Intelligent Research and Upgrade of Narrow-band Hot-rolled Steel Production Workshop

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Abstract. This paper expounds the process and equipment characteristics of the narrow-band hot-rolled steel intelligent production workshop, introduces the key intelligent model content, explains the application effect after the completion of the intelligent workshop transformation, and points out the research significance and development trend.

1. Foreword
The narrow-band hot-rolled steel intelligent production workshop aims to improve production capacity and product quality, focusing on management, quality, market, logistics and other content [1, 2]. At the same time, the product inspection equipment, safety production, production equipment, workshop information, logistics capabilities, energy management and other process systems are fully integrated. A bridge of information, automation and intelligence is built between business management and production implementation. After the transformation and upgrading, an intelligent production workshop with certain self-perception, self-decision and self-execution characteristics is generated.

2. Features of production workshop
The narrow-band hot-rolled steel intelligent production workshop adopts a new design concept of the narrow-band hot-rolled steel production workshop when designing the workshop and building the automation system. The workshop uses wide-board production line mode, selects the most advanced wide plate production technology and equipment, and applies it to the workshop production line construction, which can effectively realize temperature-controlled rolling and controlled cooling, improve the production efficiency and product quality of narrow-band hot rolling, and realize lean, diversified, miniaturized and customized production. At the same time, the intelligent interfaces [3] such as MES, robot system, finished product library system and identification system are reserved, which lays a foundation for the later intelligent transformation and upgrading.

The workshop adopts dual-heat storage step-type heating furnace temperature control technology and hydraulic AWC+SSC+AGC controlled rolling technology. For the first time, advanced cooling control and collection technologies such as laminar cooling, horizontal coiling and automatic packaging is applied in the narrow-band hot-rolled steel production workshop. The main drive system of the rolling mill adopts the all-digital speed control system, and the large-capacity DC drive adopts the SIMOREG K 6RA80 series system, which has high reliability and can meet the requirements of high dynamic quality and high speed regulation accuracy. The automation system adopts a convenient, fast and good
man-machine interface, and at the same time, it must consider the maturity, compatibility and openness of the system, so as to facilitate expansion and system transformation.

3. Research on key intelligent models

3.1. Production Line Data Model Research

The production line data model is the core of the intelligent workshop, and is also the basis for application system integration and data exchange within and between production lines. Based on the core business process of production process management and control, the business data are mined, extracted and analyzed, and the key value-added business data and key auxiliary business data of the factory are accurately described. With reference to ISA-95 standard, the data model suitable for the characteristics of the production process of narrow strip hot rolling steel is established, including business model, functional model and information model. It can support the organizational structure of multiple production lines, and can realize joint expansion application and manufacturing business collaboration of multiple workshops.

3.2. Research on the Whole Process Quality Traceability Model

Based on the multi-dimensional statistical process control, the product tracking model reflecting the evolution process of the material flow in the whole process is used to realize the material flow correlation, hierarchical query and back-track matching between different processes. The data collection technology of different time and space dimensions by product, time and event is adopted to realize accurate spatio-temporal matching of information flow and material flow data in the whole process. The module supports fuzzy and precise traceability, and it supports the traceability of information from sales and delivery, production process information, to the whole product life cycle of material supply, which can realize the rapid positioning of the cause of quality problems.

3.3. Research on Big Data Mining Model

This study mainly focuses on the process of data mining, extraction, conversion, cleaning and loading of narrow-band hot-rolled steel production systems. ETL is responsible for extracting data from distributed, heterogeneous data sources (such as relational data, flat data files, etc.) into a temporary middle tier. Then the data will be cleaned, converted, integrated according to the data requirements of the decision problem, and finally loaded into a pre-defined data warehouse or data mart, which becomes the data foundation of online workshop analysis and data mining of intelligent workshop.

3.4. Narrow-band Hot-rolled Steel Rolling Track Tracking System

It is divided into heating furnace zone, rough rolling zone, finishing rolling zone, layer cooling zone and coiling zone from the beginning of heating furnace roller table to the completion of coiling and unloading. Each tracking is divided into several tracking sections. On the one hand, correct information is displayed for the operator through rolling track, including the location, status and relevant process parameters of the rolling stock and the rolling line conditions. On the other hand, the corresponding program will be triggered according to the rolling piece tracking information: operate the database, call the model calculation, generate control information and so on.

