (hot-briquetted iron) charging to the LD (BOF) process with the Jet process
- Less than 2 kg of slag carry-over during converter tapping
- 20-year lifetime of converter suspension system with Vaicon Link 2.0
- 50% reduction of AOD converter vibrations with the Vaicon drive damper
- Less than 10 mg/Nm³ dust emissions with dry-type LD (BOF) dedusting system
- 70 Nm³ to 100 Nm³ recovered CO gas per ton of steel produced in an LD (BOF) converter
- Availability of recycling processes for 100% valorization of slags and dusts from steelmaking