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Research on Energy Efficiency Evaluation and Optimization of Intelligent Plant Equipment Based on Data-driven

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Abstract

With the arrival of the new economic environment, the government is actively promoting the development of the modern economy. All industries are following this trend and striving to enhance their technical level and implement scientific management. Additionally, the demand for intelligent life is also increasing. With the depletion of coal, oil, and other traditional energy sources, the loss and consumption are increasing, which leads to the rising price of energy and affects the cost control of production. In the context of the data-driven era, the traditional manufacturing industry is undergoing tremendous changes and innovation. Smart factories have emerged as a result, and energy efficiency management based on data-driven approaches has become the key to saving costs and reducing energy consumption. By applying advanced digital technology to the production process, the intelligent factory can effectively improve production efficiency and achieve fine monitoring and control of the entire production process using various software. This enables the factory to achieve optimal production results.

Keywords

Data-driven, intelligent engineering, equipment energy efficiency

Introduction

With the rapid progress of science and technology, the traditional manufacturing industry has undergone unprecedented changes and innovation. Especially in the era of Industry 4.0, our country has launched the "Made in China 2025" development strategy, marking the beginning of a new industrial revolution. As a major manufacturing country, we should seize this opportunity to increase our market share in the international market and have a greater influence. The development strategy of "Internet" and "Intelligent manufacturing" provides a clear direction and specific implementation measures for the development of China's manufacturing industry. The control and management of equipment energy efficiency in smart factories is the basis for the development of smart factories.

1. The data-driven-based intelligent plant equipment energy efficiency evaluation and optimization-related overview

1.1 The concept of an intelligent factory

"Intelligent Factory" aims to utilize advanced technology to achieve intelligent management of the factory. This includes improving work efficiency, reducing errors, closing loopholes, ensuring safe production, providing decision-

making support, strengthening external relations, and expanding into the international market. The construction of a smart factory requires a combination of factors, including advanced technology, a reliable design, efficient management methods, and sustainable financial support. These factors work together to help enterprises better understand market changes, enhance production efficiency, and mitigate production risks [1].

1.2 The importance of energy efficiency evaluation and optimization of intelligent plant equipment based on data-driven

With the introduction of the 14th five-year plan, the construction of intelligent factories is rapidly increasing. This is not only crucial for the digital transformation of the manufacturing industry, but also an effective means to enhance the core competitiveness of enterprises and promote high-quality economic development. The integration of scientific and technological innovation, the control of equipment energy efficiency, the implementation of scenario applications, and the reshaping of new organizational structures will help accelerate the pace of intelligent manufacturing, the realization of digitization, and the consummation of network intelligent factories [2]. By integrating advanced technologies such as artificial intelligence, the Internet, cloud computing, and big data, smart factories can automate, optimize, and digitize production processes more efficiently. This enables enterprises to provide more reliable services and establishes a solid foundation for future development. Based on data-driven analysis, it can effectively control equipment energy efficiency, improve production efficiency, produce higher quality products, and reduce production costs. For instance, the utilization of Internet of Things (IoT) technology enables real-time monitoring, data collection, processing, and analysis of equipment, products, and logistics through the installation of sensors, tags, and other facilities. This significantly enhances equipment efficiency, ensures product reliability, and improves the level of logistics management. Additionally, cloud computing and big data technology allow for the storage, processing, analysis, and mining of device data, providing effective support and guidance for decision-making. Furthermore, the introduction of artificial intelligence and robotics enables more advanced automation, intelligence, and flexibility, resulting in substantial improvements in productivity, product quality, and safety. To achieve the development of intelligent plants, it is necessary to establish an equipment energy efficiency evaluation system. All parties should accelerate the integration and develop a comprehensive solution with broad applicability to meet the development requirements of the smart factory. By integrating technologies such as factory automation, intelligent manufacturing equipment, industrial internet platforms, and intelligent logistics, a comprehensive intelligent factory support system can be established. This system enables the digitization, networking, and intelligentization of equipment energy efficiency management, resulting in significant improvements in production efficiency and product quality, as well as reduced production costs. The evaluation of equipment energy efficiency in the intelligent plant requires the implementation of scenario applications in the actual production process to meet evolving needs.

