For the engineers of Primetals Technologies, digitalization in steel production starts with genuinely future-oriented ironmaking solutions. These innovations are designed to fit the needs of all steel producers who are determined to lead the industry in the decades ahead.
The ultimate aim in pelletizing is to produce consistently high pellet quality at high productivity rates and low conversion costs—all while keeping an eye on the emission limits that the operation is subject to.

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

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

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

The DRIpax DR Plant Expert System is a rule-based advisory system and was created to assist panel operators in decision making and—if the operator so chooses—make data-driven decisions entirely on its own in “closed-loop” mode. Among other things, the system helps avoid inconsistencies in plant operation due to shift changes. At the heart of the Expert System is a knowledge base that incorporates comprehensive metallurgical and automation know-how from Primetals Technologies and Midrex as well as plant-specific operational know-how and control philosophies of the individual customers. In this sense, each customer gets an Expert System perfectly tailored to their needs.

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

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

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

- **Provide explanations:** A textual explanation is prepared to offer detailed background information regarding the current diagnoses and the corrective actions suggested to the operator.
Process evaluation is performed on a regular cycle every few minutes. The diagnoses, corrective actions, and explanations given by the Expert System are based on the logic defined in the knowledge base. An adaptive system design makes it easy to expand and adjust the Expert System to each individual type of Midrex DR plant. If required, diagnoses or corrective actions can easily be adjusted or added depending on the particular plant situation.

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

In conjunction with the full scope of the DRipax process optimization system, the Expert System represents a major step in the direction of fully automated quality control in DR ironmaking that is uniform across all operators and allows for shift-independent “best practice” plant operation.
Despite not being the main focus for investments, sinter plants often hold significant potential in terms of improvements that can be made to reduce conversion costs. One of the measures with the shortest payback time is in many cases the installation of a VAiron Sinter Process Optimization system. Due to the usage of a variety of different raw materials, the delay caused by long-belt conveyors, the interaction of the material on the strand with the ignited gas suction, and last but not least increasingly stringent environmental regulations, process optimization is not as easy as the slow motion of the sinter strand might suggest.

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

After numerous successful installations, Primetals Technologies is in a position to guarantee significant improvements in product quality and reduced fuel consumption for sinter plants using the Expert System solution. In conjunction with sinter process control and process optimization systems from Primetals Technologies, the Expert System ensures high productivity and product quality as well as stable and shift-independent operation 24 hours a day. It can easily be integrated into an existing automation environment, and the standard period of amortization can be expected to be less than a year.
Primetals Technologies is the leading supplier of blast furnace automation systems for the iron and steel industries. This is especially true for blast furnace process optimization systems, which are operating in more than 70 installations worldwide—with furnaces of all sizes, ranging from 500 m³ up to 5800 m³.

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

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

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

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

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

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

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

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

The Holistic Ironmaking concept from Primetals Technologies aims to optimize the entire process route in ironmaking as a whole rather than to offer piecemeal improvements.
Many of today’s ironmaking facilities could benefit massively from more thorough digitalization of processes. We sat down with Dieter Bettinger, Product Manager for Ironmaking Automation at Primetals Technologies, to talk about his perspective on the state of digitalization in ironmaking today, the potentials offered by artificial intelligence, and the crucial difference between data and information.

DIGITALIZATION AND PROCESS OPTIMIZATION

WHAT DOES THE FUTURE HOLD FOR IRONMAKING?

What potential for improvement do you see in ironmaking plants in terms of process optimization systems?

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

What was the starting point for the development of ironmaking process optimization?

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

There are several new measuring systems available—how do you use the related information?

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

A huge amount of data is created in modern ironmaking plants—how can it be efficiently used?

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

How do you judge the impact of digitalization?

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

What is the relevance of artificial intelligence for state-of-the-art process optimization?

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