The Application of PLC in Industry Fields

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Abstract. This article explores the widespread application and importance of the Programmable Logic Controller (PLC) in industry. PLC, as an industrial controller designed specifically for industrial environments, occupies an important position in the field of industrial automation control due to its advantages of being less susceptible to interference, high reliability, easy programming, fast installation, and small size. With the rapid development of PLC technology, great progress has been made in the development of technology, hardware, and software, resulting in increasingly powerful functionalities and significantly enhanced system development and compatibility. This paper mainly analyzes the design ideas and applications of PLC in life and industry in detail, aiming to research PLC and find more scenes in industry fields in which PLC can participate. PLC has a wide range of applications and significant importance in industry. The continuous progress and innovation of its technology will bring more opportunities and challenges to the field of industrial automation control. In the future, with the deepening development of advanced manufacturing models such as Industry 4.0 and intelligent manufacturing, PLC technology is expected to play a greater role in more fields and promote industrial automation to a higher level.

Keywords: Programmable Logic Controller, industry application, current situation and prospects.

1. Introduction

With the development of society, more and more new creations can replace the old ones that have fallen behind the Cutting-edge technology. It is also noticed that researchers invent high-tech projects to make it convenient for practitioners to do their jobs in the petroleum industry. From firepower, and electric transmission to the current intelligent transmission, the industry has evolved gradually. This paper will focus on Programmable Logic Controller (PLC) intelligent transmission control and explore more on its research and application potentiality. It is a device specially designed for industrial automation control, which combines computer hardware and programmable logic. PLC is mainly used to monitor and control various production processes, such as factory assembly lines, machine operations, environmental monitoring, etc. PLC can be applied to many industries such as electric power, metallurgy, transportation, construction, etc. The control process includes switchgear, temperature control, pressure monitoring, flow meters, etc. Besides, this technology can also be used in Petroleum Industry. The way to control on the one hand is more stable and reliable than relay controls. On the other hand, the program can be modified on-site and programming is more convenient and simpler. In the future, PLC will play a greater role in industrial production. This article first outlines the current application status of PLC control technology, emphasizing the position of PLC as the main pillar of industrial automation control. Subsequently, specific application cases of PLC in multiple industrial fields such as metallurgy, power, chemical engineering, and machinery were analyzed in detail, demonstrating the flexibility and efficiency of PLC in different industrial scenarios. Through the analysis of practical cases, this article further reveals the significant advantages of PLC in improving industrial automation levels, reducing production costs, improving product quality, and enhancing system safety. In addition, this article also focuses on the exploration of integrated teaching methods for PLC control technology, aiming to optimize teaching methods, deepen students' understanding of PLC theoretical knowledge, and improve their hands-on ability and problem-solving skills. The exploration of this teaching method not only helps to cultivate more professional talents with practical abilities in PLC control technology but also provides strong support for promoting the wider application of PLC technology in industry.

2. Analysis of Control Method in the Robotics Industry

2.1. Characteristics of the Industrial Robot Industry

Taking the automotive manufacturing industry as an example, industrial robots are mainly used in welding, stamping, painting, assembly and other process flows. Due to their advantages of high efficiency, precision, flexibility, and safety, they greatly improve the production efficiency and product quality of the automotive industry [1]. The current problem is still the need to improve the technical accuracy of robot components to make the industry work more efficiently and produce higher-quality products. In the 1950s and 1960s, robots were in their early stages, and at that time, the way people assembled robots was still through workers manufacturing on assembly lines. But by 2024, many enterprises have adopted robot assembly. Adding PLC programming systems to robots can improve assembly accuracy, and error correction ability, and make industrial operations more efficient.

The control logic of electromechanical integration equipment based on PLC technology is achieved through state logic control between variables, such as changes in load or temperature, to achieve automatic control of the equipment [2].

2.2. Traditional Electrical Control in the Robotics Industry

In the innovation and research of aquaculture robots, the electronic control system of the robot is mainly composed of sensors, control units, and actuators, and the robot mainly relies on microcomputers to control the robot's action instructions [3]. Another example is a biomimetic robot used for climbing cement poles. In the electrical control design of this biomimetic pole climbing robot, 5G technology is used as the carrier for data transmission and mechanical control. A series of physical information such as current, voltage, resistance, impedance, and temperature are obtained through various sensors and induction devices. Combined with the collected image data information, neural network judgment is carried out, and a series of functions such as automatic fault analysis and report submission are achieved based on the results [4].

2.3. PLC Control in the Robotics Industry

In the electrical control system of a fabric robot, feedback control is achieved by transmitting feedback signals from PLC to servo drives. The input and output signals are the sensing and receiving units of the PLC, which are an essential part of the automatic control of the electrical control system of the fabric robot. PLC can achieve the function of receiving input signals and implementing control for specified output targets [5].

