Innovative Practice of Applying PLC Technology in Automation Control of Mechanical and Electrical Equipment

Chun Sha[1], Ji Luo[2], Yun Chen[3]

[1]Engineering Training Center, Nantong Institute of Technology, Nantong, 226002, China

[2]School of Mechanical Engineering, Nantong Institute of Technology, Nantong, Jiangsu, 226002, China

[3]Wuxi Xinjie Electric Co., LTD., Wuxi, Jiangsu, 214161, China

Keywords: Mechanical and Electrical Equipment; Automated Control; PLC Technology

Abstract: In the wave of rapid development of modern science and technology, PLC technology has been deeply integrated into the automation control system of mechanical and electrical equipment with its excellent performance and wide application potential. The application of this technology greatly improves the operational efficiency and stability of mechanical and electrical devices, significantly optimizes production processes, and provides strong technical support for the transformation and upgrading of enterprises and the sustained growth of economic benefits. The reason why PLC technology can occupy an important position in the field of mechanical and electrical automation is due to its strong technological advantages and wide adaptability. This technology not only has high programmability and flexibility, can be customized according to different control requirements, but also has high reliability, strong anti-interference ability, and easy maintenance, ensuring that mechanical and electrical equipment can still operate stably in complex and changing working environments. This article explores in depth the innovative practical application of PLC technology in the automation control of mechanical and electrical equipment.

1. Introduction

In the wave of technology in the 21st century, computer and communication network technology are like two wheels driving profound changes in the global industrial system at an unprecedented speed [1]. In this context, PLC technology emerged and rapidly rose, becoming a bridge connecting traditional industry and intelligent manufacturing [2]. As a shining pearl in the field of automation control, PLC technology has not only witnessed the brilliance of technological progress, but also profoundly influenced every corner of mechanical and electrical equipment automation control, leading industrial production towards a more efficient, intelligent, and safe direction [3]. The birth of PLC technology originated from the demand for innovation in traditional relay control systems. In early industrial production, complex control logic often required a large number of relays, timers, and counters to implement, which not only resulted in a large system size and difficult maintenance, but also greatly reduced flexibility and reliability [4].

With the development of microprocessor technology and the widespread application of integrated circuits, PLC has rapidly replaced traditional relay control systems with its miniaturization, high reliability, and ease of programming, becoming the new favorite in the field of automation control [5]. The development process of PLC technology is a continuous process of integration, innovation, iteration and upgrading [6]. From the initial simple logic control to the addition of advanced language programming, network communication, human-computer interaction and other functions, PLC has evolved from a single controller into a comprehensive automation system that integrates control, monitoring, communication, and data processing [7]. The rapid development of this technology is due to the continuous progress of computer science and information technology, which has also brought unprecedented changes to the automation control of mechanical and electrical equipment. In modern factories, PLC technology has become the core of building intelligent production lines [8]. Through PLC control, precise control of various links on the production line can be achieved, such as material conveying, processing, quality inspection, etc.

  DOI: 10.25236/iiicec.2025.023

At the same time, by combining sensor technology and machine vision technology, PLC can collect production data in real time and perform intelligent analysis and decision-making, thereby optimizing production processes and improving production efficiency. PLC has powerful data processing capabilities, which can monitor the operating status of mechanical equipment in real time and quickly analyze and process abnormal data. Once potential faults or abnormal situations are detected, the PLC can immediately issue warning signals and automatically take corresponding protective measures to avoid equipment damage and production interruption. In addition, PLC can also record fault information and generate fault reports, providing strong support for subsequent troubleshooting and maintenance. In automation control systems, PLC is not only the core component for executing control commands, but also the key to optimizing system performance. Through advanced algorithms and strategies, PLC can optimize and adjust the control system in real-time, ensuring that the system always operates in its optimal state. This optimization not only improves production efficiency and quality stability, but also reduces energy consumption and costs.

2. Application of PLC

2.1. Application in Switch Quantity Control

The application of PLC in switch control is undoubtedly a major leap in the field of electrical automation. It not only simplifies the traditional complex circuit layout based on electromagnetic relay control, but also brings unprecedented convenience and efficiency to switch control through its powerful logic processing capability and high reliability [9]. In the scenario of switch control, PLC can accurately make judgments and output corresponding control signals based on external input signals (such as switch state changes generated by buttons, sensors, etc.) and internal preset logic programs, and drive actuators (such as motors, valves, etc.) to achieve automation control [10]. This process is entirely based on digital logic and does not require complex physical connections, greatly reducing the system's failure rate and maintenance costs. Figure 1 is a schematic diagram of the PLC hardware structure.

