

# Design of Control System for Vertical Injection Moulding Machine Based on PLC

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**Abstract.** In this paper, the working principle and control requirements of the vertical injection moulding machine are introduced. In view of the shortcomings of the traditional relay control system, such as large error, low precision and difficulty in maintenance, a control system scheme of vertical injection moulding machine based on PLC is proposed, and the whole process of software and hardware design of the control system is given. It has been proved by practice that the control system has the characteristics of high speed, high efficiency, high reliability and strong anti-interference ability, and can solve the problems of traditional control scheme well, which realizes the automatic control of the whole process of injection moulding machine.

## 1. Introduction

Injection moulding machine is a typical system which integrates machinery, electricity and hydraulics. It has become the main method of plastic processing because it is capable of forming complex products at one time and processing a variety of plastics, in addition, it has high adaptability and high efficiency in injection moulding. It is widely used in national defense, electromechanical equipment, automobile, transportation, building materials, packaging, agriculture, culture and education, hygienism and other fields of daily life. With the rapid development of the plastic industry, the injection moulding machine occupies an important position in both quantity and variety, thus becoming one of the fastest growing and most productive machines in plastic machinery<sup>[1]</sup>. China's plastic processing enterprises spread all over the country, and the technical level of equipment is uneven. Many injection molding machines use hydraulic system circuits, whose control parts are mostly electrical control. They have many defects such as complex hardware wiring, poor system reliability, low efficiency and inconvenient maintenance. Therefore, it is necessary to carry out technological transformation of traditional injection molding machines. Since PLC has the advantages of high reliability, convenient programming, strong anti-interference ability and convenient maintenance, it is chosen as the core of the control system to improve the intelligent control level of the injection moulding machine<sup>[2]</sup>.



## 2. Working principle of vertical injection moulding machine

This vertical injection moulding machine adopts screw type, and its working principle is similar to that of a syringe. First, grainy or powdery plastic is added to the cylinder, and the plastic becomes molten state by rotating the screw and heating the outer wall of the cylinder. Then the machine does the clamping and the injection seat moves forward, so that the nozzle is attached to the gate of the mould.

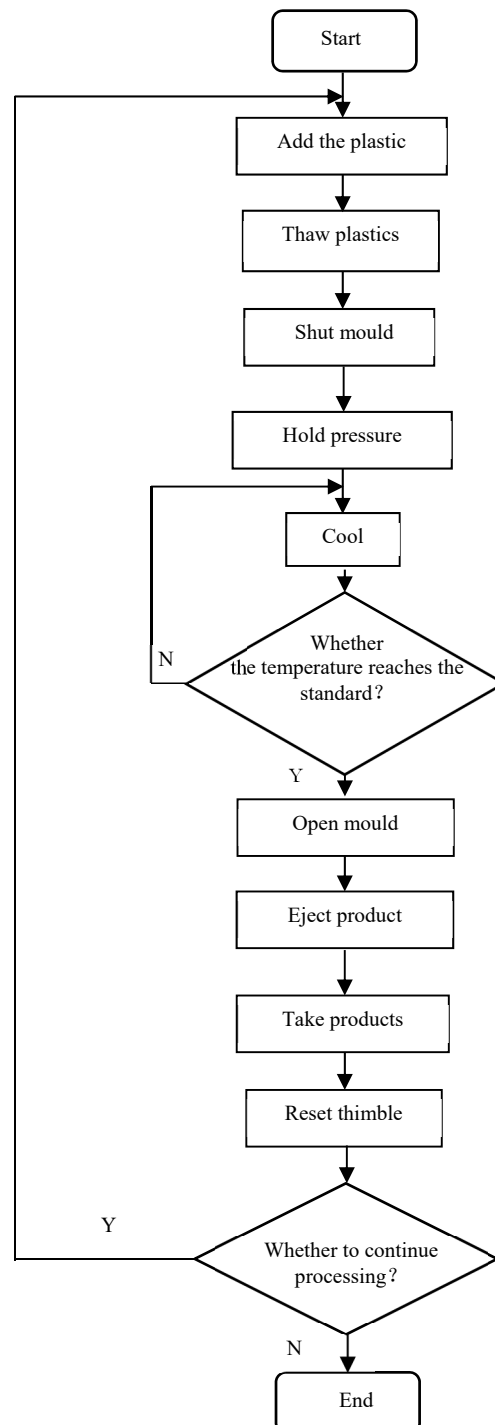


Figure1 Production process diagram of injection moulding machine

After that, the pressure oil is injected into the cylinder to push the screw forward so that the melt is injected into the closed mould with high pressure and high speed. After pressure maintenance and cooling for some time, the melt is solidified and the product can be taken out of the mould<sup>[3]</sup>. The production process diagram is shown in Figure 1.

