Product report: KPI-based Online Heat Scheduler and AI optimize melting operations sustainably

Decarbonizing Steel Production

Steel plant's operations are complex, as all production steps are partially interdependent and impossible to isolate. This makes it challenging to simultaneously optimize production processes, save energy and comply with CO_2 regulations and stay competitive with changing market demands. Planning, scheduling and logistics require innovative production management solutions for efficient production. PSI Metals has integrated new features to their solutions to support customers in their decarbonization journey.

This applies particularly to the transformation of steelmaking, from the classic BOF route to a combination of BOF and EAF route using green DRI/HBI which comes with a hybrid operation of these technologies in years, if not decades to come. With these newly integrated features, PSI is supporting the transformation path towards sustainable and decarbonized production in line with reduced production and material costs.

Online Heat Scheduler generates optimized heat schedule

Heats as well as casting sequences received from the planning systems and managed in the Schedule Execution Management on Shop floor level form the basis for online and reactive scheduling of heats and production equipment allocation in the melt shop. Based on this input, Online Heat Scheduler (OHS), which is now migrated to PSI's Service Platform (SP), creates a detailed work schedule for all planned heats which consists of all required treatment and transport steps, their durations, and the assignment of required production facilities and operating equipment where these treatments can be performed. This new solution (OHS SP) automatically reacts to all changes and delays during production to always ensure the delivery of the heats of a sequence to the caster at the required time.

For this purpose, a detailed schedule is calculated for the entire heat treatment from the primary facility via secondary metallurgy to the continuous caster. The correct equipment and available operating resources are selected, and the start and end times for each necessary production and transport step are determined. This is done for each heat in the casting sequences released for production.

Visualization of the process flow in the Gantt chart

This scheduling process is repeated whenever necessary and reacts to all kinds of events like start/end of steps, treatment delays which could be due to e.g., longer heating times or additional necessary steps. The durations of the treatment steps for heating or alloying as well as the transports are automatically adjusted within the permitted tolerances in order to adapt the subsequent production to the current situation at any time. The OHS SP naturally allows operator intervention, e.g., to change the heat sequence, the treatment steps or production line assignment.

A Gantt chart is used to visualize the present and future process flow. This chart shows plant utilization by the individual heats as well as problems like late arrival of a heat and downtimes or delays.