3.5. Virtual Rolling Model.

Model 1: The independent rolling model allows the process control system to test the function of the process control system when not connected to the rolling mill basic automation system. By simulating the signals of the rolling mill basic automation system and the corresponding data, the various functions of the process control system can be tested to check the performance of the process control system. Model 2: The combined rolling model can test various functions of the process control system close to the actual production environment through the signals and corresponding data of the real basic automation system.
3.6. Rolling Steel Process Model
1) Calculation model for rough rolling flat, vertical rolls and finishing vertical rolls. The rolling strategy is divided into the reduction rate method and the pass optimization method. The main goal is to achieve the set width, thickness and temperature under the premise of ensuring that the rolling force, torque, power, speed and biting angle are not exceeded, including SSC head and tail short stroke setting parameters. 2) Setting and calculation model of finishing rolling model. The standard load distribution strategy is adopted to ensure the set thickness, width and temperature as much as possible while ensuring that the rolling force, torque, power, speed and bite angle are not exceeded. 3) Self-learning model of rolling model parameters. Through self-learning, the set value calculation accuracy of the control model can meet the requirements of process control.

4. Application effect
The management efficiency of the narrow-band hot-rolled steel production workshop is obviously improved. 1) The time management accuracy is improved, and all data can be recorded to seconds. 2) The collection of field data is changed from manual input to scanning, making the collection result more fast and accurate. 3) Through electronic kanban management, information can be automatically collected and released. 4) The storage of warehouse materials is more transparent, and data feedback is sufficient and timely. 5) Production task allocation can be optimized. 6) Warehouse management can achieve timely and accurate system guidance. 7) Accountability can be clear and accurate. 8) Accurate data analysis can strongly support the performance statistics evaluation. 9) Statistical analysis can achieve analysis and comparison according to different time / model / production line and other angles.

In the production process of narrow-band hot-rolled steel, the data can be automatically collected and optimized. The data acquisition is carried out by using a powerful data acquisition engine and integrated narrow-band hot-rolled steel production process. The channel covers the entire manufacturing site to ensure real-time, accurate and comprehensive collection of massive field data. According to the different requirements of production process, information collection object and frequency of different production workshops, the information collection technology of hierarchical/divided workshops is adopted to better realize the collection and optimization of production information of workshops.

Narrow-band hot-rolled steel production is efficient and orderly. Through the scientific management mode and advanced data model of each module, it can help enterprises to solve the problems of high equipment failure rate, long production cycle, low product quality and excessive inventory, and effectively improve the controllability and reduce manual intervention of the production process. Real-time acquisition of narrow-band hot-rolled steel production data can realize multi-latitude multi-level intelligent manufacturing system. In the true sense, it helps solve the substantial source issues of “unbalanced order cycle, unbalanced production capacity, inability to respond to market changes agilely, low single-person output rate, difficult quality control, high internal consumption, difficult real-time collaborative work, and no cross-factory coordination”.

5. Conclusion
The narrow-band hot-rolled steel intelligent production workshop complies with the national and local strategic requirements such as "Made in China 2025", "Thirteenth Five-Year Plan for National Economic and Social Development" and "Tianjin's Several Policies on Accelerating the Development of Intelligent Science and Technology Industry". It is in line with the National Industrial Policy Guidance Catalogue of the National 13th Five-Year Plan and belongs to the professional field that encourages development and actively supports China.

On the basis of automation and informationization of narrow-band hot-rolled steel production workshop, the use of Internet of Things technology and monitoring technology to strengthen information management services, improve the controllability of production processes, reduce manual intervention of production lines, achieve reasonable planning and scheduling. Through the combination of advanced narrow-band hot-rolled steel production equipment and intelligent technology, improving production efficiency and ensuring product quality. Through the construction of intelligent workshops and the
opening of the whole process of production information, a vertical and horizontal management system platform has been established. Through production data mining, a computerized, automated and intelligent bridge has been built between the enterprise management and the specific implementation of the production plant. Integrating preliminary intelligent means and intelligent system and other emerging technologies, the company has built an efficient, energy-saving, green, environment-friendly and comfortable humanized production workshop. In summary, through the above work, the whole production process of narrow strip hot rolling steel is simulated, evaluated and optimized in the simulated environment, and further extended to the whole product life cycle, initially realizing self-perception and self-decision. It is gradually realizing self-execution and self-optimization to comprehensively improve the production efficiency, product quality and intelligent manufacturing level of the enterprise.

References
[1] L. Xu, Steel is the traditional industry most likely to transform through smart manufacturing, J. China Machinery & Electric Industry. 11 (2016) 28-29.
[2] J. Fu, Development status and trend of intelligent manufacturing equipment, J. Journal of Mechanical & Electrical Engineering. 31 (2014) 959-962.
[3] Y. Li, Research on Management Architecture in the Age of "Industry 4.0", J. Management observation. 24 (2014) 95-96.