2023 Volume 1, Issue 2
Progress of Electrical and Electronic Engineering
ISSN: 2630-4643

Research on the Application of Electrical Automation Technology in Metallurgical Electrical Engineering

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Abstract:

This article delves into the application of electrical automation technology in metallurgical electrical engineering. It first outlines the concept and advantages of electrical automation technology in metallurgical electrical engineering. Then, it analyzes the current status of the application of electrical automation technology in metallurgical electrical engineering. Finally, it introduces common electrical automation components and their practical applications in metallurgical electrical engineering, aiming to provide references for relevant personnel.

Keywords:

Electrical automation
Metallurgical electrical engineering
Application

Online publication: December 29, 2023

1. Introduction

The metallurgical industry is a foundational sector in the national economy, providing essential materials for other industries. The application of electrical automation technology in metallurgical electrical engineering enables real-time monitoring and control of the production process, helping to avoid potential flaws and errors from manual operations. This not only enhances the stability and reliability of metallurgical production but also ensures precision and efficiency. Consequently, advancing the metallurgical industry towards electrical automation has become a major trend. However, there are still numerous challenges in the practical application of electrical automation technology that require ongoing industry attention and proactive exploration of strategies to address these issues, ultimately promoting the industry's healthy development.

2. Advantages of electrical automation technology in metallurgical electrical engineering

In the field of metallurgical electrical engineering, the complexity of the production process necessitates specialized structure and process design, relying on various electrical devices working in coordination to achieve efficient and stable industrial production. Traditional metallurgical production has a high dependency on manual operations, but human errors often significantly impact product quality and production

efficiency. Additionally, electrical devices may experience various malfunctions during operation; if these are not detected and resolved promptly, they may lead to more severe production accidents, significantly affecting the entire metallurgical industry. In contrast, the application of electrical automation technology in metallurgical production presents the following notable advantages:

Firstly, it can fully adapt to complex production processes. Electrical automation technology enables real-time monitoring and management of the entire metallurgical production process, effectively organizing and addressing issues within production, thus improving both efficiency and product quality [1].

Secondly, it has a high level of technical complexity. Metallurgical production involves multiple process layers, requiring scientific and rational operation and management. The application of electrical automation technology enables management and control of the overall process through human-machine interaction, achieving bidirectional control to ensure the efficiency of the smelting process and product quality.

Finally, electrical technology offers strong reliability. In metallurgical production, electronic control is a critical means to ensure product quality. Electrical automation technology provides strong support for comprehensive electronic control, driving the overall automation and intelligent development of the metallurgical industry and injecting significant momentum into its sustainable development.

3. Current applications of electrical automation technology in metallurgical electrical engineering

3.1. Comprehensive automation of data monitoring

In metallurgical electrical engineering, automated data monitoring has become one of the core functions. This function uses advanced intelligent technology to achieve comprehensive, real-time monitoring of production equipment and the workshop environment. Monitoring sensors, as foundational equipment, can collect and monitor various process data in real time, conducting a comprehensive analysis of the production site to provide strong support for the production process through electrical automation technology.

Through electrical signals, the sensed information is transmitted to the central control center, where it is processed and converted into detection data that can be recognized by computers. These data not only reflect the environmental conditions at the production site but are also stored in on-site data storage modules, laying the foundation for subsequent data processing and communication.

To effectively prevent and address production risks in metallurgical electrical engineering, automated electronic detection devices can be installed at each stage of production. These devices can quickly identify hazards and initiate corresponding emergency measures, significantly enhancing workplace safety.

In continuous rolling production, various factors, such as temperature, airflow speed, air pressure, and air purity, greatly impact product quality. Automated detection instruments can perform comprehensive monitoring of the surrounding environment, converting various physical parameters into standardized analog parameters to provide producers with immediate and accurate production information. Furthermore, these detection instruments feature quick and easy-to-use interfaces and can automatically adjust the equipment's operating mode based on different production steps, greatly enhancing product flexibility and production efficiency.

3.2. Gradual realization of production automation

With the rapid advancement of electrical automation, information technology, and intelligent technologies, the field of metallurgical electrical engineering in China, especially in the non-ferrous metal smelting industry, is undergoing unprecedented optimization and transformation [2]. As new technologies and equipment continue to emerge, traditional analog control systems in China's metallurgical industry are gradually being replaced by more advanced control systems. From the initial analog control systems to subsequent Distributed Control Systems (DCS), Programmable Logic Controllers (PLC), and computer management systems, these technological innovations have not only improved production efficiency but also greatly enhanced product

quality. Additionally, as technology progresses, integrated controllers are gradually being replaced by decentralized controllers. This shift makes control systems more flexible and efficient, better meeting the diverse needs of the metallurgical electrical engineering field.

4. Common electrical automation components in metallurgical electrical engineering

In the field of metallurgical electrical engineering, electrical automation components play a critical role. Below are several common types of electrical automation components.