The advantages of PLC control can be seen as follows: the program can be modified on-site and programming is convenient and simple; the overall modular structure is easy to maintain; more stable and reliable than relay control devices; small size, which can save space for the control cabinet layout, also makes it more aesthetically pleasing; computers can monitor the production status of the production line at any time, detect and handle faults in a timely manner; the price is cheaper than relay control devices, saving costs.

2.4. Comparison between Traditional Electrical Control and PLC Control

2.4.1. Traditional electrical control

Traditional electrical control mainly uses hard-wired components such as relays, contactors, timers, counters, etc. to achieve logical control of circuits. This control method relies on the opening and closing of physical contacts to complete various switch operations, forming a fixed control logic circuit. The advantages are: simple and intuitive, due to its clear physical structure and easy understanding of control logic, design and maintenance are more direct for simple control tasks; lower cost, for small-scale or simple control logic systems, the initial investment cost of traditional electrical control is lower; stability, under appropriate maintenance, the durability of physical components can ensure long-term stable operation of the system.

However, there are also limitations, such as poor flexibility, once the control logic is determined, it is very inconvenient to modify and almost requires rewiring. And complexity limitation, because it is difficult to achieve complex control logic and large-scale control tasks. Also, frequent failures caused by contact wear and poor contact can affect system reliability. A large number of physical components also occupy a significant amount of installation space.

2.4.2. PLC control

A PLC is an electronic system that uses programmable memory to store instructions, perform logical operations, sequential control, timing, counting, and arithmetic operations, and interact with external devices through input and output modules to control mechanical equipment.

The advantages of PLC control analysis are high flexibility, the control logic can be easily modified through software programming to meet different control requirements; high integration, it integrates a large number of functional modules, such as analogue processing, high-speed counting, network communication, etc., reducing the need for external devices; strong reliability, adopting a scanning cycle working mode, with error detection and self-diagnosis functions, improves system stability; easy to maintain, monitoring and debugging can be done through the software interface, reducing maintenance difficulty and time costs.

However, compared to simple traditional electrical control, the initial hardware and software investment of PLC systems is higher. Programming, configuration, and troubleshooting require professional electrical engineers, which increases human resource costs. For extremely complex control systems, PLC programming and debugging may become quite complex, requiring more time and professional knowledge. Although modern PLCs respond quickly, certain applications with extremely high real-time requirements, such as microsecond-level control of high-speed robotic arms, may require special design or additional hardware support.

2.4.3. Comparison and analysis

PLC integrates the central processing unit, memory, and input/output interface modules, achieving integrated control of logic, arithmetic, counting, timing, and other functions [Chen Minghao]. Users can establish the control logic of the machine tool by editing the user program of the PLC, without the need for tedious circuit connections. Compared with relay control systems, PLC control structures are more flexible, and programming and maintenance are simpler and more convenient. PLC supports various digital and analogue input/output control signals and can achieve closed-loop control of temperature, pressure, displacement, and other parameters by configuring different modules, improving the control accuracy of the process. In addition, the high-speed computing capability of PLC can achieve complex batch production control, CNC interpolation calculation, and other functions. By adopting fieldbus technology, PLC can also be integrated with human-machine interfaces, sensors and other devices for networked control [6].

Although traditional electrical control methods are simple, intuitive, and cost-effective, they still have poor flexibility. Complexity is limited, and there may be high failure rates in certain fields that require extensive use of electrical control. At the same time, there is also a problem of a large number of physical components occupying a large installation space.

All in all, in different industries and fields, practitioners should have a clearer understanding of the advantages and disadvantages of traditional electrical control methods and PLC electrical control methods, and learn to flexibly choose control methods. For example, in the transmission mode of the production line, PLC control circuits can be chosen to achieve autonomous distribution. while in the field of oil production control, a new PLC has been designed to control the motor operation of the oil production machine, which can achieve independent monitoring of motor faults and more convenient control methods to achieve faster troubleshooting and more efficient oil production.

3. Suggestions for PLC Applications and Prospects for the Future

PLC is equivalent to a small computer system, mainly including a central processing unit (CPU), memory, input/output interfaces, and communication interfaces. It controls various mechanical equipment and production processes through programming instructions.

To improve the performance of PLC, firstly, the hardware should be improved, for example, to increase the memory. In daily life, if a computer does not have memory, it cannot perform storage tasks. Therefore, the memory of the PLC can be set to be larger, which can avoid insufficient memory for memory replacement and data transfer in the later stage. Furthermore, it is suggested to replace the CPU with a higher-performance one, which is the 'brain' of the PLC system. A level CPU can improve the overall performance of the system and better complete tasks when computing big data and complex tasks. Also, education should be more focused on practice rather than theory.

The current trend in the industrial industry is towards modularity, miniaturization, and modularization. The young generation needs to study PLC technology seriously to accelerate the process of intelligence. Through learning, modular production systems such as MPS can be developed. MPS is a production teaching system related to industrial automation control, involving multidisciplinary technologies such as machinery, sensing, detection, electronics, communication, etc. In this system, a series of technologies such as PLC programming can be learned, resulting in more modular systems [7]. Students can learn the installation, debugging, maintenance, and repair knowledge of modular automated production lines by controlling and debugging equipment, and acquire the professional skills required for their positions. After modularization, the program becomes more organized. It is suggested to correct and edit errors by modifying certain modules, ultimately achieving the goal of intelligence and modularization.

