ELECTRICS AND AUTOMATION FOR ELECTRIC ARC FURNACE
ENHANCING THE PERFORMANCE OF YOUR ELECTRIC ARC FURNACE

STATE-OF-THE-ART SOLUTIONS FOR
FULLY OPTIMIZED EAF PRODUCTION

YOUR CHALLENGE

The market for steel from electric steel plants continues to grow, similar to the demands on cost-efficient production and productivity. Low consumption levels and efficient energy use have to be achieved. In recent years there has been a growing awareness of cost cutting potential in electric steel production due to increased prices for electric energy, scrap and raw materials.

Converting raw materials into finished steel products is very intensive in terms of energy consumption. The continuous efforts of the metals industry are driven by cost pressure and environmental regulations. However, despite the steel producers' success in reducing energy input, it is still one of the leading cost factors.

International agreements and national laws call for further reduction of pollution, energy consumption and CO_2 emissions. This has to be achieved in the most cost-efficient way. Rising environmental standards requires intelligent approaches in electrics and automation.

The challenges described above must be met in order to ensure a competitive edge for your electric steel plant and to meet future market requirements like stricter emission limits or more challenging customer demands.

OUR SOLUTION

EAF automation solutions, based on decades of combined engineering, plant-building, operational, metallurgical and automation experience are the key to ensure high-performance and cost effective EAF steelmaking. The modular, expandable and upgradeable automation packages are developed for a wide range of plant setups, operational strategies and input materials. They optimize EAF steelmaking without compromising raw material selection, steel quality, energy efficiency, and productivity.

The EAF automation solutions can be installed into existing automation environments easily and rapidly. Our vast in-house experience in software and hardware engineering secures fastest project implementation and start-up.

Unique features include the electrode control system; the foaming slag manager, the contact-free temperature measurement and the holistic process model for significantly lower production costs. All in all the EAF steel production can be fully optimized by the application of various automation packages, that flexibly can be adapted to changing production and market conditions.

Primetals Technologies combines decades of experience in steelmaking technology, unique software features and innovative modular-designed packages to provide truly complete and intelligent automation solutions for the one purpose: highest EAF efficiency.

ADVANTAGES OF PRIMETALS TECHNOLOGIES EAF AUTOMATION

- A more profitable production – due to higher availability and reduced delay times

- Complete solutions – by combined technological, operational and automation expertise from one source

- A higher level of safety – by fully automatic control of oxygen, carbon and gas injection

- Short amortization time – based on reduced energy consumption and increased yield

- Short commissioning time – thanks to easy system integration into existing automation environment

OVERVIEW EAF ELECTRICS & AUTOMATION
RELIABLE CONTROL AND IMPROVED PERFORMANCE

Overview EAF automation packages

We offer a comprehensive spectrum of EAF automation solutions, from instrumentation and process control, optimization packages up to manufacturing execution systems (MES), energy management systems (EMS) and logistics management systems. The decisive factor for safe and optimized control of the EAF is our technological knowledge in the provided packages. The integrated automation solutions are suitable for the entire spectrum of EAF technologies, from AC and DC EAFs, stainless EAF to shaft furnaces, for new as well as existing plants of any size, regardless of the furnace supplier. These solutions ensure best performance for small revamps as well as entirely new furnaces.

ENERGY SUPPLY AND POWER QUALITY

The products from our power family represent a number of world-class solutions from furnace switchgears for ultra high power furnaces up to dynamic reactive power compensation to ensure safe and stable energy supply throughout the plant.

PROCESS CONTROL

In order to comply with the special requirements of the electric arc furnace, the process control system for EAF basic automation (level 1) and technological control packages for all areas of electric steelmaking.

ELECTRODE CONTROL SYSTEM

With more than 35 years of experience and almost 600 installations worldwide, Primetals Technologies is the dedicated partner for electrode control systems.
We provide a fully automatic electrode control system for most efficient melting process. Enhanced control algorithms ensure highest arc stability and therefore the electrode and energy consumption are reduced. Integrated self-diagnostic functionalities provide highest availability and lead to reduction of maintenance costs and minimize unplanned downtimes.
Implementation of extension modules for foaming slag management and dynamic melting control provide fully automatic furnace operation. Cost savings are reached by essential reduction of power on time and carbon consumption.