4.1. High-voltage load switch

The high-voltage load switch is one of the most essential automation components in electrical systems. It provides effective control over load and overload conditions and has breaking capacity in both upward and downward directions, offering comprehensive protection for equipment. In the metallurgical industry, to ensure the safe and stable operation of equipment, the high-voltage load switch is often used in conjunction with a high-voltage fuse, together forming a safety protection system for the electrical setup.

4.2. High-voltage fuse

The high-voltage fuse is designed to provide comprehensive protection for electrical equipment, especially meeting the safety protection needs of the metallurgical industry. When the short-circuit current in the circuit exceeds the set value, the high-voltage fuse can quickly cut off its internal fuse element, thereby disconnecting the working current of the equipment. This effectively prevents damage to the equipment and extends its service life.

4.3. Transformer

Transformers in electrical systems are used to transmit high voltage to metallurgical electrical engineering setups, ensuring the safe operation of the engineering process. At the same time, they help reduce energy losses and improve the efficiency and service life of the metallurgical electrical systems.

5. Practical applications of electrical automation technology in metallurgical electrical engineering

Applying electrical automation technology in metallurgical electrical engineering, along with appropriate electronic components, allows for in-depth analysis of vibration signal characteristics under fault conditions. This enables precise fault detection, early warnings, and protection measures, reducing equipment failure rates and ensuring the safe and stable operation of metallurgical electrical equipment.

5.1. Practical application of relay protection

The core function of relay protection is to provide comprehensive protection for electrical equipment and systems. When a fault occurs in metallurgical electrical engineering, relay protection devices can quickly analyze the fault location, assess the likelihood and severity of the fault, and issue an early warning signal [3]. At the same time, they can develop effective preventive measures to prevent the fault from escalating, thus ensuring the stability of the electrical system. In the practical application of relay protection, the following two aspects are particularly crucial.

5.1.1. Longitudinal protection of electrical lines

This protection method can simultaneously disconnect the switches on both ends of the fault line during a fault, thereby quickly isolating the fault area and preventing further impact on the entire metallurgical electrical engineering system. **Figure 1** illustrates the specific implementation of this protection method.

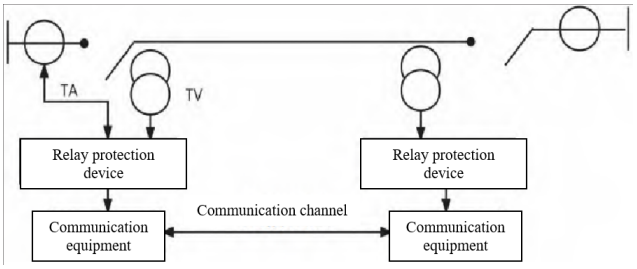

Figure 1. Longitudinal protection of electrical lines

5.1.2. Single-phase power voltage and current protection in metallurgical electrical engineering

This is one of the basic functions of relay protection equipment. It not only includes functions such as

voltage limiting and overload protection but also has the ability to quickly analyze the cause of the fault and take appropriate protective measures [4]. Once td data reaches the set standard values, the relay protection equipment immediately disconnects all circuits in the fault area to ensure the safe operation of metallurgical electrical engineering.

5.2. Deep application of PLC technology

PLC technology plays a critical role in metallurgical electrical engineering due to its high application value. It enables precise control and management of various electrical devices and can customize auxiliary devices and components according to users' actual needs, significantly enhancing production efficiency and quality in metallurgy. By integrating computer technology, PLC technology can establish a highly automated feeding system to automatically supply, adjust, and monitor metallurgical raw materials [5].

Moreover, PLC can help create an advanced weighing system for accurate measurement of various materials in the metallurgical industry. This weighing system not only significantly reduces measurement costs but also ensures accuracy and reliability, providing robust data support for metallurgical production. As shown in **Figure 2**, the application of PLC technology in weighing systems makes the entire measurement process more efficient, accurate, and reliable.

5.3. Innovative application of InTouch technology

The core advantage of InTouch technology lies in its efficient data collection and processing capabilities, designed specifically for information integration in smelting processes. This technology not only rapidly collects relevant data but also processes it in-depth, converting it into intuitive graphical formats to facilitate data analysis and decision-making for personnel. In converter smelting processes, InTouch technology enables precise monitoring and optimization of production processes. Its use in embedded controllers within smelting furnaces demonstrates the significant benefits it brings to production.

Through pre-programming, InTouch technology can detail the project content and extract, organize, and import relevant real-time production data into a database. By integrating InTouch technology with the latest Manufacturing Execution System (MES), various types of information in the production process can be collected and tracked in real time. This enables comprehensive management and optimization of the entire production flow, thereby improving production efficiency and quality.

