Design of Online Quality Analysis Platform for High-Speed Wire Rod Production Line Based on Big Data

Xiuqi Wu[1], Ju Yan[2], Jietao Dai[2, a*], Liejun Li[3]
[*]Corresponding author's email: daijietao@gzhu.edu.cn

Xiuqi Wu's email: 54120863@qq.com

Ju Yan's email: 1164479844@qq.com

Liejun Li's email: liliejun@scut.edu.cn

[1]Guangdong Songshan Vocational and Technical College, Shaoguan, Guangdong, China

[2]School of mechanical and electrical engineering, Guangzhou University, Guangzhou, Guangdong, China

[3]School of mechanical and automotive engineering, South China University of Technology, Guangzhou, China

Abstract: The traditional iron and steel industry has been optimized by advanced foreign technology, and its products have been improved. However, there are some urgent problems to be solved, such as the gap between product quality and foreign countries, overcapacity, and so on. By building an "online quality analysis platform based on big data," this design integrates the quality information of products scattered in different systems of each manufacturing unit into an integrated quality control system, so as to realize the connection of quality information between upstream and downstream processes such as steelmaking, continuous casting, rolling, heat treatment, inspection, and testing. The system is designed according to user's needs so that the product quality of steel enterprises has achieved a consistent system. It can improve quality control from empiricism to scientific and systematic platform data analysis, improve the stability of product quality production and user satisfaction, and promote the vigorous development of Intelligent Manufacturing in iron and steel enterprises.

Keywords: Quality analysis; Big data; Quality control; System design; Auto-Control

1 Introduction

Big data, the Internet of things, mobile Internet, cloud computing, and other new generation information technologies have been widely popularized and promoted the rapid change of production mode. The deep integration of industrialization and informatization with industrial big data as the carrier has become necessary for enterprise development. Information technology has been everywhere, from computing, transmission to processing, and from perception to sensing to intelligence, laying the foundation for the intellectualization of production, management, and services [1].

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As a traditional large-scale manufacturing industry, the iron and steel industry has developed rapidly in recent years with the continuous introduction of advanced foreign technology and equipment, and the product quality has also been significantly improved. However, there is still a gap between the product quality of some varieties and that of foreign excellent iron and steel enterprises. The problem of homogenization competition is serious, which leads to overcapacity, production efficiency, and product quality not reaching the world-class level. The transformation of the relationship between supply and demand and the price of iron and steel products also causes the contradiction between user demand and production organization management. In order to solve the above contradiction, iron and steel enterprises urgently need to adopt new process technology and production mode to improve product quality and reduce production costs simultaneously to achieve the purpose of a win-win between users and enterprises.

There are dozens of high-speed wire rod rolling production lines in China with the ability to produce industrial wire rods [3]. Still, compared with foreign steel mills such as Nippon Steel and POSCO, the domestic steel for fasteners, automobile springs, bridge cables, and some special steel, the product quality stability is insufficient, causing downstream processing and use enterprises to rely on imports for a long time for high-end materials. One of the reasons for the insufficient stability of product quality is that the quality control means are backward, and the ability of industrial informatization and quality information analysis is insufficient. It is urgent to improve the informatization and intelligent means of quality analysis of China's high-speed wire rod production enterprises, and improve the accuracy and timeliness of quality analysis. The adoption of automation + big data analysis has become a development trend.

How to big data analysis technology and application characteristics in the service of steel enterprises manufacturing process and product quality analysis and control, the quality control from empirical to scientific system platform data analysis, improve the stability of product quality production and improve user satisfaction, promote the vigorous development of steel enterprises wisdom manufacturing today is a hot problem in the development of traditional industries [4].

This paper has designed a set of high-speed wire process quality analysis platforms to improve the process quality management efficiency and reduce the product quality objection rate. Through the design of the quality analysis platform, the level of enterprise information and intelligence has further improved.

2 System design

2.1 Problems

There is little research on big data applications for quality control in the steel industry, especially in the application of high-speed wire and steel rolling production lines, which still needs to be deeply studied.