PROCESS OPTIMIZATION

The application of Steel Expert, a comprehensive group of dynamic process models, optimizes the EAF steelmaking process. The prediction model provides a forecast of the progress and the final condition of the heat, whereas the supervision models are monitoring the metallurgical and thermal process. The setpoint models determine the energy supply and the material additions that are required to meet the target steel quality. The holistic process optimization Heatopt takes further the off-gas characteristics (analysis, flow) into account to dynamically control the oxygen and gas burners, the carbon injectors as well as the post-combustion burners in closed-loop operation.

ENERGY SUPPLY AND POWER CONTROL
FOR A SAFE AND STABLE PLANT OPERATION

Furnace switchgear

Switchyard and compensation systems for meltshop and mill, Nucor, Crawfordsville, USA

FURNACE SWITCHGEAR

The furnace switchgear solution is perfectly adapted even for the extreme requirements of ultra high-power arc furnaces. At voltages of up to 40.5kV and load currents up to 4,500A, and with the newly developed VCB (vacuum circuit breaker) as single circuit breaker for up to 4,500A, it ensures reliable energy supply and plant operation. Moreover, the long maintenance interval of 30,000 operating cycles allows for very low operating costs with only minor maintenance after 10.000 operation cycles. More than 30 years of experience in vacuum circuit breaker application, as well as our in-depth knowledge of furnace switchgears ensures smooth and reliable production without excessive over voltages or switch failures. In addition to its impressive performance characteristics, our solution excels through its simple operation and high efficiency.

MAIN BENEFITS

• Improved energy supply

• Greater operational safety

• Unprecedented operating reliability

• Suitability for restricted spaces

• Short amortization period

• Power quality in compliance with utility regulations

## POWER DISTRIBUTION AND POWER QUALITY SYSTEMS

The solutions represent easy to use and highly cost-effective solutions. Voltage dips or outages can incur high costs when they lead to production downtimes. Therefore, secure power supply via a well-designed and -equipped supply network is one of the prerequisites for successful plant operation. But most of all, the specific technological requirements of the production process must be considered during the conceptual design of a network concept. Whether switchgear, substations or plant components, transformers, reactors or accessories – our product base always represents the state of the art, from engineering through manufacturing, installation, and commissioning.

Large electrical loads in mines, steel plants or rolling mills have a significant effect on the public electrical supply network. Network disturbances such as reactive power generation, flicker, voltage distortion or voltage variation frequently occur. Power quality systems do not only reduce the negative impact of typical plant loads to specified limits, but can also result in savings in energy costs – and can thus pay off quickly. Based on our extensive experience with the processes in meltshops and rolling mills, we can reliably evaluate the potential disturbances that can arise in a given network configuration and implement a sustainable power quality system that offers the best price-performance ratio for the specific application.