### 3. Operation mode of vertical injection moulding machine

At present, there are three kinds of operation modes of the vertical injection moulding machine: manual, semi-automatic and fully automatic<sup>[4]</sup>.

#### (1) Manual operation

Manual operation mode mainly means that the operator handles the injection moulding machine through the buttons on the screen to achieve the relevant action, which is usually used in the initial debugging.

#### (2) Semi-automatic operation

Semi-automatic operation mode means that all other operations are completed by a predetermined program, except that the switch of the safety door is completed by the operator. This operation is generally used in the workshop with insufficient automation.

#### (3) Fully automatic operation

The full automatic operation mode means that all the movements of the injection moulding machine in the whole injection period are all automatically run according to the present program. This operation mode has high degree of automation and high efficiency, which is the main working way of the injection moulding machine at present.

### 4. Hardware design

The core of control system is PLC, and the control module is mainly composed of PLC input / output circuit. The PLC selected in this system is SIEMENS S7-200 series CPU226. According to the actual input and output situation, the I/O point assignment is shown in Table 1.

Table 1. I/O point assignment table

| Input point | Input signal | Remarks         | Output point | output signal | Remarks          |
|-------------|--------------|-----------------|--------------|---------------|------------------|
| X0          | SB1          | Start button    | Y1           | YV1           | Solenoid valve 1 |
| X1          | SB2          | Stop button     | Y2           | YV2           | Solenoid valve 2 |
| X2          | SB3          | Manual          | Y3           | YV3           | Solenoid valve 3 |
| X3          | SB4          | Semi-automatic  | Y4           | YV4           | Solenoid valve 4 |
| X4          | SB5          | Fully automatic | Y5           | YV5           | Solenoid valve 5 |
| X5          | SB6          | Electric eye    | Y6           | YV6           | Solenoid valve 6 |
| X6          | SQ1          | Travel switch 1 | Y7           | YV7           | Solenoid valve 7 |
| X7          | SQ2          | Travel switch 2 | Y8           | YV8           | Solenoid valve 8 |
| X8          | SQ3          | Travel switch 3 | Y9           | YV9           | Solenoid valve 9 |
| X9          | SQ4          | Travel switch 4 |              |               |                  |
| X10         | SQ5          | Travel switch 5 |              |               |                  |
| X11         | SQ6          | Travel switch 6 |              |               |                  |
| X12         | SQ7          | Travel switch 7 |              |               |                  |
| X13         | SQ8          | Travel switch 8 |              |               |                  |

### 5. Software design

The injection moulding machine is controlled in sequence. Its working cycle is started from the closed mould step by step, and every step execution makes the corresponding solenoid valve act. Travel switches or process are used to determine if each step is completed and decide whether to start the next step. Semi-automatic mode comes into force when X3 is closed. After a product is finished, it is in a waiting state. Until the safety door is closed again, the next cycle starts. When X4 is closed, fully automatic mode comes into force. After the product is finished (when the electric eye detects the drop

of the product), the next product is automatically processed. Then the cycle automatically continues like this<sup>[5]</sup>.

In Figure 2, the state component  $S_0$  is the initial state of the state transition diagram. The state components  $S_1$ -  $S_{10}$  are used to identify every step in the process. When PLC is powered up,  $S_0$  is placed. In this state, press down the start button  $X_0$ . When the safety door is closed,  $X_7$  will be closed and the action moves to the State  $S_1$ . That is the closed mould step. The next steps are followed in turn until the plastic parts are finished. After the product is taken out, if the semi-automatic operation mode  $X_3$  is closed, the reset signal is produced. The action state returns to  $S_0$  and the device is in the waiting state. Until the safety door is closed again, the next product processing cycle starts. If it is fully automatic operation mode,  $X_4$  is closed. When the electric eye detects the drop of the product,  $X_6$  is closed and the reset signal is produced. The action state returns to  $S_1$ , then the next product processing cycle starts<sup>[6]</sup>.