With the gradual deepening of a steel enterprise, the existing information system layout is still insufficient in ensuring a consistent product quality system, and the main performance is as follows:

1) The whole process of parameter monitoring related to quality is weak. Metallurgical specification requirements, manufacturing process parameters, and process control parameter changes related to product quality are scattered in various independent systems, and there is a lack of effective correlation between them. Most quality problems are "post monitoring," and the quality consistency system is difficult to guarantee.

2)The dynamic correlation between data is insufficient. To analyze quality problems, we usually need to go through different processes to obtain different types of data. The data itself is difficult to obtain, time-consuming and laborious, and the data association is difficult, so it is difficult to mine the data value efficiently and accurately.

3)Lack of efficient quality traceability, analysis, and optimization technology. At present, the quality problems left over by the iron and steel industry usually belong to multivariable comprehensive impact problems. It is difficult to find the root cause of the problem through simple threshold analysis and comparative analysis, and quality defects occur frequently and repeatedly. In order to solve the above problems, we need to continue to consolidate and improve the existing automation level with the help of the new generation of information technology and gradually develop towards the goal of intelligent manufacturing. At present, the iron and steel industry is in the stage of supply exceeding demand, and downstream customers have increasingly stringent requirements for product quality. At the same time, personalized and diversified demands are also rising. Therefore, iron and steel enterprises should mainly combine structural reform and supply-demand side reform to establish an effective quality control system.

2.2 Design requirements

By building an "online quality analysis platform based on big data," this design integrates the quality information of products scattered in different systems of each manufacturing unit into an integrated quality control system, so as to realize the connection of quality information between upstream and downstream processes such as steelmaking, continuous casting, rolling, heat treatment, inspection, and testing. On the basis of big data collection, through monitoring the whole process data, quality exception management, process rating, and quality analysis, the production process is controlled, and the continuous improvement of product quality is promoted. The knowledge model and process law contained in massive data are obtained through data mining algorithms and mathematical analysis, and the production line process model is optimized. Therefore, the development and application of quality control big data platforms play a positive role in realizing a consistent quality system for steel enterprises and leading the production technology in the future.

2.3 Program

As an important product in steel production, the quality of wire rods is directly related to the economic benefits of enterprises. Monitoring the production quality of wire rods is of great significance in the national strategic height, enterprise competitiveness, and social needs.

First, we carry out specific data collection:

1) Basic automation system of the production line, L1;

2) Process control system L2 of the production line;

3) MES system;

4) Line surface detection system;

5) Large-scale measuring instruments, etc.

Network and hardware solutions are as follows:

In the face of industrial big data applications, we must provide high-performance, high storage, highly scalable hardware and network systems. The project adopts a two-level equipment layout, central server group, and data acquisition network. The data collection network is connected to the central server through the backbone network

The system network topology is shown in Figure 1:

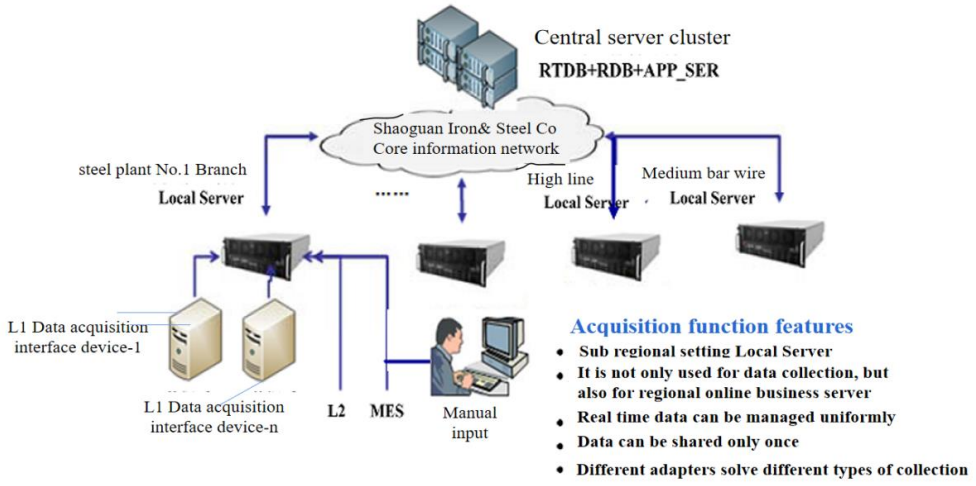

Fig.1 System network topology

The central server system includes a real-time database server, relational database server, data acquisition server, and quality management application server. The data acquisition network needs to be distributed in different geographical locations, so the physical machine needs to be placed in the corresponding machine room in each section, connected to the central server through the network, and regularly synchronized with the real-time data on site and the quality data generated by other production management systems. The hardware configuration structure is shown in Figure 2.

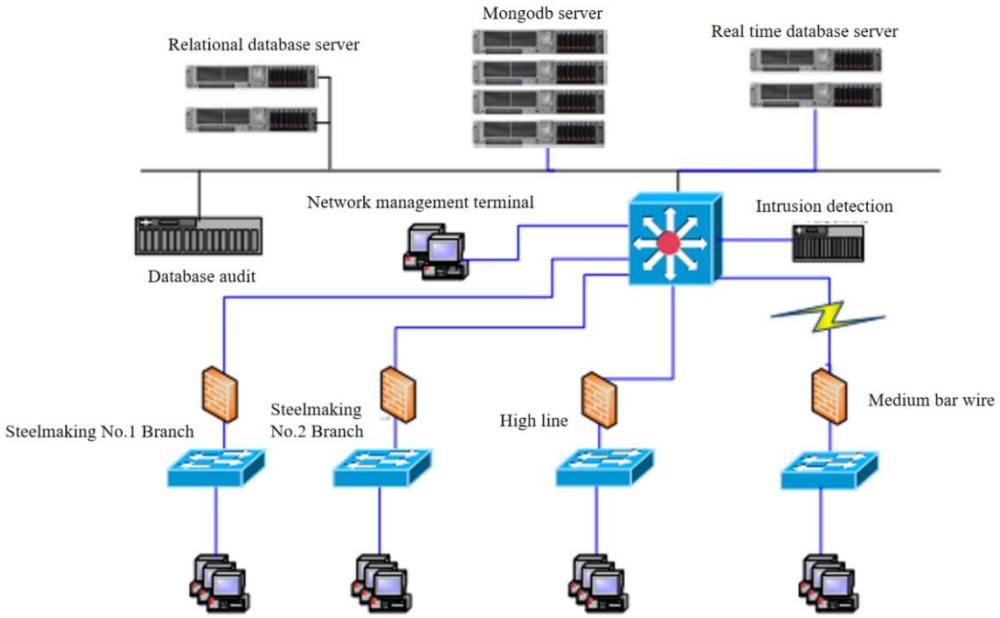

Fig.2 Hardware configuration structure

The regional server can be used as a cache. When the central server is unavailable, it can be cached locally. When the central server is restored to use, it can upload the cached data to the central server. As a front-end processor, the data acquisition interface machine is directly connected to the production control network to realize the communication with L1, IBA PDA, L2, MES, etc. at the same time, the front-end processor also plays the role of isolation between the control network and the data acquisition network, so that the upper and lower network systems cannot be directly connected, ensuring the safety and reliability of the production control network. Different data acquisition adapters will be customized according to different systems for product quality data to realize automatic collection and synchronization of quality data.

The architecture of the data acquisition and the quality platform is shown in Figure 3.