> *The KPI-based heat schedule optimization not only enables early prediction of bottlenecks and the impact of production delays, such as the late arrival of heats at the caster, and their transparent visualization in an interactive Gantt chart, but above all also offers a decision-making support in finding the right balance between economic and ecological melt shop planning. This is an important added feature for our customers, on their transformation path to sustainable and CO_2-free steel production.*
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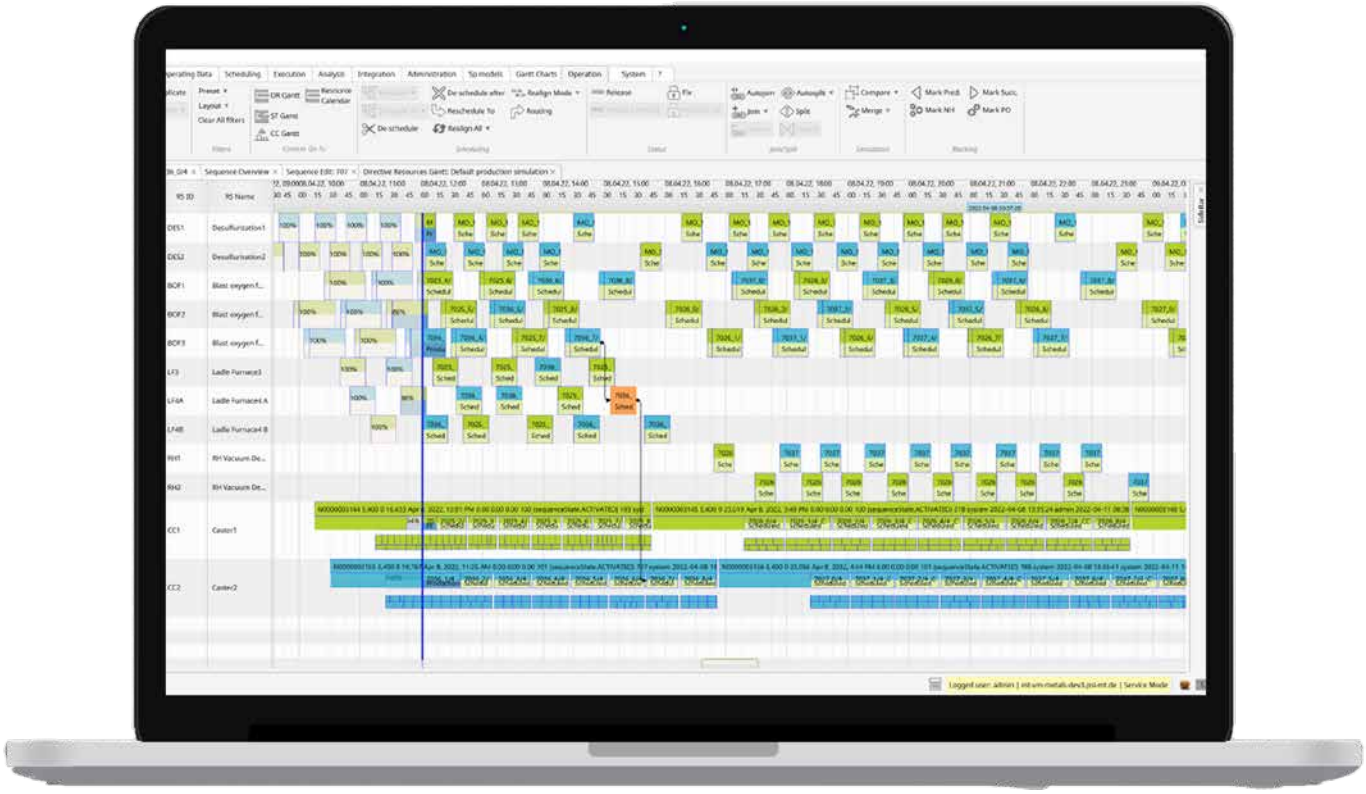

Visualization of the process flow in the Gantt chart.

Melt shop optimization not only offers savings potential

The functionality of OHS enables the continuous supply of the caster lines and prevents casting discontinuity. An unpredicted discontinuity can result not only in throughput problems and sequence interruption but also in more energy consumption due to additional heating or higher tapping temperature, hence increased CO_2 emissions.

A mathematical model optimizes the navigation of all current heats through the facilities of the melt shop. The respective restrictions with regard to throughput optimization and the coordination of bottleneck equipment like cranes are presented. At the same time, a transparent overview of the availability of ladles and lines/facilities is ensured. In addition, planned downtime/maintenance work and plant problems, as well as Hot Metal, DRI or oxygen availability, energy demand forecast including the current energy situation can be displayed and taken into account.

Processes in future hybrid steel plant will become more complex forecasting of Hot Metal, Scrap, DRI or HBI and Energy, considering the availability as well as the transport logistics, will become important Key Performance Indicators (KPIs) for scheduling and facilities dispatching. The results of this steel plant optimization are not only savings in production and material costs but supports the future decarbonisation goals of steel production. Already today, some global steel makers have successfully integrated Online Heat Scheduler in their steel plants.

Towards green KPI-driven steel mill optimization

Decarbonization and digitalization are two factors that are crucial in today's production. In the coming decades, steel producers have to cope with pressure to reduce their carbon footprint. Besides the pressure coming from these factors, recent studies reveal that 14 percent of steel companies' potential value are at risk if active measures are not taken to decarbonize steel production. Hence, the need for green melt shop optimization that is driven by targeted KPIs. Excellent production starts with intelligent product design and enhanced features and continues with excellent and intelligent production management.

For this, PSImetals OHS SP offers features that support the customer to optimize green KPI-driven melt shop. This enables them to better optimize the tapping temperature, reduce buffer times, avoid unnecessary heating or cooling through transparent time management, and prioritize heats and sequences. In this way, the hot connect rate can be increased, media consumption can be forecast, and these

forecasts can be made available to energy management systems and utilities. To provide the best possible support to customers, PSImetals OHS SP with a stand-alone service architecture via PSIbus standard interfaces allows simplified integration into existing IT landscapes.