In the operation of water conservancy pumping stations, N500PLC intelligent monitoring technology is used. During the operation of water conservancy pumping stations, the I/O template of PLC is used to comprehensively collect data such as unit, buffer tank liquid level, AC contactor status, etc., transmit and perform logical operations to the CPU module to achieve the purpose of intelligent monitoring [8]. This intelligent monitoring system monitors the flow rate of the tank by monitoring the changes in the buffer tank liquid level, and outputs instructions to meet the normal operation needs of the pumping station after feedback to the PLC through sensors for processing

The latest information technology and control technology are integrated into the intelligent lighting system for daily life, which not only meets basic visual needs but also further maximizes energy efficiency and optimizes user experience. It not only meets people's daily lighting needs, but also optimizes energy distribution design through PLC, which can further improve the quality of life and accelerate the construction of smart cities. The control system uses PLC as the central control unit and collects parameters through various sensors to achieve control. The automatic dimming of the wall lamp can be achieved by adjusting the parameters in the PLC.

PLC programming involves multiple languages such as ladder diagrams, functional block diagrams, and instruction lists, and these languages can meet the needs of different programming habits and application scenarios. Some PLCs have started using high-level languages such as BASIC and C++ [9]. In intelligent lighting systems, the primary task of programming is to convert control strategies into specific program codes to ensure that the PLC can make correct control decisions based on input signals from sensors [10].

4. Conclusion

After an in-depth exploration of the application of PLC in industry, the following conclusions can be drawn: As a controller designed specifically for the industrial control field, PLC has been widely used in modern industry due to its unique functions and significant advantages. PLC, with a microprocessor as its core, integrates computer technology, automatic control technology, and communication technology, demonstrating a series of advantages such as high reliability, small size, powerful functions, simple and flexible program design, strong universality, and easy maintenance.

These characteristics make PLC play an irreplaceable role in multiple industrial fields such as metallurgy, energy, chemical industry, transportation, and power.

PLC has powerful functions and can control the operation of industrial equipment through programming, achieving automated control of the production process. Its programming method usually adopts a ladder diagram similar to a logic diagram, allowing programmers to intuitively and conveniently implement various control logics. In addition, PLC also has the ability to communicate with personal computers, which can be programmed and controlled through computers, further enhancing the usability and flexibility of PLC. In summary, the application of PLC in industry not only improves production efficiency and reduces labor costs, but also enhances the stability and reliability of the production process. Nowadays, PLC is developing towards diversified varieties, and programming languages are advancing towards advanced and diversified aspects. The programming language used by small and medium-sized PLCs tends to use ladder diagram language. The future industrial situation is developing towards miniaturization, intelligence, modularity, and other directions. In order to achieve this goal, more microcomputers and programming languages will be used in the industry to create intelligent industrial fields that replace manual labor. It is believed that the application of PLC will greatly increase and be optimized in future industrial development. Therefore, it is more important to improve the education system, enhance national quality, and ultimately achieve the goal of industrial intelligence. With the continuous development of Industry 4.0 and intelligent manufacturing, PLC, as one of the key technologies for industrial automation control, will continue to play an important role and contribute more to the high-quality development of industry.

References

[1] Wang Kunlun. The Current Situation, Competitiveness, and Future Development Strategies of China's Industrial Robot Industry. 2024. 3, 100036.

[2] Li Jingfei. Research on Intelligent Control of Mechatronics Equipment Based on PLC Technology. 2024, (12), 49 - 51.

[3] Zhao Qinzhe, Zhang Jianbin, Gu Tianle, Lou Jiawei, Shi Mofei. Innovation and research of aquaculture robots. 2024, 3, 7, B07.

[4] Chen Minghao, Wang Zhuo, Sun Yanan, Yang Haoyu, Liu Xiaoyang. Design of Biomimetic Robot for Climbing Cement Electric Poles. 2023, 01 - 088 - 03.

[5] Sun Yiqing. Design of Electrical Control System for Fabric Robot and Application of PLC Technology. 2024, 05 - 0086 - 03.

[6] Nie Lei. Design and Optimization of Electrical Control System for Forming Machine Tool Based on PLC. 2024. 6.

[7] Sun Shuwen, Ding Jiawang, Dong Mingjie, Huang Chao. Design and implementation of a modular production system practical teaching platform based on digital twins. 2024. 3, 100124.

[8] Zhang Lei. Research on Intelligent Technology for Operation of Water Conservancy Pumping Stations. 2024. 14 – 0005 - 04.

[9] Wang Ying, Wang Yan. A Preliminary Analysis of the Application Prospects of PLC.2015.

[10] Lv Ning. Control and Implementation of Intelligent Lighting System Based on PLC. 2024. 6, 06 - 108 - 03.