THE NEXT LEVEL IN EAF PROCESS CONTROL ...
PROVEN PACKAGES FOR ECONOMIC PRODUCTION
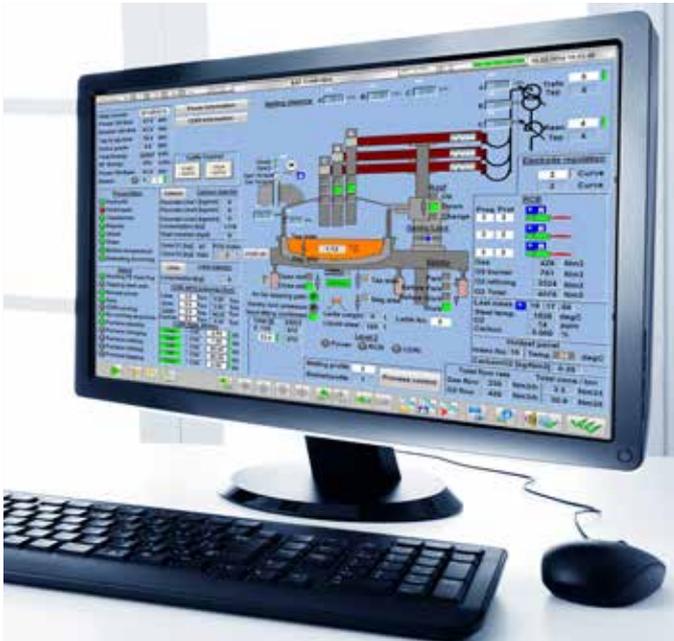
EAF automations overview display
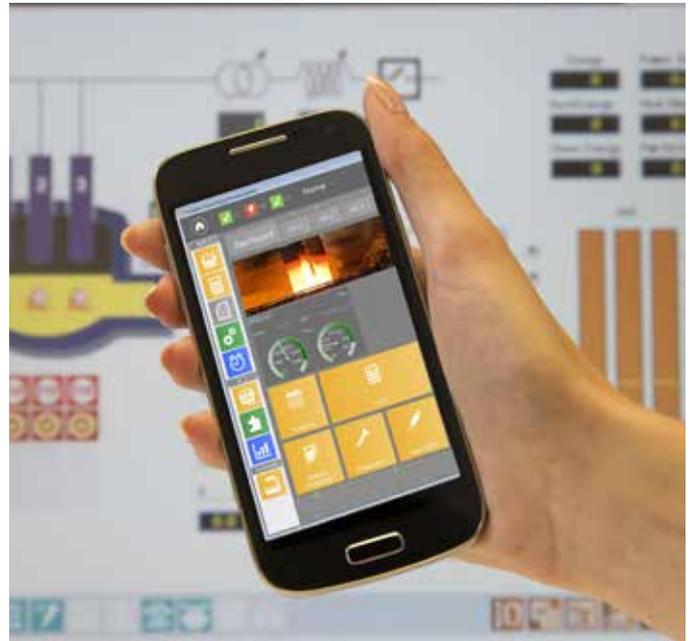
System and process diagnostic on all devices

The process control system EAF Control includes basic automation (level 1) and technological control functions to enable EAF steel production in an effective and safe way. A user friendly and redundant HMI layout configuration combined with the application of fail safe state-of-the-art control devices ensure highest availability of the automation system. A set of advanced features which perfectly complement one another stabilize and improve the EAF process:

ADJUSTABLE PROFILES
The automation concept allows defining individual profiles for transformer tap changer, reactor tap changer, electrode control curves, burners, RCBs (Refining Combined Burners) and injectors which minimize the operator actions.

MAINTENANCE CONTROL
Mobile panel and local pulpits make it possible to precede local operation control of all movements for maintenance reasons.

INTERFACES
Highly developed standard solutions make it easy to implement intelligent communication to external systems like: Scrap yard, dedusting system, material handling, carbon / lime injection, offgas analyzer system and power plant.

SYSTEM AND PROCESS DIAGNOSTICS
Diagnostic functions like condition monitoring, heat reporting and trend recording support trouble-free and reliable EAF operation.

SOFTWARE SIMULATION
All implemented functions are simulated during factory and on-site tests according to specific operational rules. This covers e.g. hydraulic station, movements and furnace operations. The simulation of the complete heat cycle verifies the correct functionality of the automation software.

FACTORY AND INTEGRATION TESTS
Only if the final tests in the real environment are successful the automation system is released for commissioning. These tests comprise mechatronical packages, electrical equipment and software.

MAIN BENEFITS
• Fully automatic operational sequences

• High reliability

• Transparent process

• User-friendly operation

• Extendable solution

• Short commissioning time

... WITH UNIQUE MEASUREMENT TOOLS
FAST AND RELIABLE RESULTS THROUGH CONTACT FREE MEASURING

Contact-free temperature measurement

Off-gas probe for continuous gas anaylsis

MULTI-PURPOSE INJECTION LANCE

RCB Temp uses a supersonic oxygen injection technology combined with analyzing and control units for contact-free temperature measurement. This unit allows to measure the temperature of liquid steel inside the furnace with doors closed. RCB Temp includes three main functions:

Burner mode
During the melting phase RCB Temp can be used as a burner to preheat the scrap using various power settings.

