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Automatic Control Design of Pneumatic Solenoid Valve Based on Siemens PLC

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ABSTRACT

PLC control system is an advanced industrial control equipment that can achieve precise control of objects and respond quickly to them. This paper aims to propose an automatic control design scheme for pneumatic solenoid valves based on the Siemens miniature PLC (S7-200). This scheme realizes precise automatic control of pneumatic solenoid valves by integrating low-voltage electrical appliances (including C6 type air circuit breakers, 220V-to-24V power supplies, terminal blocks, etc.) with Siemens PLC technology. During the design process, the STEP7-MicroWIN SMART software was used for PLC programming, and comprehensive debugging was conducted to ensure stable system operation. The system features high automation, strong reliability, and easy operation, capable of realizing timing switching and automatic adjustment of pneumatic solenoid valves.

KEYWORDS

Siemens Miniature PLC (S7-200); Low-voltage Electrical Appliances; Assembly of Low-voltage Electrical Appliances; Automatic Control.

1. INTRODUCTION

With the continuous development of industrial automation technology, PLCs (Programmable Logic Controllers) play a crucial role in the field of industrial control as core control devices [1]. PLC technology boasts significant advantages in harsh factory environments due to its high reliability, strong anti-interference capability, and ease of programming. Pneumatic solenoid valves control the direction of gas flow through electromagnetic means, driving the piston movement of cylinders or hydraulic cylinders. They are widely used in automation equipment and industrial process control, especially in explosive and flammable hazardous locations [2]. This paper designs an automatic control system for pneumatic solenoid valves based on the Siemens miniature PLC (S7-200), aiming to improve production efficiency and automation levels. This system achieves precise control of pneumatic solenoid valves by integrating low-voltage electrical appliances with PLC technology. Through this research, we hope to provide an efficient and reliable solution for the automatic control of pneumatic solenoid valves.

2. OVERALL SYSTEM DESIGN

2.1. Initial System Scheme

The system composition is roughly divided into three parts: assembly of low-voltage electrical appliances, programming of the Siemens miniature PLC (S7-200), and comprehensive debugging.

(1) Assembly of Low-Voltage Electrical Appliances

The assembly of low-voltage electrical appliances is shown in Figures 1, 2, and 3, respectively.

Fig 1. Layout Diagram

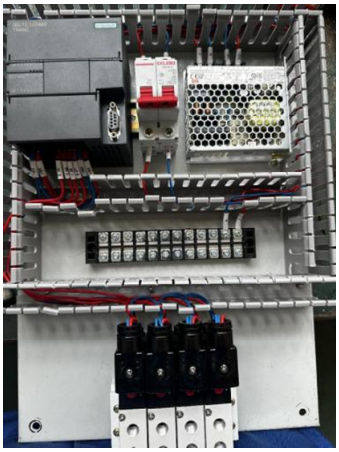

Fig 2. Wiring Diagram

Fig 3. Completed Diagram

(2) Programming of the Siemens Miniature PLC (S7-200)

The STEP7-MicroWIN SMART software was used for programming, as shown in Figure 4.

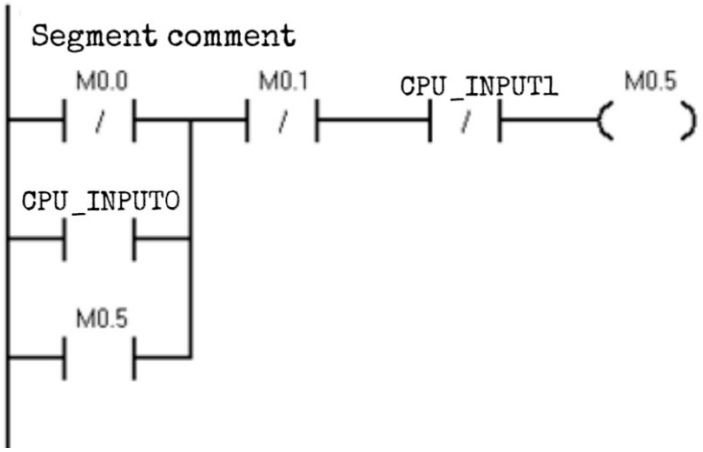

Fig 4. Programming

(3) Comprehensive Debugging

1) Programming of the Siemens PLC (S7-200)

2) Assembly of electronic components (switches, power supplies, terminal blocks, Siemens PLC (S7-200), pneumatic solenoid valves)

3) Setting the operating time or threshold for the pneumatic solenoid valve

4) Downloading the program to the PLC using STEP7-MicroWIN SMART software

5) Conducting power line testing after program downloading

2.2. Final System Scheme

Based on the above, the final system scheme is clarified as follows.

