



**BLAST FURNACE
PROCESS AUTOMATION**
MASTERING THE COMPLEXITY OF
BLAST FURNACE OPERATION

THE NEXT LEVEL OF INTELLIGENT BLAST FURNACE AUTOMATION

IMPROVE YOUR BLAST FURNACE PROCESS FOR OPTIMUM PERFORMANCE

The Blast Furnace Process Control System in combination with the Blast Furnace Optimization System creates the next level in intelligent blast furnace automation. The optimal interaction between sophisticated models and the expert system provides extended assistance to plant operators and minimizes the risk of human errors. The Primetals Technologies blast furnace automation system is the next decisive step toward a smart factory.

OUR SOLUTIONS

Cost-optimized operation, process improvements that don't compromise burden-material selection, the highest product quality, and achieving and maintaining your desired productivity are the core challenges for our most advanced blast furnace automation system. The optimized burden calculation with precise chemical targets and subsequent closed-loop controls form the basis for producing hot metal and slag at the highest quality, while simultaneously reducing energy consumption.

The optimization system provides easy access to all process parameters, material properties, and productivity data - including charging information, chemical and physical burden material, and process measurements so that the optimal conditions for producing hot metal and slag at the best quality level can be determined.

The system guarantees shift-independent plant operation where manual interactions are reduced to a minimum. The result is smooth blast furnace operation 24/7, increased equipment lifetime, and reduced production costs.



pure.hmi - multi-use in many types of devices





ADVANTAGES

- **High productivity**
Keeps the blast furnace running at peak performance while minimizing consumption of electrical energy and fuel
 - **Product quality**
Maintains the chemical properties of hot metal and slag at the desired levels
 - **Reduced fuel consumption**
Keeps the hot metal's temperature constant through small modifications of the fuel rate, based on the thermal conditions of the blast furnace
 - **Stable and shift-independent operation**
Best-practice blast furnace operation 24 hours a day to ensure efficient production
 - **Easy integration**
A comprehensive range of metallurgical models and packages that can be easily integrated into any existing automation environment
 - **Fast response to market demands**
Enables quick and flexible reactions to market requirements as well as unexpected situations
 - **Lifecycle services**
Service and support for upcoming system extensions after startup guarantee sustainable benefits
 - **Return on investment**
The standard period is expected to be less than one year
-



Optimized operation set-points are executed precisely by the highly sophisticated process control system in closed-loop mode.

BLAST FURNACE CONTROL RELIABLE PROCESS CONTROL - EXPERTISE FROM EXPERIENCE

EXPERIENCE MAKES THE DIFFERENCE

Knowledge and experience accumulated by our specialists combined with innovative technologies are the decisive factors that will lift your blast furnace to the next level of automation. We understand our business to be a partnership with our clients, and so we deliver proven and cost-effective solutions from a single source.

We draw on our substantial engineering and operation expertise that spans the entire blast furnace lifecycle. Our many years of experience in realizing blast furnace automation projects all over the world enable us to master all the challenges of today and tomorrow - immediately and definitively.

The efficiency of your automation strongly depends on the proper instrumentation. We provide the right instruments at the proper place and integrate them seamlessly in our automation solution.

A reliable process control system is the basis for your transition to Industry 4.0. Established and efficient techniques such as server virtualization increase your system's flexibility and availability and help you save hardware and maintenance costs. The latest industrial Ethernet technologies and proven hardware architecture deliver maximum performance while maintaining the highest IT security levels - especially when a technical and strategic course is set to allow the business to efficiently make the transition to a smart factory.

SAFETY INTEGRITY LEVEL (SIL)

To ensure maximum operation safety for your personnel and the blast furnace equipment, it is of the utmost importance to be aware of the hazards in the metallurgical process. Based on our extensive process expertise, Primetals Technologies is able to support a process and hazard analysis (HAZOP) based on the IEC 61511 standard as well as a risk analysis per the EN ISO 13849 standards. All safety-related functions are integrated in the process control system to safeguard personnel and equipment and to fulfil environmental regulations - without compromising production.

