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Energy-Saving Design of Electrical Automation Based on PLC Technology

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Abstract: *In the process of rapid social and economic development, the electrical industry has developed rapidly, and electrical automation and related technologies have also been widely used. At present, some companies have relatively low utilization rate of power resources, so it is necessary to improve the current energy-saving measures. At the same time, PLC technology is widely used in the field of industrial automation. It plays an important role in industrial equipment control, production process control, and production management. Therefore, this article is based on PLC technology to conduct research on electrical automation and energy-saving design. This article adopts the experimental analysis method and the data analysis method, intends to understand the performance of the electrical automation control simulation system through the experiment. According to the experimental results, the system monitors the power equipment in the experimental environment in real time, and the time required for online diagnosis of the equipment is 39, 31, 26, and 26 seconds, respectively. It can be seen that the system requires less time for online diagnosis of equipment, can better realize the requirements of electrical automation, and achieve the purpose of energy saving.*

Keywords: *PLC Technology, Electrical Automation, Energy-Saving Design, Automatic Control*

1. Introduction

With the rapid development of social economy, industrial production technology has also made great progress, and higher requirements are put forward for the level of electrical automation. At the same time, the application of PLC technology in the field of electrical automation has become a trend. It is an emerging discipline developed after disciplines such as relay science and cybernetics. Its main characteristics are flexibility and versatility. Due to PLC's advantages in logic processing functions, combined with the flexibility brought by improved communication skills, and high scalability, it has been widely used in the field of industrial automation control.

At present, the research results on PLC technology and electrical automation are very rich. For example, Zheng Quan pointed out that PLC's performance can be extremely effective when it comes to automation and control electrical engineering [1]. Lv Yong believes that PLC, as a core professional course of electrical engineering and automation, should start from the perspectives of the actual needs of the enterprise and the improvement of students' ability, and be guided by task-driven teaching [2]. Jiang Longfei proposed that the application of PLC in automation control can not only improve the production efficiency of industrial production, but also reduce the cost of hardware configuration and improve the market competitiveness of the electrical industry [3]. Therefore, this article starts from a new perspective, combined with PLC technology, to carry out research on electrical automation energy-saving design, which has important research significance and research value to a certain extent.

This article mainly discusses these aspects. First, the PLC technology and related research are explained. Then, the content related to electrical automation and energy-saving design was introduced. Finally, this article also carried out experimental research, and got the corresponding experimental results and analysis conclusions.

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2. Related Theoretical Overview and Research

2.1 PLC Technology and Related Research

PLC takes the microprocessor technology as the core and is a new type of universal automatic control device developed through the combination of computer technology, automation technology, communication technology and electrical control technology. With the rapid development of automation, PLC will also rapidly develop into an irreplaceable means and method in the process of industrial automation control. In terms of logic operation and network communication, PLC has also been greatly improved, and it has become an indispensable part of on-site automatic control equipment and has played a great role.

PLC is an industrial control equipment with a wide range of products, with different structures, control ranges and functions performed, but the basic components are the same [4-5]. The basic structure of PLC is shown as in Figure 1.

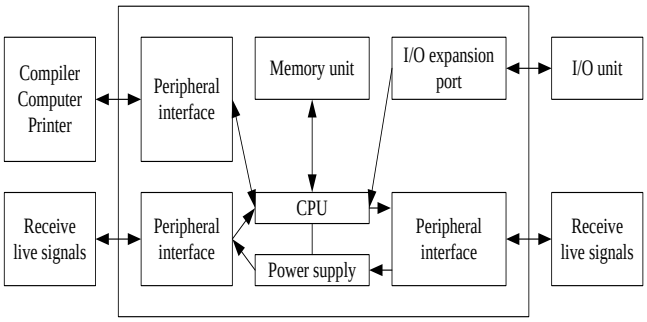

Figure 1: Basic Structure of PLC

According to the structure, PLC can be divided into two types: integrated type and combined type. According to PLC control performance, it can be divided into low-end PLC, middle-end PLC, and high-end PLC. PLC technology has the following characteristics.

(1) Strong anti-interference ability and high reliability. PLC is often referred to as a "slightly damaged" instrument because it has been strictly manufactured during the design and manufacturing process, and a high level of interference measurement has been performed in both software and hardware. The equipment has multiple anti-interference measures such as grounding, shielding, filtering, isolation, etc. The model shell is designed for perfect electromagnetic compatibility. A number of automatic diagnosis, anti-interference and system-level technologies are applied in redundant configuration, etc., so that the PLC can generally and reliably work in a harsher environment.