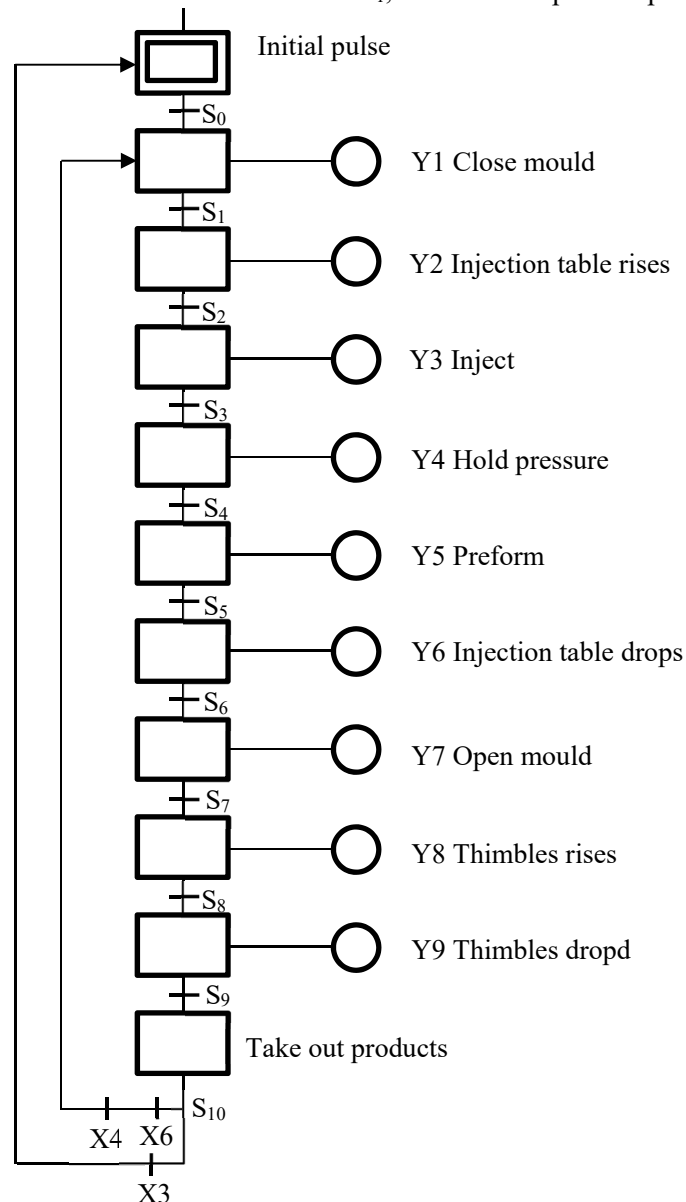


Figure2 State transition diagram

## 6. Conclusion

With the continuous improvement of the automation degree of control equipment, the economic, convenient and practical PLC has increasingly entered the field of industrial control, which greatly improves the reliability and automation level of the system. According to the injection moulding cycle process and the corresponding control requirements of the injection moulding machine, a control system based on PLC is designed in this paper. It overcomes the difficulties of the traditional injection machine such as low product precision, difficult equipment maintenance and low working efficiency, which improves the stability of the control system, reduces the failure rate and improves the rate of production efficiency. The control system is easy to be maintained and can change the action program at any time to meet the special requirements in production. It fully embodies the reliable, fast and flexible characteristics of PLC<sup>[7]</sup>.

After the application of PLC in the injection moulding machine, all the indexes of the system have been obviously improved, and a variety of complex control and protection those were hard to achieve in the past have been realized. The state transition diagram is used for programming, making the system program design simpler and quicker. In a word, the application of PLC makes the system have miniaturization, operation simplification and control intellectualization, which realizes the automatic control of injection moulding process and has high price-quality ratio.

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