Lance mode
At the end of the melting phase and start of the liquid steel phase, the system switches to lance mode to provide a supersonic oxygen stream for decarburization.

Temperature mode
When a defined homogenization level of the liquid phase is reached, the system switches from lance to temperature mode and the temperature measurement cycle can start.

MAIN BENEFITS

• Reliable and accurate measurement

• Safety improvement

• Increased productivity

• Reduction of production costs

### LOMAS® OFFGAS ANALYZING SYSTEM

A proven solution for EAF off-gas measurement is Lomas, which carries out fully automatic continuous gas analysis. The gas sampling device is placed in the water cooled primary EAF off-gas duct.
The offgas is continuously analyzed during power on time. During the power off time fully automatic sample probe purging and cleaning is performed. Therefore Lomas enables nearly maintenance-free operation, even under the very hot, corrosive and extremely dust-laden environment conditions.

MAIN BENEFITS

• Patented probe design for high availability

• Automated three steps probe cleaning circle ensures high reliability

• High accuracy in measurement of CO, CO_2, H_2, O_2 and CH_4

• Short response time

• Low maintenance operation

MELT EXPERT ELECTRODE CONTROL
NEXT GENERATION OF ELECTRODE CONTROL SYSTEM
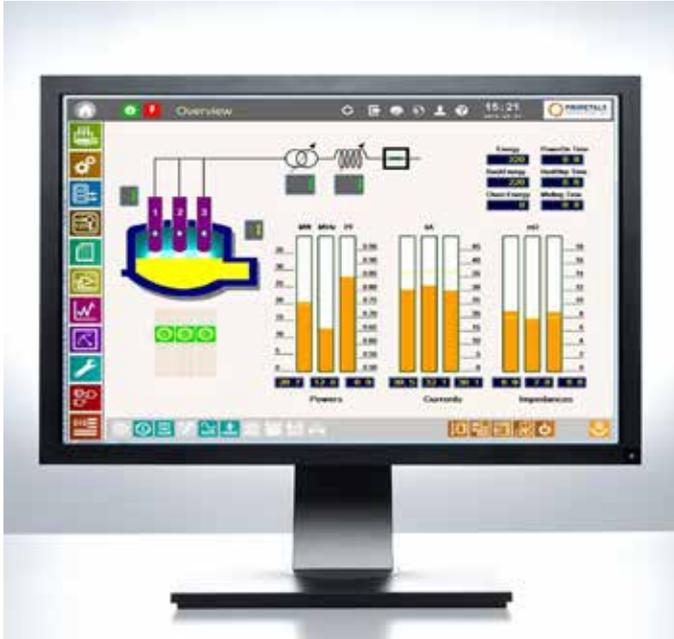
Electrode control overview display

Fully automatic electrode control system

FULLY AUTOMATIC ELECTRODE CONTROL

Primetals Technologies offers a fully automatic, end-to-end solution for electrode control in three-phase electric arc and ladle furnaces. The system regulates and dynamically adjusts the electric arc and makes the most efficient use of electric energy. Auto adaptive correction of set-points as well as regulation behavior are important procedures to optimize the melting performance.

Melt Expert is the next generation of electrode control. Enhanced new algorithms assist to increase arc stability even during critical melting situations. A novel model for loop gain linearization is simplifying the parameter tuning process and thus shortening commissioning times. Besides the core regulation functions, a main focus is set on improved reporting functionality and KPI indication. Most important process data is shown on individual screens and gives quick overview about actual system performance.

The Melt Expert system includes on-board diagnostics of furnace equipment. Mechanical, electrical and hydraulic parts related to the electrode control system are continuously monitored. Malfunctions and failures in these systems are detected in a very early stage which is an important tool for predictive maintenance and reduction of power off and down times.

Beside the basic module an optional melt down control (MDC) module is available. This add-on is able to control the auxiliary furnace aggregates automatically. It can be adapted to any furnace and steel grade using defined melting programs. Well defined interfaces allow easy and seamless integration into any automation system and architecture.