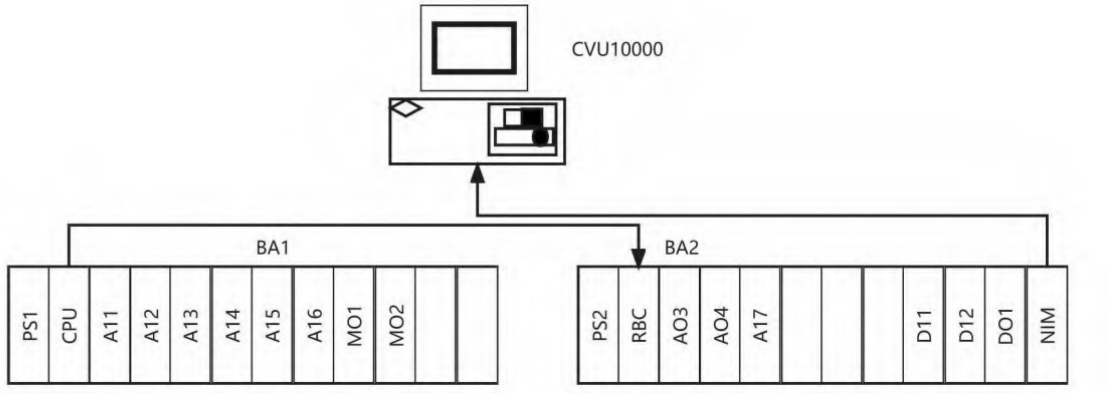

Figure 2. Application of PLC technology in weighing systems. Abbreviations: BA, frame; RBC, remote controller; PS, power module; CPU, processor; A1, analog input module; AO, analog output module; D1, digital input module; DO, digital output module; NIM, network interface module

6. Strategies to optimize the application of electrical automation technology in metallurgical electrical engineering

6.1. Enhancing the quality of electrical project optimization

Faced with diverse electrical projects and their varying completion requirements, staff need to thoroughly understand the work content and optimization needs. They should comprehensively analyze potential issues that may arise during project operations and improve cross-departmental communication to ensure the specificity and effectiveness of technical applications.

6.2. Addressing energy-saving issues in electrical automation

Although electrical automation technology significantly enhances production efficiency in metallurgical electrical engineering, energy consumption remains a critical concern. Staff should study the system's operating conditions in-depth and use technological means to develop efficient implementation plans that reduce resource waste and increase operational efficiency.

6.3. Using PLC technology for electrical automation control

The application of PLC technology in metallurgical electrical engineering provides strong support for real-time monitoring and control. This technology is easy to operate, highly effective, and can significantly reduce operating costs. When applying PLC technology, staff should focus on process design, ensure error-free implementation, and avoid programming mistakes to maximize its advantages in electrical automation control.

6.4. Strengthening external equipment protection measures

During metallurgical electrical engineering production, external environmental factors such as extreme temperature and humidity can pose potential threats to electrical equipment, leading to equipment aging, corrosion, and even malfunctions. To ensure the safe and stable operation of electrical equipment, external protective measures should be enhanced. This includes regular inspections and maintenance, establishing an equipment inspection system, and conducting periodic checks to ensure equipment is in good condition. If any safety hazards are found, immediate measures should be taken for repair or replacement. Reliable protective materials should be applied to safeguard electrical equipment based on the specific environment, such as waterproofing, dustproofing, and corrosion prevention. A corresponding emergency response mechanism should also be established to quickly locate and address issues if equipment malfunctions, minimizing the impact on electrical equipment operation.

6.5. Building a unified system development platform

To fully utilize the value of electrical automation technology in metallurgical electrical engineering, a unified system development platform can be constructed to ensure the consistency and stability of metallurgical electrical engineering operations. This platform should possess the following characteristics:

(1) Standardization and compatibility: The platform should adhere to unified technical standards and specifications to ensure compatibility among system modules, avoiding resource wastage.

(2) Centralized management and monitoring: The platform should provide centralized management and monitoring functions, allowing staff to fully understand the operational status of metallurgical electrical engineering and promptly identify and address potential issues.

(3) Flexibility and scalability: The platform should support flexible configuration and expansion to accommodate the continual growth in scale and evolving technical requirements of metallurgical electrical engineering.

7. Conclusion

In summary, metallurgical engineering, which encompasses the production and processing of ferrous and non-ferrous metals, plays a critical role across various sectors, including national economic development, national defense construction, resource utilization, and environmental protection. With continuous social progress, market demands for the production of metallurgical products have been steadily increasing.

The high complexity of metallurgical processes requires a wide range of electrical technologies and equipment in actual production. Traditional production methods, primarily relying on manual operations, are no longer adequate to meet modern development needs. Therefore, an in-depth exploration of the application of electrical automation technology in metallurgical electrical engineering is of great significance. It can break through the limitations of traditional manual production, improve the application quality of metallurgical processes, enhance the level of automated production in metallurgical enterprises, and promote the healthy development of the industry.

Disclosure statement

The author declares no conflict of interest.

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