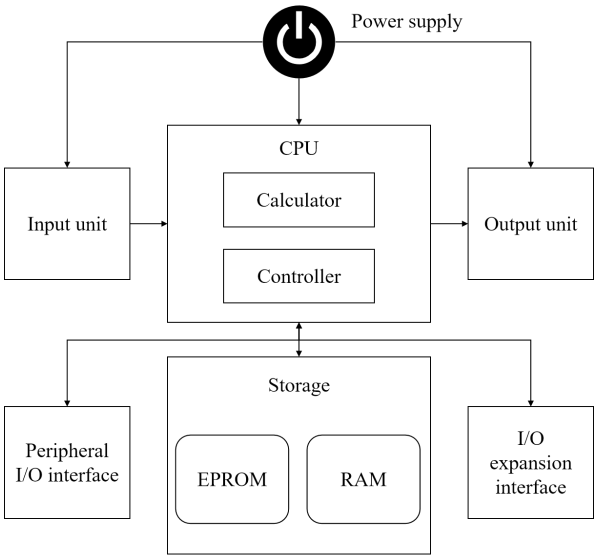

Figure 1 Schematic diagram of PLC hardware structure

In addition, the programming flexibility of PLC enables switch control to no longer be limited to simple on/off logic, but to support more complex timing control, condition judgment, counting, cycling, and other functions, meeting diverse and refined control needs. By modifying the program, it is easy to adjust and optimize the control logic without changing the hardware structure, greatly improving the adaptability and scalability of the control system. At the same time, PLC also has powerful data processing and communication capabilities, which can exchange data with other automation equipment or upper computers, achieve remote monitoring, fault diagnosis and

centralized management, and further enhance the intelligence level of the entire control system. In many fields such as industrial automation, mechanical manufacturing, building control, and environmental engineering, PLC has become the preferred solution for switch control, providing strong technical support for the automation upgrade and intelligent transformation of enterprises.

2.2. Equipment Assembly Automation

In the field of modern production, automation of equipment assembly has become a key way to improve production capacity, ensure quality, and reduce costs. The traditional manual assembly method is not only inefficient, but also susceptible to human factors, making it difficult to ensure assembly accuracy and consistency. With the advancement of technology, assembly automation systems based on PLC technology have emerged, bringing revolutionary changes to the manufacturing industry. As the core of automation control, PLC plays a crucial role in equipment assembly automation due to its high reliability, strong adaptability, and easy programming. This system, through precise programming, can coordinate and control multiple automated devices and robotic arms, achieving full process automation such as precise positioning, grasping, assembly, and inspection of components. This not only significantly improves the operating speed and assembly accuracy of the production line, but also significantly reduces human errors, ensuring the stability of product quality.

In addition, the assembly automation system also has intelligent management functions, which can monitor the production status in real time, respond quickly and handle abnormal situations, effectively prevent production accidents, and ensure production safety. At the same time, through data analysis and optimization, the system can continuously optimize the production process, improve overall production efficiency, and reduce operating costs. In summary, equipment assembly automation not only represents the transformation and upgrading of production methods, but also an important step for the manufacturing industry to move towards intelligent and efficient development. With the continuous maturity of technology and the widespread expansion of applications, assembly automation systems will demonstrate their strong vitality and unlimited potential in more fields.

3. Innovative Practice

3.1. Construction of Intelligent Production Line

In the grand blueprint of modern factories, PLC technology is like the central nervous system, leading the construction and upgrading of intelligent production lines (as shown in Figure 2). The application of this revolutionary technology not only greatly improves the automation level of production lines, but also lays a solid foundation for achieving intelligent manufacturing. PLC, with its powerful logic processing capability and high reliability, has become a bridge connecting various links of the production line. Through programming settings, PLC can accurately control the entire process of automated transportation of materials from storage to outbound, ensuring timely supply of production materials and smooth production of finished products. During the processing, PLC precisely regulates the operating status of the machine equipment based on preset process parameters. Whether it is temperature, pressure, or speed, it can achieve precise control without any deviation, thereby ensuring the stability and consistency of product quality.

It is particularly worth mentioning that the deep integration of PLC with sensor technology and machine vision technology has given wings to intelligent production lines. Various sensors scattered throughout the production line are like sharp antennae, capturing real-time environmental parameters such as temperature, humidity, vibration, and production status information, and transmitting these data to the PLC. Machine vision systems, with their extraordinary image recognition and processing capabilities, perform high-precision inspections of product appearance and identify any subtle flaws or defects. After receiving these massive data, PLC uses built-in intelligent algorithms for rapid analysis, automatically adjusts production parameters or triggers warning mechanisms, effectively avoiding production abnormalities and achieving continuous

optimization of the production process. In addition, PLC also has strong communication capabilities and can easily access enterprise information management systems to achieve real-time uploading and sharing of production data. This not only facilitates remote monitoring of production status by management and timely adjustment of production plans, but also provides rich data sources for enterprise big data analysis and intelligent decision-making.