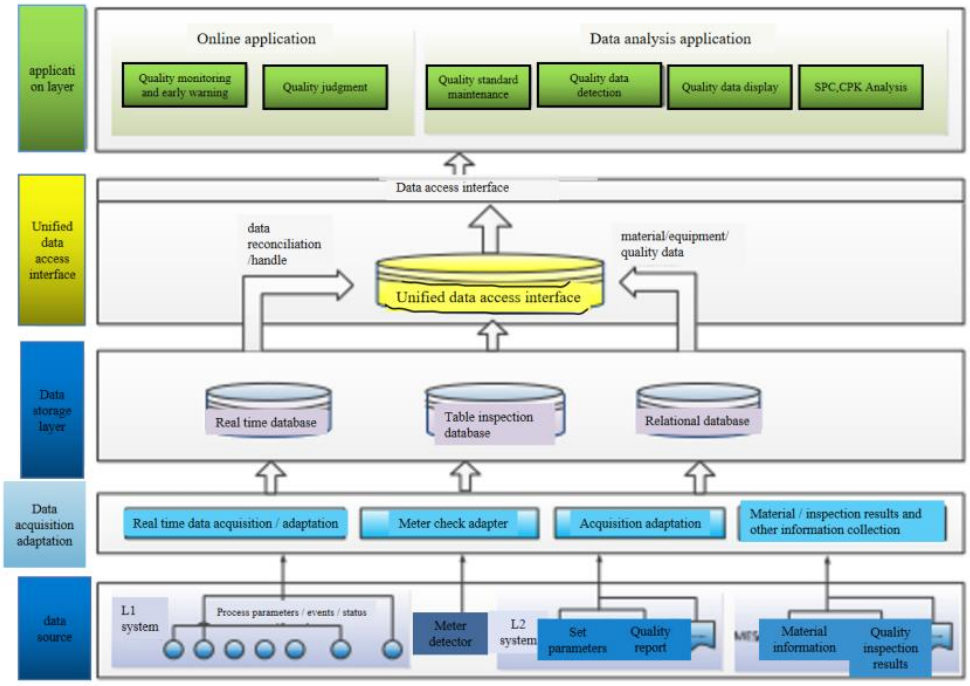

Fig.3 System architecture diagram of the data acquisition and quality platform

All kinds of data collected are processed and reorganized in real-time, and the relationship between different source data is constructed according to the process characteristics of the manufacturing process for unified data storage.

After realizing the whole data collection process, the application layer of the process quality control big data platform is designed based on the on-site demand analysis. The online application function of the application layer carries out online monitoring of each process and online prediction and rating of product quality according to user configuration, which is used for real-time early warning of manufacturing process quality, preventing batch problems, and ensuring product quality consistency. Online ratings can be customized according to different products and rules. According to the online warning, field operators and quality inspectors can optimize the manufacturing process. At the same time, the warning information or rating report can also be used for operation optimization or operation guidance in subsequent operations, including the following points:

1) Online monitoring of the whole process quality, online monitoring and offline playback of the process parameters and quality data of each process section of the whole process, and the diagnosis and early warning of product quality based on the process parameters.

2) The whole process quality judgment and decision-making, formulate corresponding quality judgment rules for different process sections, and conduct online judgment on key process quality parameters. The judgment results trigger the judgment of scrap, or prompt the dynamic adjustment measures of subsequent production and post-process.

3) Quality analysis and Optimization: analyze the relevant factors (equipment, process, control, operation) of quality abnormality and quality accuracy, and adjust the process parameters or optimize the control model parameters based on the influencing factors of the analysis results;

4) Use the online rating, quality monitoring, and other functions of the system to find the quality problems in the product manufacturing process in time, and put forward flow control suggestions for the products with quality problems in time, so as to avoid unqualified products from continuing to be put into production;

5) The development and application of intelligent terminals push the qualification rate, production line capacity, and abnormal quality status of products to relevant technicians and managers to facilitate a timely understanding of the site situation and make corresponding decisions. All kinds of data collected are processed and reorganized in real-time, and the relationship between different source data is constructed according to the process characteristics of the manufacturing process for unified data storage.

The system framework is shown in Figure 4.