By analyzing and reconstructing the traditional production mode, intelligent manufacturing is achieved, thereby enhancing production efficiency and enabling the realization of intelligent manufacturing. For example, the application of vision technology in equipment energy efficiency evaluation can effectively detect and classify equipment quality, greatly improving production efficiency while reducing labor costs. Additionally, the use of Internet of Things (IoT) technology to enable real-time monitoring and management of equipment usage will help increase productivity. The assessment and optimization of equipment energy consumption in smart factories require the support of new organizational structures. These structures can facilitate the shift in production methods, the innovation of business models, the optimization of resource allocation, and the improvement of overall business performance [3]. Therefore, the smart factory must constantly adjust and change its organizational structure to meet the development needs. The new organizational structure of an intelligent factory can provide robust support for managing equipment energy consumption. It also enables a more flexible and open production and management environment, significantly enhancing production efficiency and innovation capabilities. This, in turn, promotes synergy and cooperation with the external environment, driving the intelligent plant to achieve a higher level of development.

1.3 The energy efficiency evaluation and optimization target of intelligent plant equipment based on data-driven

Through intelligent evaluation and optimization of equipment energy efficiency management, the intelligent plant can utilize the energy consumption control center system to achieve comprehensive equipment monitoring, thereby enabling sustainable energy consumption. By utilizing advanced information technology, the energy consumption

control center system can effectively improve the energy efficiency of enterprises, thereby achieving the objective of energy conservation and emission reduction. The Equipment Energy Consumption Management Center adopts a comprehensive, automatic, information-based, and intensive management method. This approach effectively monitors, dispatches, distributes, and utilizes energy at each stage, aiming to achieve optimal resource utilization. By implementing the Energy Efficiency Management Center system, intelligent plants can significantly reduce energy consumption and facilitate energy-saving transformations in production equipment. This lays a solid foundation for establishing an efficient energy-saving system. By establishing energy efficiency control centers, smart factories can monitor and optimize the operation of their equipment in real-time. This not only helps improve equipment utilization but also reduces energy consumption, ultimately enhancing the overall operational efficiency of the plant [4].

2. Based on data-driven intelligent plant equipment energy efficiency assessment of the status quo

2.1 Lack of understanding disrupts the pace of building smart factories

Based on the data-driven background, the enterprise's lack of understanding of the energy efficiency evaluation of intelligent workers and equipment results in a lack of understanding of the data-driven energy efficiency evaluation and optimization of intelligent plant equipment. Many companies lack an understanding of information technology, digital technology, and big data. They are concerned about data security, investment costs, industry trends, and the future of smart factories, so they choose to hesitate. Some enterprises blindly follow the trend and carry out large-scale reform and upgrading of equipment energy efficiency management without considering the actual situation of the factory.

2.2 The equipment base is weak, increasing the difficulty of building an intelligent factory

Due to the low efficiency of data collection on the energy efficiency of current equipment, operations and decision-making lack reliable data support and heavily rely on individual experience. At the same time, the lack of effective communication channels between devices in the intelligent factory prevents the establishment of efficient data interaction among different devices, units, and levels. This results in the emergence of "Information Islands" [5]. Currently, the high failure rate of equipment in the intelligent plant results in frequent equipment problems, including unexpected stoppages, which disrupt the normal operation of the entire system.

2.3 Lack of talent pool and ability to manage the energy efficiency of smart plant equipment

As the population ages and the workforce in smart factories evolves, many companies face significant challenges in attracting and retaining talent. Intelligent manufacturing is a complex process involving multiple disciplines, such as technology, automation, information technology, machinery, and electrical engineering. It requires a team of skilled technical personnel. However, the factory is only in the initial stage of development and lacks a sound human resource management system. This has led to challenges in recruitment and training, resulting in a high turnover rate and a need for improved staff capabilities.

3. The energy efficiency evaluation and optimization strategy based on data-driven

3.1 Establish a real-time monitoring system

The intelligent plant can obtain real-time running status data of equipment through an energy efficiency monitoring system. This allows for the improvement of the system's automatic management level and ensures the safe and reliable operation of various energy-using equipment and systems.

3.1.1 Energy consumption statistics of regional equipment

Through the graphic display, it can clearly reflect the energy consumption of each area in the building. This allows for a better understanding of the energy consumption level of the equipment in each area. The display includes real-time power consumption parameters, energy consumption, and regional energy consumption ratio, providing valuable information.

3.1.2 Energy consumption statistics by equipment category

In the real-time monitoring system, the equipment can be divided into several categories for effective management and control. First, the classification of energy includes electricity, water, steam, heat, and cold. Second, the sub-items of energy consumption include lighting, air-conditioning, power, and special purposes. Third, there are sub-items such as heating and cooling systems, air-conditioning systems, elevator systems, and water pump systems.