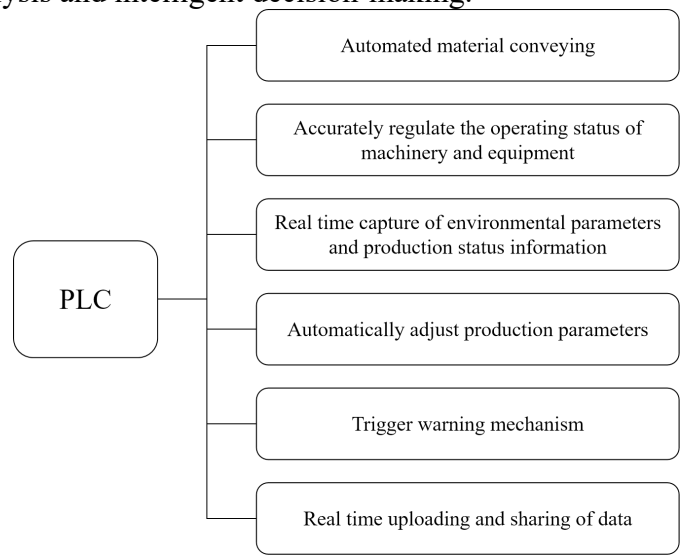

Figure 2 Construction and upgrade of intelligent production line

3.2. Fault Diagnosis and Warning

In the innovative practice of PLC in the field of industrial automation, its fault diagnosis and warning functions are particularly prominent, demonstrating its outstanding ability as the core of intelligent control. By integrating advanced data processing algorithms, PLC can continuously monitor the operating status of various mechanical equipment on the production line, including key parameters such as motor speed, temperature fluctuations, and pressure changes, achieving a comprehensive assessment of the equipment's health status. When the PLC detects any abnormal data that deviates from the normal range, its built-in intelligent analysis module will quickly start, deeply analyze these data to identify potential fault modes or abnormal situations. Once it is confirmed that there is a risk of malfunction, the PLC will immediately trigger the warning mechanism, notify the operators or maintenance team in a timely manner through sound and light alarms, sending text messages or emails, etc., to ensure that the problem can be discovered and dealt with in the first time.

More advanced, PLC can automatically adjust the working mode of the production line according to the type of fault, take temporary protective measures such as reducing production speed, switching backup equipment, or initiating emergency shutdown procedures to minimize the risk of equipment damage and production interruption. This ability for immediate response and self-protection is crucial for ensuring the continuous and stable operation of the production line. In addition, PLC also has powerful fault recording and reporting functions. During the occurrence of a fault, the PLC will record in detail the time, location, type, and related operating parameters of the fault, providing detailed data support for subsequent troubleshooting and maintenance. By generating fault reports, technicians can quickly locate the root cause of the problem, develop effective repair plans, shorten fault recovery time, and improve the overall reliability and efficiency of the production line.

4. Conclusions

The innovative practical application of PLC technology in the field of mechanical and electrical equipment automation control not only significantly improves the intelligence and automation level of production lines, but also promotes the transformation and upgrading of the entire industrial

manufacturing industry. As the core tool of automation control, PLC brings higher production efficiency, lower production costs, and stronger market competitiveness to enterprises with its powerful data processing capabilities, precise control functions, and efficient fault diagnosis and warning mechanisms. Looking ahead to the future, PLC technology is still in a rapid development stage, and its application areas will continue to expand, with increasingly improved functions. However, facing the increasingly complex and ever-changing industrial automation environment, PLC technology also faces many challenges, including how to further enhance safety and reliability to meet stricter production standards; How to optimize network communication capabilities to achieve wider device interconnection and data sharing; And how to better integrate cutting-edge technologies such as the Internet of Things, big data, and artificial intelligence to promote the in-depth development of intelligent manufacturing. Therefore, continuously strengthening the research and innovation of PLC technology, promoting its technological progress in safety, reliability, network communication, and other aspects, will be an important direction for future development. Through continuous exploration and practice, we have reason to believe that PLC technology will play a more important role in the field of mechanical and electrical equipment automation control, contributing greater strength to the intelligent, green, and service-oriented transformation of industrial manufacturing.

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