The key to avoiding bottlenecks

Can you effectively combine the strength of human insight with automated precision to enhance efficiency?

In the competitive and complex landscape of the steel industry, maintaining consistent and efficient production flow is crucial. The industry's unique challenges, such as fluctuating demand, diverse product specifications and high-quality standards, necessitate a robust planning framework. Mid-term planning, focussed on a six-month horizon, is essential for anticipating and managing potential bottlenecks, optimising resource allocation and aligning production capabilities with market demands. It sets the stage for short-term scheduling, enabling leading companies to secure high throughput and enhance both production efficiency and adaptability, by strategically employing open-box models, particularly mixed-integer linear programming (MILP).

While the key value drivers can vary between integrated steel production and thin slab casting set-ups, effective planning and production scheduling, can significantly increase efficiency by optimising resource utilisation, minimising disruptions and enhancing overall productivity for both scenarios.

The role of mid-term planning

Mid-term planning involves a comprehensive approach to resource management, forecasting and strategic decision-making. It encompasses the entire production process, from raw material procurement to the delivery of finished products. One critical element is managing scrap availability, as variations in quality and composition can significantly impact efficiency and final product quality. Effective planning ensures that the appropriate quality and quantity of scrap are available, reducing the risk of production delays and quality issues.

Additionally, mid-term planning serves as a forecasting tool, predicting future orders through close coordination with sales and marketing teams and analysis of historical data, using statistical tools or artificial intelligence (AI) models. By forecasting demand, companies can plan their production schedules more accurately, ensuring they meet customer needs without overextending resources. This alignment aids in scheduling maintenance activities during periods of lower demand, minimising downtime and ensuring critical equipment is available when needed. Moreover, mid-term planning helps balance production schedules, preventing overproduction of certain grades or types of steel, which can lead to inventory build-up and increased storage costs.

Limitations of manual scheduling and planning

Traditionally, the steel industry has relied on manual scheduling and planning, often using pen and paper, spreadsheets or very basic scheduling software. These methods have several limitations. They are time consuming, labour intensive and require significant effort from skilled personnel who must consider numerous variables and constraints.

While manual procedures allow quick adaptation to unexpected changes, such as sudden shifts in demand or unplanned equipment outages, they rarely deliver optimised schedules. It is challenging for humans to balance multiple key performance indicators, especially under pressure when immediate scheduling decisions are required to avoid delays or standstills. This often leads to suboptimal production sequences and increased costs, as companies may be forced to make last-minute adjustments that disrupt the entire production flow.

Challenges of full automation

The limitations of manual planning highlight the desire for automated solutions, including those powered by AI models. However, fully automating production scheduling presents significant challenges. Automated systems, particularly those based on black-box models, require clearly defined cost functions and constraints. Training these constraints into a comprehensive AI model using available historical data is challenging, as events leading to production delays and equipment failures often have unique characteristics not reflected in the data with statistical significance. Therefore, these models may not fully capture the nuanced decision-making processes of experienced schedulers, who rely on a deep understanding of the production environment and its complexities.

The dynamic nature of the steel industry complicates full automation further. Rapid changes in economic conditions, customer preferences and regulatory requirements necessitate frequent adjustments to production schedules. In the context of AI models, this would require retraining the models. Fully autonomous systems may struggle to keep pace with these changes, as they often lack the flexibility to incorporate new information or adapt quickly to evolving circumstances. The opacity of black-box models is a significant drawback, as it makes it challenging for users to understand how the model arrived at certain conclusions and to modify the decision-making process. This lack of transparency makes it difficult to guide the models in response to events in the mill.

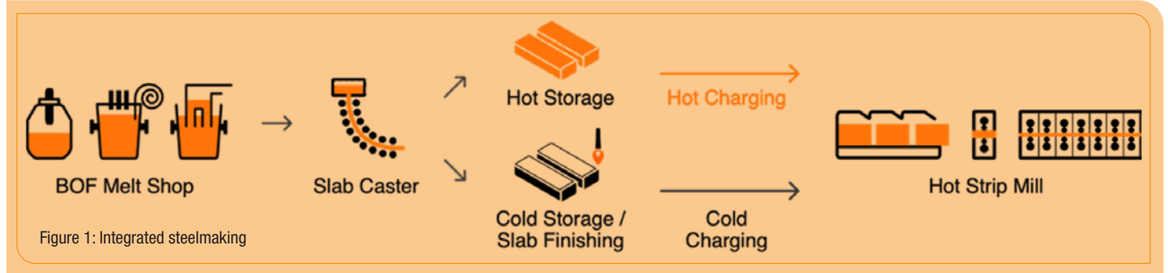

Figure 1: Integrated steelmaking

Figure 2: Figure 2: Modern thin slab production

Overcoming challenges by user-guided automation

Open-box models, such as rule-based MILP models, offer a balanced approach to overcoming the challenges of both manual and fully automated scheduling. These models provide transparency, allowing users to understand the underlying decision-making processes and make necessary adjustments. This transparency is crucial for gaining the trust of stakeholders and ensuring that the scheduling system aligns with organisational goals and priorities.