Advanced configuration options allow individual adaptations

Flexibility is an indispensable feature in schedule management during steel production. A new functionality in the Advanced Schedule Management Platform provides for increased transparency and responsiveness during production. Enhanced configuration capabilities of the Gantt chart allow users to configure their individual information which is visualized in the bars while accessing all available attributes in the database.

There is also enhanced configuration and transparent visualization of alternate line allocation of facilities depending on the planned throughput, hot metal, energy or media demand and availability. A newly integrated drag and drop feature for all the heat movements enables customers to move heat positions in sequence including moving follow-up of sequences which further offers additional flexibility to move heat from one production line to another.

AI-based decision support in the steel mill

Companies rely on data and KPIs in order to achieve their strategic production and business goals. PSIqualicision was designed to ensure and optimize the process quality by means of intelligent data collection, analysis and balance between goal and criteria conflicts.

AI-based scheduling with PSIqualicision.

The AI-based decision support by OHS/PSIqualicision, involves three simple workflow steps structured to optimize process quality: automatically analyze inputs /set up constraints and business goals, run the solver, analyze and balance KPIs with Qualicision AI, and finally iterate, compare and release Qualicision AI-based scenario management.

Optimization of times reduces energy consumption and the carbon footprint

Scenario Management means that the operator can simulate different scenarios to solve a problem, e.g., by adding re-work steps, changing the sequence of heats or shortening treatment, transport or buffer times. Especially, optimization in terms of times has significant impact in reducing energy consumption and thus the carbon footprint. Scenarios can be compared to find the right solution.

Balance between economic and ecological production benefits

First, strategic business and production goals are measured against a specific KPI goal. Then automated evaluations of the raw process data are used to create qualitative labels for optimization. And finally, the KPI-oriented Qualitative Labeling which could be KPI modelling by Qualicision tolerance and non-tolerance functions, qualifying the KPIs and giving them elementary labels using the Qualicision Labeling Functions and setting the KPI preferences using sliders.

The PSIqualicision AI Solver enhances the qualification of (raw) process data into value-adding information. It further analyzes business processes according to incompatible KPIs & non-symmetrical goal relations while also improving the learning sensitivity analysis of the adjustable KPI preferences.

For Online Heat Scheduler, the AI

Solver makes it easier to deal with bottleneck facilities as it allows multi-criteria monitoring and optimization. The solution offers combination of benefits that allows maximizing efficiency and optimized heat scheduling. For example, the "ladle make span" (tap-to-cast time) can be optimized. Improved and thus more reliable time management ultimately also enables lower tapping temperatures and thus significant energy and CO_2 savings.

But, what do you do in case of production disruptions? For this purpose, the relaxation of "hard" constraints is also taken into account where the scheduler indicates possible delays in the handover to the caster. This provides the operators with a transparent overview of the current and future planning situation at all times and gives them sufficient time to compensate for disruptions and time losses.

Internal logistics are supported and improved by deriving specific transport orders for the cranes to transport steel and pig iron ladles or scrap baskets. Customers are thus supported in finding the right balance between economic and ecological production benefits.

[1]GLOSSARY

BOF stands for Basic Oxygen Furnace (LD converter), today's classic method of steelmaking, whereby a mix of pig iron and scrap is "refreshed" by the addition of oxygen, i.e. the reduction of carbon and other accompanying elements.

DRI stands for Direct Reduced Iron—a porous sponge iron produced by direct reduction processes—still widely used today using natural gas, but in the future using green hydrogen.

EAF stands for Electric Arc Furnace, on the so-called scrap-based route; recycled steel scrap is re-melted in the furnace mainly for the production of special steels. The EAF is therefore already more environmentally friendly than the classic BOF and will be charged in the future with a mix of pig iron, DRI/HBI and scrap.

HBI stands for Hot Briquetted Iron, sponge iron pressed into briquettes after the reduction process.

Conclusion: Steel production at the crossroads of decarbonization and digitalization

Steel is one of the most important engineering materials to date due to its qualities. Decarbonization and digitalization are keys to some of the industry's challenges. Although software cannot change the steel making process, digitalization of the process, like the use of the new PSImetals Online Heat Scheduler with integrated PSIqualicision AI Solver, helps reducing carbon footprint, including material and production costs, optimize energy consumption and efficient utilization of steel plants.

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