SIMULATION

Thanks to our detailed cause-and-effect process expertise, we can simulate all process measurements on the process control system. For example, an operator-trainee initializing a sequence uses the simulation to receive immediate feedback about the process results.

This makes the simulation system ideal for training new process engineers and operators for effective and efficient plant management. Enhancements to the process control system can be tested with worst-case scenarios before it is used in the production environment.

The concepts of flexible thinking, bold innovation, and intelligent measurements will play an ever-more important role in the future for ensuring your plant's flexible and trouble-free production. At shell, we sustainably optimize your assets for lifecycle value through the integration of numerous technological packages that forge a bridge from the intelligent cooling system with prevention and detection of water leakage to a fully automatic cast house management.



STOCK HOUSE CONTROL

The innovative material-based charging system allows for the dynamic assignment of different materials to the stock house bunkers. The charging matrix is related to available materials only and not to the bunkers. The effect is a more flexible plant operation with no need for program adjustments. Primetals Technologies also provides a more elaborate version of the conventional bunker-based charging matrix.

Independent of the type of charging matrix, an intelligent compensation of dosing deviations is considered a matter of course. The stock house control calculates all possibilities of material overlapping on the charging conveyor belt. Along with comprehensive material tracking functions from the stock house to the furnace top, a smooth and efficient operation is achieved.



BURDEN DISTRIBUTION CONTROL

Primetals Technologies provides smart distribution solutions for all standard types of material distribution systems.

A smart version of the most common ring distribution logic is enhanced by the options to enable spiral charging, full rings, and weight or time distribution. As a result, flexible and marginal distribution modifications between individual batches are possible.

Spot and sector charging offer a flexible and easy opportunity to react to the actual furnace status under demanding blast furnace conditions.

Smooth free shape distribution is a combination of ring and spot distribution applying speed variations to the distribution device. This mode combines the stable ring-mode distribution with the flexibility of free-shape distribution.



HOT STOVES CONTROL

Modern blast furnaces are typically operated very close to the maximum hot-blast temperature that the stoves can sustain. If the dome temperature does not increase rapidly enough, sophisticated controls are provided to enrich the blast furnace gas with a fuel of higher calorific value to obtain a faster heating rate.

The Primetals Technologies' optimized combustion control comprises the following features:

- control of excess air
- consideration of flue gas oxygen or chemical combustibles analysis, or both
- dome temperature influences the gas enrichment ratio
- sequencing for either three or four stoves

Comprehensive pre-commissioning and process simulation with process models are performed prior to the shipment.



BLAST FURNACE OPTIMIZATION - DISCOVER THE COMPLEXITY OF THE PROCESS

METALLURGICAL PROCESS MODELS MAKE THE BLAST FURNACE PROCESS TRANSPARENT

CORE FUNCTIONALITIES OF BLAST FURNACE OPTIMIZATION

Blast Furnace Optimization is an innovative process optimization system that lifts plant automation to a completely new level. Our solution is based on a well-tested and proven basis system that guarantees the highest availability and efficiently combines data acquisition, processing, and visualization. Over the past 20 years the system has demonstrated its reliability and cost savings in more than 60 installations all over the world.

A broad spectrum of raw data sources (including front-end signals, amount of material charged, laboratory data, events, model results, and cost data) is stored throughout the entire plant lifetime. Specialized tools are provided that allow process information to be linked to analysis data and burden matrices. Flexible interfaces, modularization, and state-of-the-art software architecture provide the means to easily adapt and maintain the system in an ever-changing environment of raw materials, operation philosophy, and connectivity to third-party systems.

In addition to the robust basis system, numerous interacting process models support operators and metallurgical engineers in their daily decisions. Plant-specific requirements are incorporated into these metallurgical process models.

DATA ANALYZER FUNCTION

With our Blast Furnace Optimization System, operators have complete data transparency across the entire process. This enormous variety of process and meta data (for example, shifts, alarms, and materials) is made transparent, accessible, and understandable through the concise reports generated by the system.

Smart tiles serve as glazed doors that automatically display live information from your favorite applications, even if the application isn't running. In the event of a significant deviation from normal process parameters, related production data come alive on the home screen, enabling the operator to make important decisions and master any and every situation.