(1) Selection of low-voltage electrical appliances: C6 type air circuit breakers, 220V-to-24V power supplies, terminal blocks, AirTac 06 type pneumatic solenoid valves, Siemens miniature PLC SMART (S7-200)

(2) Adoption of the Siemens miniature PLC SMART (S7-200)

(3) Selection of the AirTac 06 type pneumatic solenoid valve

(4) Point setting for the PLC automatic control program

3. HARDWARE SYSTEM

3.1. Siemens Miniature PLC (S7-200)

The Siemens miniature PLC (S7-200) is a high-performance controller in the Siemens automation series. It integrates an advanced 32-bit processor and rich communication interfaces, featuring modular design and ease of programming. It is widely used in various automation control systems to meet complex control requirements in different fields [3,4].

3.2. C6 Type Air Circuit Breaker

The C6 type air circuit breaker is a circuit protection device with a rated current of 6A. It features high craftsmanship, stringent standards, and quality certification. Utilizing thermal-magnetic trip technology and flame-retardant materials, it supports tool-free installation. When the current exceeds its rated value, the C6 air circuit breaker can rapidly cut off the circuit, preventing electrical fires and ensuring electrical safety.

3.3. 220V to 24V Power Supply

The installation position of the 220V AC to 24V power supply has been carefully adjusted. The oscillator frequency is stably adjusted to 31kHz and has jitter suppression characteristics, significantly enhancing EMI performance. Additionally, this power supply has light and heavy load modes, making its standby time not exceed 50mW.

3.4. Binding Post

The binding post is an essential component in power amplifiers and speakers, serving as a terminal specifically for connecting speaker wires. It is typically made of highly conductive metal materials such as copper or brass, ensuring stable transmission of audio signals. It is an indispensable connecting element in audio systems.

3.5. Pneumatic Solenoid Valve

As an electromagnetically controlled industrial device, the pneumatic solenoid valve can effectively regulate pneumatic states. It can effectively block and release various emissions and adjust the valve position according to needs, thereby controlling and monitoring the pneumatic state. Its operating principle lies in that when the valve is open, compressed gas can be transported to various discharge outlets, causing the electromagnet of the pneumatic solenoid valve to generate current, thereby regulating the pneumatic state [5].

3.6. Overall Circuit Electrical Schematic Diagram

The overall circuit electrical schematic diagram is shown in Figure 5.

4. SOFTWARE DESIGN

4.1. Main Program Flow

Figure 6 illustrates the flowchart of the PLC main program. After powering on, the entire program needs to be manually started. Once started, it enters automatic control mode and can only be manually

shut down or automatically shut down at a set time. When certain conditions (manually set, such as time, pressure, etc.) are met, the timers and port working states within the PLC program change. After starting, once a certain value is reached, the starting point switches, and automatic control is achieved.

