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The Pathway to Autonomous Ironmaking

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Achieving autonomous operation requires automation and digitalization systems with advanced control and learning capabilities. This paper discusses key elements on the pathway to autonomous blast furnace and DR operation:

Autonomous decision-making for ironmaking operations leverages sophisticated technologies, including AI and ML, to measure, control, and optimize key parameters of ironmaking processes. Online sensors monitor raw material, process, and product parameters, providing a comprehensive digital image of the plant. This data is analyzed using hybrid models that combine metallurgical knowledge with data-driven models.

The benefits of hybrid digital twins are compared in detail to classical first principles models and pure Machine Learning models, reviewing the potential and limitations of different types of digital twins and self-learning decision-making systems.

Based on the model results, rule-based Expert Systems generate process diagnoses, triggering transparent closed-loop process optimization actions, resulting in stable, efficient, and shift-independent operation. A learning condition monitoring system assesses equipment status, supporting preventive and predictive maintenance.

The Expert System and the Condition Monitoring System both digitalize knowledge and provide actionable information—one for operation, the other for maintenance. These local optimization systems are complemented by higher-level systems that orchestrate upstream and downstream plants for production planning, overall process optimization, and maintenance management –resulting in stable, efficient, and shift-independent operation.

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