MAIN BENEFITS

- Reduced energy consumption and increased melting efficiency due to auto-adaptive regulation algorithms
- Higher productivity ensured by automatic melting profiles and process parameter adaptation
- Highest reliability due to main focus on robustness and operational safety in an industrial environment
- Ensured process quality due to integrated process visualization, data recording and extensive evaluation modules
- Amortization within less than six months

ADVANCED ADD-ON PACKAGES
FOAMING SLAG MANAGEMENT AND POWER CONTROL

Slag door with foaming slag

FOAMING SLAG MANAGEMENT

Foaming Slag Management systems are advanced add-ons to the electrode control system and are enabling a fully automated foaming slag process. A sophisticated algorithm is controlling and optimizing the carbon injection based on the actual slag height inside the furnace. The actual slag height can be determined either by means of structure borne sound analyses (Sonarc FSM) or by an optical camera targeted towards the slag door (OFSM). As a third option the classical evaluation of current harmonics is also available. With these three options we can provide high quality foaming slag management for any customer needs.

MAIN BENEFITS

- Controlled and optimized foaming slag process

- Reduced specific electric energy and carbon consumption

- Shorter power-on times and increased productivity

- Reduced CO_2 emissions due to lower carbon and energy consumption

- Real improvement of foaming slag practice in electric arc furnaces

CONDITION-BASED SCRAP MELTING

SonArc CSM uses also structure borne sound measurement equipment as SonArc FSM to analyse the scrap behaviour during the melting process inside the furnace. The electrical operating point is adapted to the progress of scrap meltdown. Therefore, a smooth and standardized meltdown behavior is achieved under SonArc CSM operation. Furthermore, the system enables for optimal charging of subsequent scrap baskets by signalizing the completed meltdown of the actual basket.

MAIN BENEFITS

- Standardized and controlled meltdown behavior of scrap

- Reduced thermal loads at the furnace's water cooled panels

- Shorter power-on times

- Reduced specific energy consumption

- Reduced on-load tap changings of the furnace transformer

- Shorter tap-to-tap times and consequently higher productivity

EAF PROCESS OPTIMIZATION
IMPROVED PERFORMANCE FOR HIGHER PROFIT

EAF pulpit at Aperam Stainless, Charleroi, Belgium

Our process optimization system is made for the electric steel producer in order to achieve cost-efficient and flexible production by intelligent usage of available energy and raw materials. The process optimization solution provides basic functionality such as process tracking, production plan handling, graphical user guidance and extensive reporting. A close connection to the EAF process control (level 1) ensures the proper signal processing and reaction by the EAF process models. Steel Expert, the comprehensive group of metallurgical process models, features dynamic online optimization taking all process and quality-related data into account. The model results combined with technological instructions are forwarded to the level 1 process control system to optimize the production process. The easy to use HMI (human machine interface) guides operators through the production process. EAF operator interaction is limited to quality and safety-related topics. The comprehensive HMI supports easy maintenance and instant access to important information.

STEEL EXPERT PROCESS MODELS FOR EAF

- Steel Expert Prediction performs a precalculation of the complete heat, tracing the defined melting practice. It gives a preview of the entire steelmaking process with regard to required electrical energy, process gases, alloys, slag formers and treatment times.

- Steel Expert Charge calculates all materials to be added to the melt - via baskets and bins - to reach the target steel grade specification.

- Steel Expert Supervision monitors cyclically the physical and chemical processes in the EAF and provides online information about steel and slag weight, analysis and temperature.

- The amount of electrical energy necessary for melting the prepared and charged materials and for heating the steel bath up to tapping temperature is determined by Steel Expert Temp.

- For stainless steel production, Steel Expert Reduction finally calculates the amount of reduction agents and the required reduction time.

- In case of continuous DRI feeding, DRI Feed Rate Control dynamically controls the DRI feed rate targeting a constant steel bath temperature.