(2) Strong flexibility and flexible combination. Towards serialization, standardization and even modularization is the main direction of PLC development at present. Under this unified standard, users can control the system through flexible combinations. This can improve the PLC's communication capabilities and human-computer interaction functions, and at the same time PLC can easily control various systems. Communication network modules, man-machine interface modules and I/O modules are mainly used to connect field devices and provide a variety of industrial field signals. The workload of construction, programming and installation is reduced, and the operation is very flexible and convenient. At the same time, the expansion of these modules is also relatively flexible, and can be continuously expanded in terms of application range, storage capacity, application fields, and control functions [6-7].

(3) Powerful computing and processing functions. PLC has high-speed data processing capabilities, which can meet various complex industrial control requirements.

(4) Programming is simple and easy to learn. The PLC interface is simple, mainly through the computer to control the industrial process. The purpose is to learn and understand industrial control equipment. Ladder language is a commonly used language in programming. This language is simple and easy to use for those who are familiar with electromechanical programming, and it also provides convenience for those who want to take the lead in the field of control.

(5) Less labor for design, installation and commissioning, and easy maintenance. In a control system composed of relays, if you want to change the control method or object, the traditional method is to change the wiring method to achieve this. This is to encapsulate the PLC in it, similar to

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"software" control, by changing the external pins to obtain Logic control. If the production process changes, you only need to change the program, which significantly shortens the design and construction cycle of the controller and is easy to maintain. During the installation process, there are no strict requirements on the installation environment and interference measures. The system can only operate normally if the components are connected correctly; each module is equipped with operation and error indicators to provide instructions.

(6) Small size, light weight, low power consumption and high performance. In order to meet the control requirements of industrial production systems, PLC has a compact and sturdy design, and is developing in the direction of volume integration, volume reduction, weight reduction, and easier maintenance and system transfer. In the mechatronics control unit, integration and strong anti-interference ability are well reflected in the PLC. PLC uses highly integrated software to implement wiring on the hardware, which reduces the wiring between devices, while achieving control, and at the same time facilitating the daily maintenance of equipment. This use of program changes to control different industrial processes has important practical significance, and is particularly suitable for cross-brand production in small batches [8-9].

2.2 Electrical Automation and Energy-Saving Design

In the process of rapid social and economic development, the electrical industry has developed rapidly, and electrical automation and related technologies have also been widely used. At present, some companies have relatively low utilization rate of power resources, so it is necessary to improve the current energy-saving measures.

Electrical automation technology plays an important role in the entire industrial production process. Most of the energy used in industrial production is embodied in the form of electrical energy. The realization of electrical automation and energy saving design is an important part of the realization of energy saving and emission reduction in the entire industrial production process.

With the breakthrough of modern science and technology and the improvement of related theories, people have put forward the concept of automatic control. Its building blocks include artificial intelligence, control theory, and computer science.

With the development of information technology and knowledge economy system, the concept of electrical automation technology came into being. It is the product of time, and its basic connotation will change over time. When integrating construction machinery, the focus is on automation technology, and many sensors are in a secondary position. They perform their own duties to monitor various operating parameters of the system in real time. Sensors with a wide range of applications include temperature sensors, humidity sensors, flow sensors, pressure sensors, etc. [10-11].

The basic principle of electrical automation energy-saving design is to adopt safe, reliable, economical, and practical power-saving technologies to improve equipment energy efficiency and operating energy efficiency, and reduce building power consumption.

(1) Ensure the normal operation of power equipment. (2) Consider actual economic benefits. Electric energy conservation must be combined with technical and economic analysis, starting from the actual economic benefits of investment returns, choosing reasonable energy-saving measures and energy-saving equipment, conducting scientific and reasonable management, and reducing operating costs. (3) Save unnecessary energy consumption. In the industrial production process, there is unnecessary energy consumption. For example, the design of illuminance is too high, which leads to too high power density; the selection of transformer capacity is too large, which leads to increased no-load loss; and the equipment that should be out of service runs for a long time. (4) Adopt advanced and reliable technology. Technology is the most important productivity. Only by relying on advanced technology can energy conservation be improved and exert its greatest effect. At the same time, the stability of technology is also a factor that must be considered.