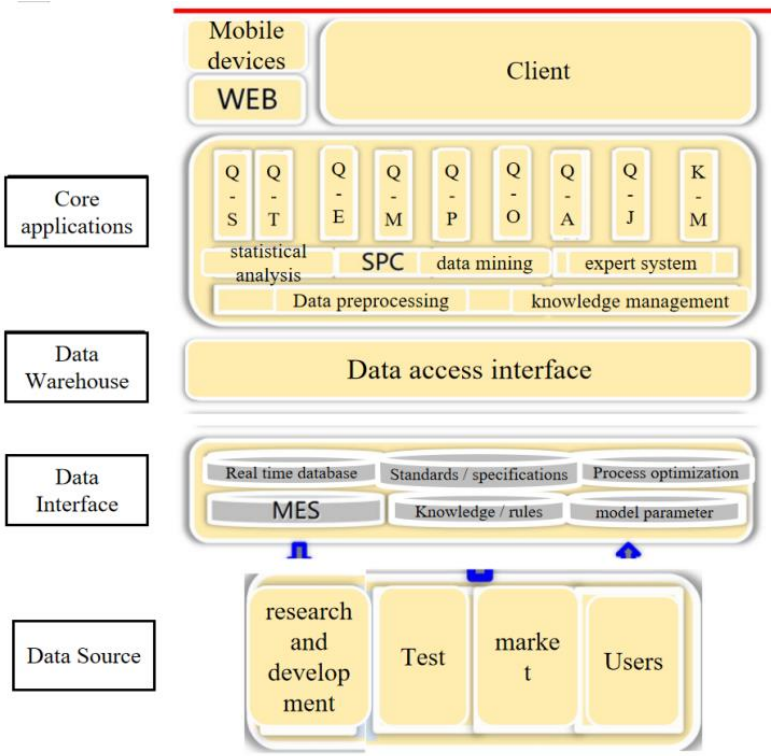

Fig.4 System framework

1) Data acquisition and storage layer

Composed of real-time database and relational database, collecting all process-related data and

providing data support for upper-level applications;

2) Data access layer

For the core application layer to provide the database access method, mainly composed of real-time database interface access component and relational database interface access component, respectively encapsulate the standard method of access to the corresponding database;

3) Core application layer

It is composed of analysis components and application functional components. Among them, the analysis component consists of statistical analysis components, SPC components, data mining formation, and expert system components.

The quality information data warehouse includes: ①Standard data: International standards/national standards/enterprise standards, specifications, internal control, etc.; ②Production process/quality data: MES; ③Inspection data: chemical composition, mechanical properties, etc.; ④Surface detection system data: hot rolling, cold rolling, galvanizing and other surface detection systems; ⑤Process anomaly/process ledger data: various production records; ⑥Quality objection/user research data; ⑦Material database/research and development process data; ⑧Index system database; ⑨Knowledge / rules; ⑩Type parameters/optimization results, as shown in Figure 5 below.

3 Conclusion

The design has no direct economic benefits, but it has very far-reaching social benefits. A complete set of wire process quality analysis platforms has been formed; the efficiency of process quality management is increased by more than 20%, and the product quality objection rate is reduced by more than 10%.

Through design and research, we establish a quality analysis platform based on industrial big data technology, realize the consistent system management of product quality from the perspective of the whole process, further improve the information and intelligent foundation and level of enterprises, and lay a good foundation for steel enterprises to realize intelligent manufacturing. The main work includes basic data collection and storage, preliminary quality process monitoring and analysis, develop urgently needed quality analysis tools and modules, can effectively improve the management efficiency of process technical personnel, improve the level of process and quality process control, no quantitative economic benefits, but the social benefit, can lay a foundation for building intelligent steel enterprises.

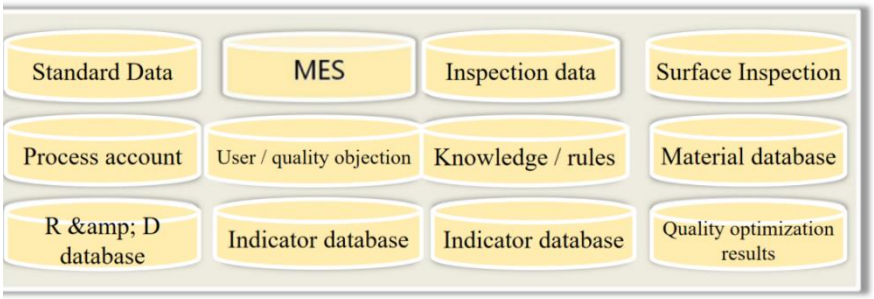

Fig.5 Quality information and data warehouse

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