HOLISTIC PROCESS OPTIMIZATION
PROCESS MODEL FOR HIGHEST PRODUCTIVITY
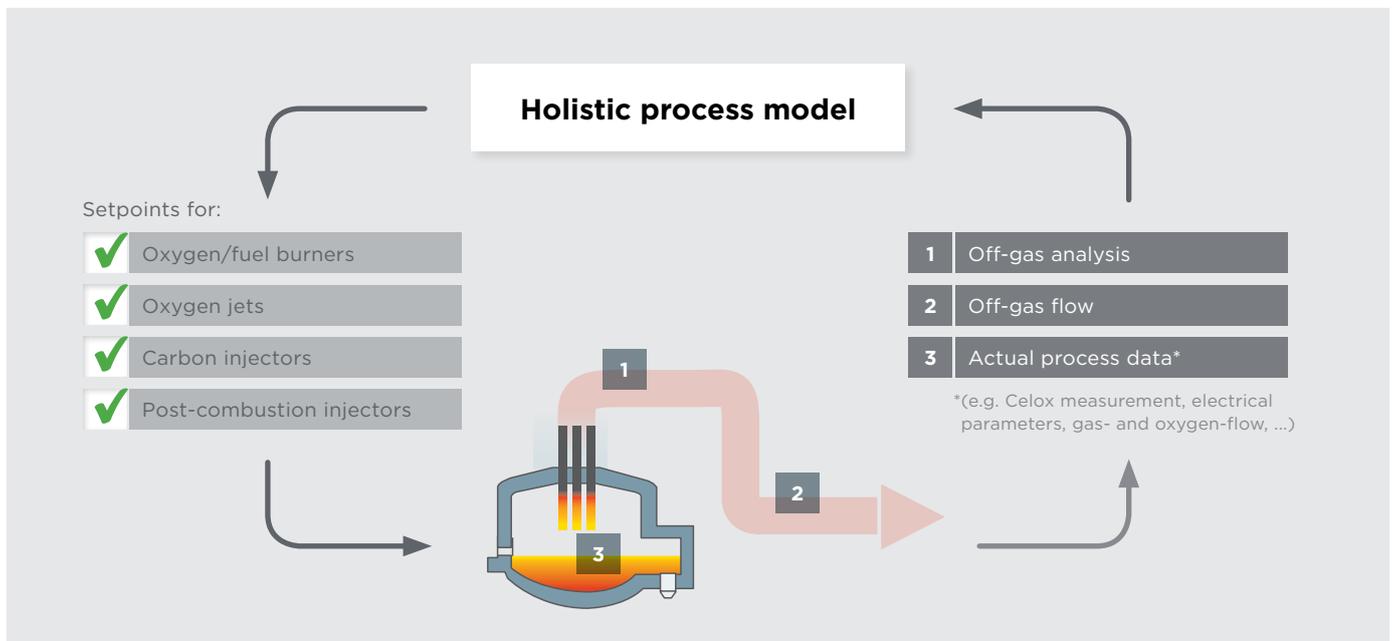
Implemented closed loop control

HOLISTIC PROCESS OPTIMIZATION

Today a significant amount of energy is created by chemical reactions of fuel or gas, oxygen and carbon injected into the furnace. With EAF Heatopt the optimized on-line control of these input materials is possible to tap the full saving potentials.

The newly developed EAF Heatopt system has proven to enable a closed-loop control of the oxygen and gas burners, the carbon injectors as well as the post combustion injectors. It takes actual EAF process data, the continuously measured Lomas off-gas analysis, the off-gas flow and the foamy slag index into account.

Such an „all-inclusive" automation approach has shown significant advantages compared to usual, rigid melting diagrams. It allows to dynamically optimize the EAF production based on actual process conditions.

The main advantages are the minimized and efficient use of fossil and electrical energy, reduction of tap-to-tap time and an overall reduction of conversion costs.

SUSTAINABILITY IMPACT

The EAF Heatopt optimization system complies with today's and future environmental regulations. The holistic approach for optimum usage of electrical and chemical energy results in a reduction of greenhouse gas emmissions. Furthermore the process safety is increased due to the fast detection of dangerous situations.

MAIN BENEFITS

- Minimized and efficient process-related use of natural gas, oxygen and carbon
- Saving of energy (electric and / or fossil fuel)
- Reduction of tap-to-tap time
- Increased transparency of the EAF process
- Increased process safety
- Water leakage detection system
- Fast start-up for high-quality production