Take the water pump motor automatic speed control system as an example. The water pump motor is a kind of energy-consuming equipment, and its power consumption is the largest part of the whole station. Therefore, the implementation of variable frequency speed regulation and energy-saving technology for water pumps can greatly improve the economic efficiency of pumping station operation. The maximum load of the pump is often adjusted according to the maximum pressure head and maximum hourly flow under the most unfavourable conditions. In actual operation, the pump only needs a short time to reach the maximum flow: its real-time flow changes with the change of external

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water consumption, and its head also changes with the change of the flow level. Controlling the speed of the water pump and controlling the opening of the valve are common methods for adjusting the flow. Valve control involves adjusting the flow rate by changing the impedance of the water pipe. This method inevitably consumes energy. The speed control of the water pump changes the working point of the water pump by adjusting the rotation speed of the water pump motor to achieve the effect that the delivery head and flow are adapted to the water consumption, and finally achieve the purpose of energy saving [12]. When pumping water, the relationship between output power, speed, water pressure and flow rate of the pipe network can be expressed by formula 1) 2).

$$Q = a_1 GW \tag{1}$$

$$m = a_2 W \tag{2}$$

Among them, Q is the output power, m is the speed, G is the water pressure of the pipe network, W is the water flow, and a_1 and a_2 are both proportional constants. In this way, by adjusting the frequency of the asynchronous motor, the water flow rate and working height of the water pump can be changed. As long as the water supply needs are met, the power consumption of the water pump can be effectively reduced and can achieve the purpose of energy saving.

3. Experiment and Research

3.1 Experimental Environment

This experiment, combined with PLC technology, and optimized energy-saving processing, designed an electrical automation control simulation system. The system is equipped with dual-core processors, Core 1 is used for program operation, and Core 2 is used for communication processing. M258 has 8 built-in high-speed counter inputs with a frequency of up to 200 kHz. Built-in Ethernet function, support EthernetTCP-Modbus, Somachine, UDP, TCP and SNMP communication. The electrical automation control simulation system includes functions such as general event actions and information, event reminders, accident recurrence, and wave recording analysis. The analysis of the recurrence of accidents and recorded waves is of great significance for analyzing the causes of accidents and preventing accidents.

3.2 Experimental Process

In this experiment, in order to better understand the performance of the electrical automation control simulation system for this experiment, a total of 4 tests were carried out. In this experiment, the power equipment in the experimental environment was monitored in real time, and the time required for online diagnosis of the equipment, fault detection, and automatic alarm was tested. The experimental results are shown below.

4. Analysis and Discussion

In this experiment, a total of 4 tests were carried out to monitor the power equipment in the experimental environment in real time, and to test the time required for online diagnosis of the equipment, fault detection, and automatic alarm. The test results are shown in Table 1.

Table 1: Test Results of the System

Test times	Online diagnosis(s)	Fault positioning time(s)	Automatic alarm(s)
1	39	41	19
2	31	57	23
3	26	66	21
4	25	51	26

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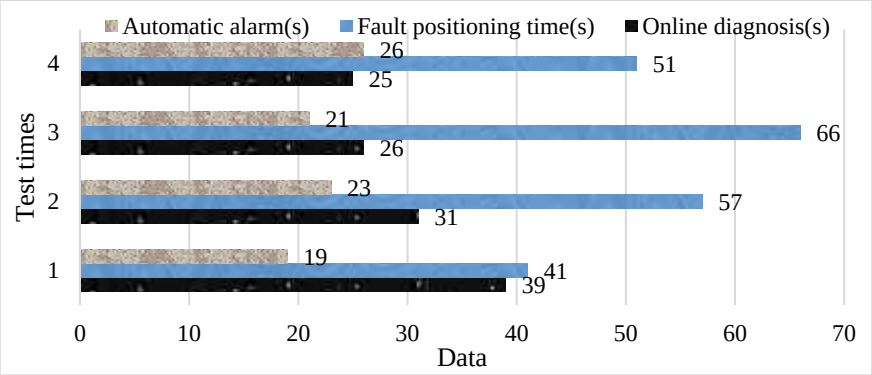

Figure 2: Test Results of the System

It can be seen from Figure 2 that the system performs real-time monitoring of power equipment in the experimental environment, and the time required for online diagnosis of the equipment is 39, 31, 26, and 26 seconds, respectively. It can be seen that the system requires less time for online diagnosis of equipment, can better realize the requirements of electrical automation, and achieve the purpose of energy saving.

5. Conclusion

At present, with the development of social economy, people have put forward higher requirements for electrical automation control. However, some companies have relatively low utilization rates of power resources, so they must improve current energy-saving measures. At the same time, the continuous development and application of PLC technology has brought greater and greater influence in industrial automation. It has greatly promoted the level of industrial automation and has certain advantages in practical applications. PLC technology plays a very important role in industrial automation control, and with the development of modern technology, its application range is becoming wider and wider, and it has become a very critical technology in modern production. This article starts from a new perspective, combined with PLC technology, to carry out research on electrical automation energy-saving design, which has important research significance and research value to a certain extent.

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