3.1.3 Management of carbon emissions from equipment

The utilization of energy consumption conversion technology in real-time monitoring systems can offer a comprehensive overview of the carbon emissions produced by equipment. This enables the effective measurement of equipment's carbon emissions and provides robust support for the objective of low-carbon development. Additionally, it facilitates the implementation of intelligent factory policies.

3.1.4 Time-sharing energy efficiency statistics of equipment

By analyzing the energy efficiency data of the equipment, we can gain a better understanding of the performance of the equipment under various conditions and at different times. Specifically, energy consumption can be divided into peak and off-peak periods, and the analysis focuses on the energy consumption of the equipment during these two periods. In addition, you can also analyze the trend of equipment energy consumption, proportion, year-on-year ratio, and ranking to gain a better understanding of equipment energy-saving information.

3.1.5 Equipment Energy Efficiency Map

The intelligent factory can utilize energy efficiency analysis to clearly display the energy efficiency status of the equipment within the factory through a map. This analysis includes real-time power consumption parameters, regional energy efficiency trends, rankings of energy efficiency in different regions, conversion costs, carbon emissions, standard coal usage, and energy efficiency per square meter.

3.1.6 Energy efficiency alerts

In the energy efficiency warning can customize the warning object, cycle, severity and notification mode, in order to timely find the equipment energy efficiency exceeding the situation. Workers can view the warning message through a pop-up window, and businesses can also query the history of the warning based on the type and severity of the warning.

3.1.7 Equipment Energy Efficiency Report

Through the creation of various types of business reports, including equipment energy efficiency data reports, energy efficiency analysis reports, energy balance reports, and consolidated reports, as well as reports that cover annual, monthly, cycle, and date ranges, the system can collect different types of equipment energy efficiency data, such as energy consumption value, energy consumption per unit area, and energy consumption per capita. You can convert reports to Excel or other formats using a variety of methods, such as curves, scatter plots, dials, pie charts, text, and tables. The smart plant calculates various indicators of equipment efficiency, such as total energy consumption of equipment and energy consumption per square meter. It then compares this data with historical data and analyzes equipment trends. In addition, the smart plant can also be set to meet the minimum energy requirements set by the government and compare its equipment energy efficiency management to the industry's advanced level indicators to assess its level.

3.2 Strengthening the management of operation and maintenance

3.2.1 Multi-level authority management

Through the design of the system, the management of equipment energy efficiency in an intelligent factory can be categorized into three levels: the Operation Level, the Management Level, and the Decision-making Level. Additionally, the system ensures the security and privacy of the data, effectively preventing unauthorized behavior.

3.2.2 Data Management

Data management includes regular backup, recovery, import, export, and logging of operations. By utilizing the dispatching and decision-making function of energy efficiency management, managers can monitor the real-time operation of equipment and related systems. This allows them to promptly identify any changes in the energy supply and demand imbalance, record dispatch logs, and create emergency plans. Ultimately, this leads to a more effective

improvement in energy efficiency. In data management, combining historical and current data can create a comprehensive database that can be automatically analyzed, calculated, and displayed. This enables better forecasting of energy production, purchase, and usage in the future. It also helps guide dispatchers in identifying imbalances between energy supply and demand, ensuring the security and stability of energy supply. Ultimately, this approach aims to save resources, improve economic efficiency, and enhance overall energy management.

3.3 Fine report management

First, by implementing an intelligent equipment energy efficiency analysis system, it is possible to automatically generate multi-stage, comprehensive, integrated, and effective equipment energy efficiency reports. Additionally, the system provides various forms of energy efficiency indicator charts, which can provide more accurate information for managers at different levels regarding equipment energy efficiency. Second, with the intelligent system, staff can generate equipment energy efficiency analysis reports automatically based on the needs of managers and within a specified time frame. These reports are then sent to the designated manager. Third, staff can easily customize personalized energy efficiency analysis reports through the web interface. Fourth, the report can be customized to suit your requirements, and it can be exported in various formats or printed online.

4. Conclusion

In the context of a data-driven era, the Internet is not only a driving force for social change but also a pervasive force in computing, data, and new technologies. With the development of the Internet of Things, cloud computing, 5G, and other cutting-edge technologies, the construction of intelligent factories is progressing in an unprecedented manner. The evaluation and optimization of equipment energy efficiency will be the perfect integration of information technology and manufacturing technology, resulting in a new and diverse model.

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