USE IT FLEXIBLY

The industry's information technology is shifting, and mobile access is expected to outpace desktop-based access. Our human-machine-interface is designed to be responsive and flexible, whether it's a desktop or a novel multi-touch interface. Its simplicity allows operators to work more efficiently and effectively.

BURDEN CONTROL MODEL

CHARGING MATRIX
BASED ON OPTIMIZED
BURDEN COMPOSITION



Optimized blast furnace operation demands the accurate charging of the raw materials, including sinter, pellets, ores, coke, and additives. To modify the charging set-points, the coke rate, slag basicity, and actual raw material analyses and their influence on the blast furnace parameters must be taken into consideration. This procedure is complex and requires computer assistance.

The purpose of the burden control model is to establish a precise burden composition that fulfills the assigned target values for coke and injectant rates, slag basicity, hot metal quality, and burden feed rates. The final result of the Primetals Technologies Burden Control Model is a charging matrix that can be transferred to the basic automation system for execution with a single mouse click. In combination with the expert system, the Burden Control Model is the central part of the fully automatic burden composition optimization.

BENEFITS

- Constant product quality: maintains the chemical properties of hot metal and slag at the desired levels
- Shift-independent burden modifications: calculating the new burden composition is performed automatically using recent raw material analyses and standardized calculation procedures
- No manual operator interaction required for calculating and activating a new charging matrix

BURDEN DISTRIBUTION MODEL

IMPROVED GAS
UTILIZATION THROUGH
PRECISE MATERIAL
DISTRIBUTION



Bell-less type chutes as well as bell-type charging devices with moveable armor enable a precise distribution of ferrous and coke layers into the blast furnace. The Burden Distribution Model assists the process engineers to modify the actual distribution in order to improve the gas-flow pattern and burden permeability according to the actual process requirements.

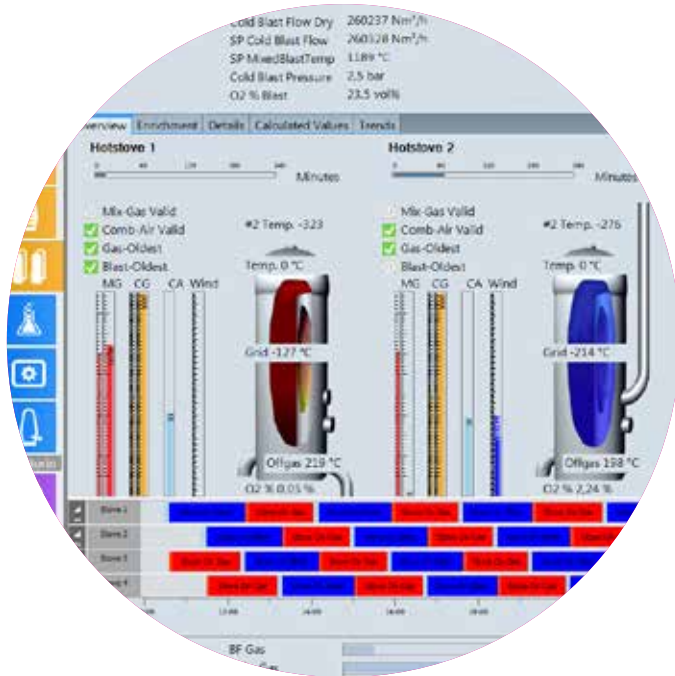
The model simulates the burden descent through the blast furnace shaft and calculates the actual shape of material layers in the upper part of the shaft. It also computes the radial volume, chemical properties, and particle size distribution, taking into account material segregation.

The online Burden Distribution Model performs the calculation based on actual charging data and actual stockline measurements and calculates the current burden distribution in the upper shaft. This gives the operator the opportunity to detect irregularities in the burden distribution in a timely manner.

In offline mode, the model calculation is based on a charging matrix and a pre-defined stockline. The offline Burden Distribution Model is a valuable tool for designing new distribution matrices for optimized gas-flow patterns and burden permeability.