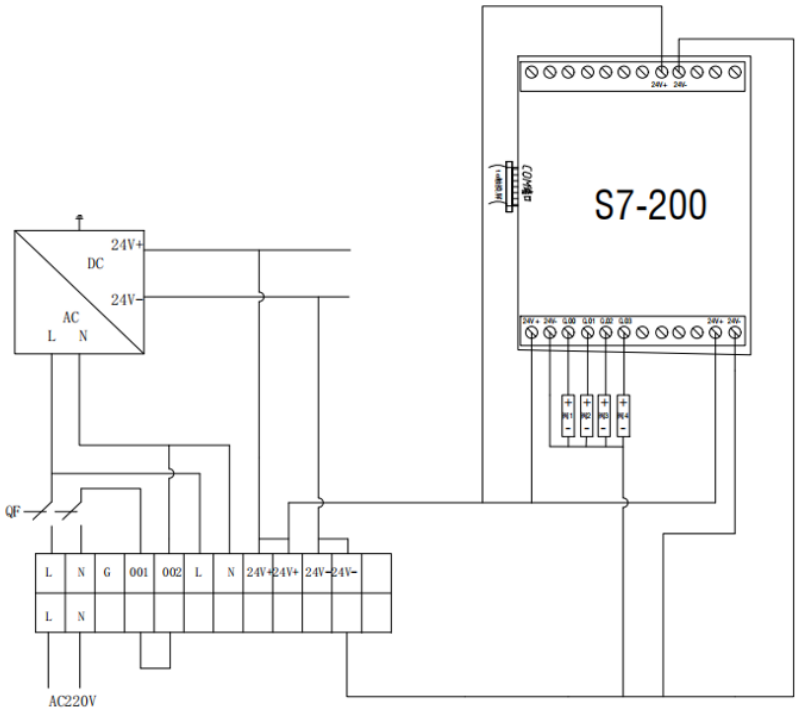

Fig 5. Electrical Schematic Diagram

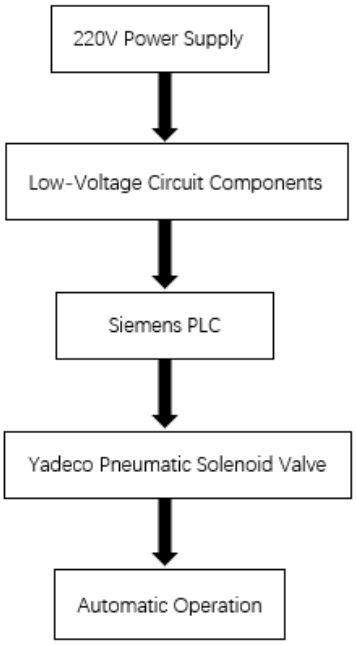

Fig 6. Main Program Flowchart

4.2. Control Point Program Flow

Figure 7 depicts the program flow for control points. This program uses timing triggers. During debugging, the pneumatic solenoid valve will automatically switch after a certain amount of time has elapsed, while the previously operating solenoid valve will stop working. This product has four

pneumatic solenoid valves. When a certain threshold is reached, they will automatically switch. One solenoid valve operates once, and four solenoid valves operating once constitute a group. After one group operates, it will automatically cycle until manually shut down.

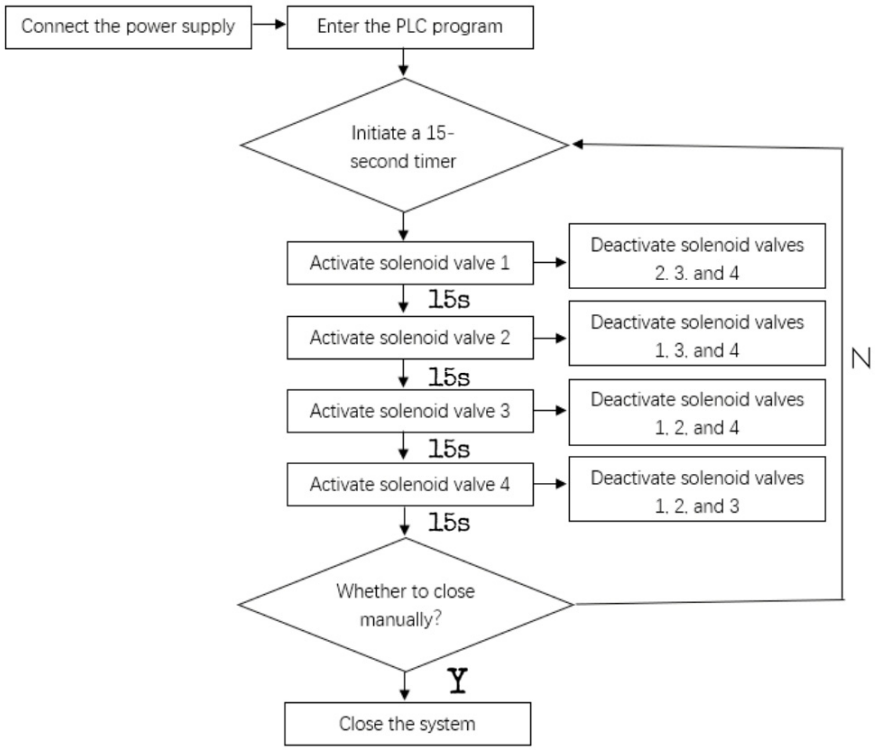

Fig 7. Control Point Flowchart

5. SYSTEM TESTING

This design connects the various components of the hardware system and integrates the subprograms into the software system. Upon initiation, the PLC program outputs a timed switching signal, which is then relayed through a timing module back to the PLC. Subsequently, the PLC transmits the timed switching signal to the pneumatic solenoid valve, causing it to automatically switch between valve bodies when a certain threshold is reached. After completing one cycle, the signal is automatically sent back to the PLC, which then proceeds to transmit the signal for the next cycle to the solenoid valve. When power is turned on and the program is written into the SMART (S7-200) PLC, the indicator lights on the PLC illuminate, signaling the activation of the entire system. Upon connecting to power, the online execution command must be initiated on the computer to enable automatic cycling of the process. To shut down the system, the stop command must be manually executed on the computer or the power supply must be manually disconnected.

6. SUMMARY

This paper designs and implements an automatic control system for pneumatic solenoid valves based on the Siemens miniature PLC (S7-200). By integrating low-voltage electrical appliances (including C6 type circuit breakers, 220V to 24V power supplies, binding posts, etc.) with PLC technology, a highly automated and reliable control system is successfully constructed. The PLC program was written using STEP7-MicroWIN SMART software and comprehensively debugged to ensure stable system operation. The system can achieve precise automatic control of pneumatic solenoid valves, including timing switching and automatic adjustment functions. Experimental results show that the pneumatic solenoid valve can automatically switch between valve bodies according to preset times

or thresholds and automatically cycle after completing one group of operations until manually shut down. This design not only provides an efficient and reliable solution for the automatic control of pneumatic solenoid valves but also offers new ideas and methods for the development.

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