By combining the precision and efficiency of automated systems with the insight and expertise of human operators, user-guided automation enables more flexible and responsive scheduling. Schedulers can modify constraints and the cost function, prioritising certain orders or managing resource allocation during periods of scarcity. This input allows the system to generate schedules that are optimised for efficiency and aligned with both strategic objectives and practical considerations. If the model is efficient enough, new optimised schedules can be released within minutes.

Simulation of 'what-if' scenarios

A significant advantage of user-guided automation is the ability to simulate 'what-if' scenarios. These simulations allow companies to explore the potential impacts of various decisions, such as changes in order volume, shifts in market demand, or equipment maintenance schedules. By modelling these scenarios, companies can better anticipate potential challenges and make informed decisions to optimise production outcomes.

For instance, simulating the impact of a sudden increase in demand for a specific steel grade or a delay in delivering certain scrap mixes, can help companies assess whether their current resources and production capabilities can meet this demand, without disrupting other operations. Similarly, simulations can assist in planning maintenance activities by predicting the best times to schedule them to minimise disruption. These capabilities are particularly valuable in a highly dynamic and competitive industry, where the ability to quickly adapt to changing conditions can provide a significant competitive advantage.

MILP models

MILP models are particularly well-suited for the complex scheduling needs of the steel industry. These models offer a transparent, open-box approach, allowing users to see and adjust the parameters and constraints guiding the scheduling process. This transparency is a key advantage over black-box models, which can be difficult to interpret and modify.

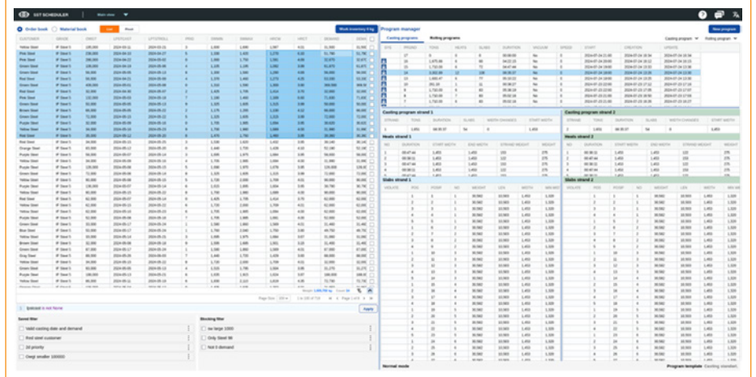

Figure 3: SST Scheduler

By forecasting demand, companies can plan their production schedules more accurately

MILP models can handle a wide range of variables and constraints, making them ideal for the multifaceted nature of steel production. These models can account for constraints related to equipment availability, material flow, production priorities and quality control. By incorporating these factors into a single coherent model, MILP allows for the generation of highly optimised schedules that align with both short-term operational needs and long-term strategic goals.

User-guided automation in practice

In practice, user-guided automation involves a collaborative approach where schedulers and automated systems work together. Schedulers provide input based on their expertise and operational knowledge, while the automated system handles complex calculations and optimisations. This partnership allows for more accurate and efficient scheduling, accommodating the dynamic and often unpredictable nature of steel production.

For example, during periods of resource scarcity, such as limited availability of a particular grade of scrap, schedulers can prioritise critical orders requiring that specific material. The automated system can then optimise the allocation of available resources, ensuring that high-priority orders are fulfilled while minimising disruptions to other production processes. Similarly, during periods of high demand, the system can help balance the production load across different facilities or production lines, preventing bottlenecks and ensuring timely delivery of products.

The SST Mid-Term Planner, combined with the SST Scheduler (Figure 3), forms a comprehensive suite of tools that empowers planning teams to forecast demand and resource availability accurately. It facilitates the simulation of various scenarios, ensuring a smooth transition from broad mid-term planning to the detailed short-term scheduling of individual material production. This integrated approach allows for precise planning and optimisation, enhancing overall production efficiency and responsiveness to market changes.

Conclusion

Mid-term planning is a crucial strategy in the steel industry for ensuring smooth operations and preventing bottlenecks. By leveraging user-guided automation and open-box MILP models, companies can achieve a balanced approach that combines the strengths of both human insight and automated precision. This approach not only enhances efficiency and reduces costs, but also ensures that production schedules are flexible and responsive to changing market conditions.

As the steel industry continues to evolve, adopting robust mid-term planning and advanced scheduling models will be key to achieving long-term success and sustainability. Companies that invest in these tools and strategies will be better positioned to navigate the challenges and opportunities of a rapidly changing market, ensuring they can meet customer demands while maintaining high levels of efficiency and profitability.

Author

Michael Peintinger
Managing director Americas,
Smart Steel Technologies Inc

www.smart-steel-technologies.com