HOT STOVES OPTIMIZATION

HIGH EFFICIENCY, FLEXIBILITY, AND ENERGY SAVINGS



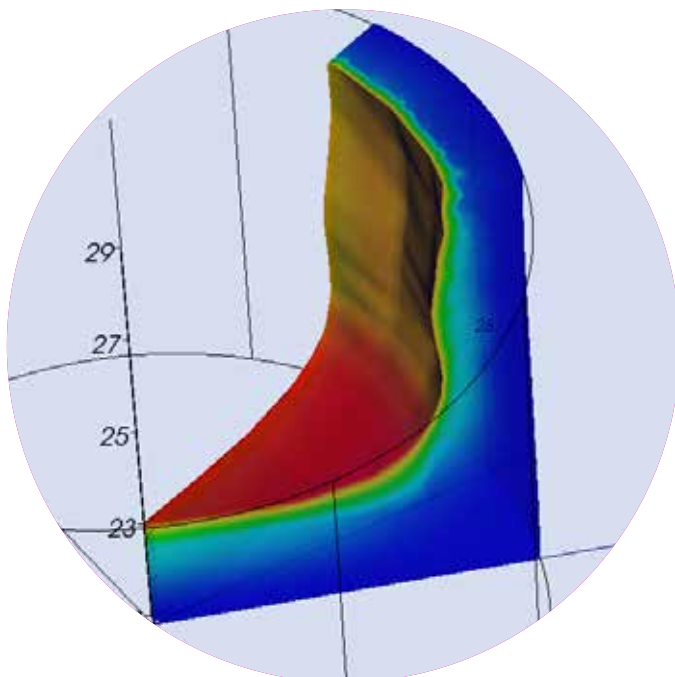
The blast-heating process offers significant energy-saving potentials. The challenge for plant operators is to optimize the energy input to the stoves while keeping the blast temperature at given targets of the blast flow rate and the blast time.

The Hot Stoves Control Model combines short-term direct control and longer self-tuning algorithms. Rapid control is used to correct the firing rate for maintaining the proper stoves operation parameters. These fast controls reduce CO₂ emissions and maximize stove efficiency. Artificial intelligence algorithms are used to optimize the stoves' efficiency performance. These self-learning algorithms enable operators to identify and correct measurement errors.

The Hot Stoves Control Model supports all operation modes in combination with various rich gas types. All state-of-the-art stove types (for example Cowper and Kalugin) as well as pre-heating and heat-recovery systems are covered. With more than 15 years of experience in stoves optimization, Primetals Technologies guarantees energy savings by increasing stove efficiency.

3D HEARTH LINING MONITORING

SAFE, DURABLE, AND RELIABLE PRODUCTION

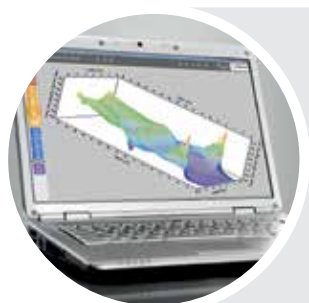


The campaign duration of a blast furnace is mainly determined by the lifetime of its hearth. Therefore, it is clear that monitoring the refractory thickness in the hearth wall and bottom areas is important for estimating the lifetime of the hearth lining.

The Hearth Wear Model includes mathematical algorithms that solve the inverse heat-transfer problem in three spatial dimensions based on statistical evaluations of thermocouple measurements and the heat conductivities of the refractories. The model calculates the erosion profile and the formation of the solidified skull layer. The computed wear velocity together with the remaining wall thickness allows plant operators to predict the lifetime of the hearth refractory.

The 3D Hearth Lining Monitoring Model includes state-of-the-art user interfaces and reports for visualizing the results of the model over the entire life of the blast furnace. For every calculation the HMI screens show 3D graphs of the actual and maximum wear lines. This means that the contour can be efficiently compared with the original lining, a single isothermal area with configurable temperature (for example 1,150° Celsius) can be displayed, and horizontal and vertical angle ranges can be selected.

End-to-end transparency in real time through up-to-date data visualization and metallurgical process models lead to better collaboration, improved workflows, and reduced errors while also supporting decision-making. Even important process parameters such as the flame temperature and indirect reduction percentage are implemented as soft sensors, which makes them indistinguishable from conventional measurements.



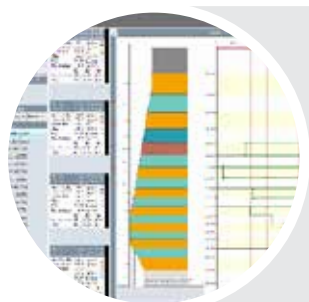
THERMAL INDEX CALCULATION MODEL

The energy consumption and productivity of the blast furnace are reflected by the thermal index, which can subsequently be used to predict the development of the hot metal temperature and Si content. The model result is used as an input to the Blast Furnace Expert System for controlling the thermal state of the blast furnace process.



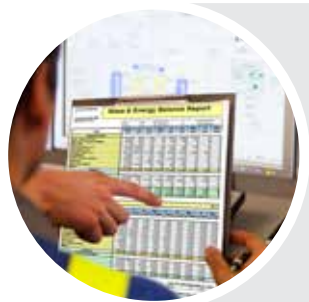
TAPPING MANAGEMENT MODEL

The tapping management model calculates the actual hot metal and slag production rates as well as the drainage rates through the open tap holes. This allows it to continuously compute the actual amount and level of hot metal and slag in the hearth. The model result is used as an input to the Blast Furnace Expert System, which will make a recommendation on opening a tap hole.



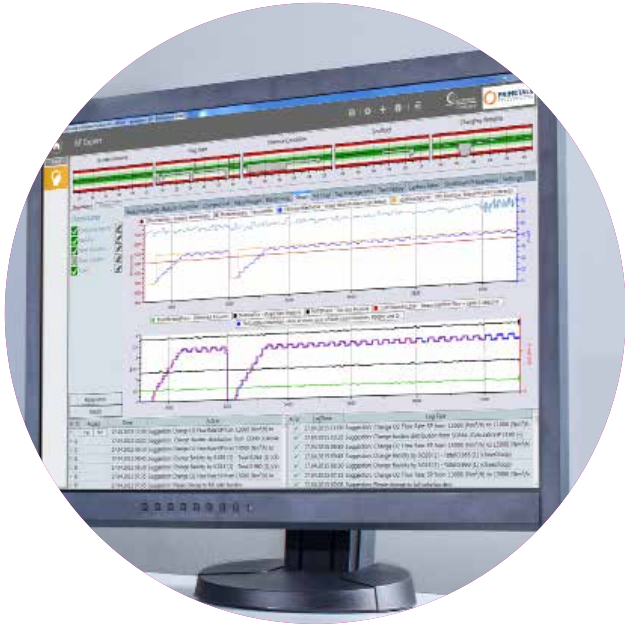
SHAFT CALCULATION MODEL

The model performs a mass-balance calculation based on actual charging data using the materials of one charge, consisting of one coke and one burden layer. These individual charges are tracked from the furnace top down to the tuyere area. The results are displayed graphically and allow the operator to track burden composition and burden distribution changes. The model also computes the time when burden changes will become effective on hot metal and slag.



MASS AND ENERGY BALANCE PLAUSIBILITY MODEL

The model automatically generates reports based on actual charging, process, and production data over a predefined time period, taking into account the material retention time in the blast furnace. The mass and energy balance calculation is used to detect the buildup of alkaline and zinc circuits or to identify systematic measurement inaccuracies. The subsequent balance plausibility algorithm indicates the most probable sources of measurement faults.



CLOSED-LOOP EXPERT SYSTEM SHIFT-INDEPENDENT BEST-PRACTICE BLAST FURNACE OPERATION – 24/7

AS FEW ACTIONS AS POSSIBLE, AS MANY AS NECESSARY

The closed-loop blast furnace expert system was designed according to the principle “As few actions as possible, as many as necessary.” The goal was to optimize blast furnace operation and reduce operator interactions to a minimum.

The expert system – which is designed as a rule-based decision system – counteracts process fluctuations caused by changes in burden-material composition and quality, human factors, and process conditions. The sooner the system responds to an abnormal or changing process situation, the smoother the overall blast furnace operation will be. Timing control activities accurately and anticipating disturbances are both of the utmost importance in order to avoid critical process conditions and to maintain a high production rate at low costs.

With numerous successful installations, Primetals Technologies is in a position to guarantee significant improvements to product quality and reduced fuel consumption with the available burden materials.

The expert system recommends operational changes in a two-step process:

- The first step is an analysis of the current situation, called process diagnosis. The expert system studies the occurrence of phenomena in the blast furnace using a variety of technical calculations based on a vast amount of process measurements and analysis data that are collected continuously.
- In the second step, corrective actions are proposed if required. An extensive rule set forged by experienced blast furnace process experts and operators on the basis of cause-and-cure relationships results in recommendations for best-practice and shift-independent operation. Corrective actions to achieve and maintain the smooth operation of the blast furnace are reported to the operators. The actions can be executed either in closed-loop mode or after operator confirmation.

The following set of major corrective actions results in a continuous, shift-independent blast furnace operation. The guidance of the expert system, especially during startup and shutdown periods, leads to energy savings and minimized production losses. This uniform operation contributes to prolonging the lifetime of the blast furnace.



FUEL RATE AND INJECTION CONTROL

The expert system observes the thermal state of the blast furnace hearth and suggests a change of the fuel rate as soon as significant deviations from optimal conditions are recognized. According to the rules defined in the knowledge base, either a change of injected fuel or coke rate is suggested and can be executed fully automatically.



OXYGEN ENRICHMENT AND STEAM ADDITION CONTROL

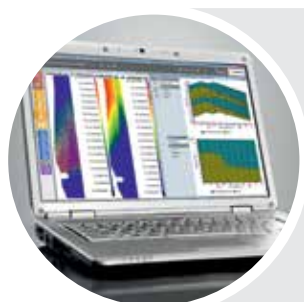
The oxygen enrichment control calculates an optimized oxygen addition rate to achieve the target hot metal production. Critical situations caused by rapidly increasing production rates can now be avoided.

The expert system uses steam addition to maintain the burden permeability at a target level. Thanks to fast control cycles, it is possible to precisely adjust the addition of steam to the amount required by the process. In this way the steam input is reduced whenever possible directly leading to energy-savings.ossible directly leading to energy savings.



SLAG BASICITY CONTROL

On the basis of recent slag analyses and hot metal temperature data, the expert system recommends changes in the burden composition as soon as a deviation from the target slag basicity is detected. Working with the Burden Control Model, a new charging matrix is calculated automatically and can be transferred to the process control system for execution.



FINE TUNING OF BURDEN DISTRIBUTION

Closed-loop burden distribution control is a unique feature of the Primetals Technologies automation system for blast furnace process stabilization and reduction of fuel consumption. Based on radial temperature measurements in the shaft, the model calculates modifications of the distribution pattern in order to achieve a target temperature profile. The system supports either an in-burden probe or above-burden temperature measurements based on conventional and acoustic techniques.

Primetals Technologies Austria GmbH

A joint venture of Mitsubishi Heavy Industries and partners

Turmstrasse 44
4031 Linz
Austria

primetals.com

Brochure No.: T01-1-N095-L2-P-V2-EN

Printed in Austria

© 2020 Primetals Technologies Ltd. All rights reserved

The information (including, e.g., figures and numbers) provided in this document contains merely general descriptions or characteristics of performance based on estimates and assumptions which have not been verified.

It is no representation, does not constitute and/or evidence a contract or an offer to enter into a contract to any extent and is not binding upon the parties. Any obligation to provide and/or demonstrate respective characteristics shall only exist if expressly agreed in the terms of the contract.

These estimates and assumptions have to be analyzed on a case-to-case basis and might change as a result of further product development.

Primetals Technologies excludes any liability whatsoever under or in connection with any provided information, estimates and assumptions. The provided information, estimates and assumptions shall be without prejudice to any possible future offer and/or contract.

Any use of information provided by Primetals Technologies to the recipient shall be subject to applicable confidentiality obligations and for the own convenience of and of the sole risk of the recipient.

Primetals is a trademark of Primetals Technologies Ltd.