Application of PLC-Based Stroke Control in Industrial Production

Xiaodan He¹, Xiaosheng Chen²,*

¹Guangzhou Huashang Vocational College, Guangzhou 511300, China;
²Huali College Guangdong University of Technology, Guangzhou 511325, China.

*Corresponding author Email: xiaoshengchen@gdut.edu.cn

Abstract. According to the requirements of large-stroke and high-precision positioning control in industrial production, the paper proposes a position closed-loop control system based on belt-type magnetic scale and PLC. The Siemens S7-200 PLC is used to capture the high-speed pulses of the magnetic scale in real time, realize the closed-loop automatic positioning control of the large-stroke position, and apply it to the plastic steel profile sawing centre control system, which solves the traditional stepper motor open loop at a lower cost. The accuracy problems caused by the control greatly reduce the threshold of precise positioning control, which has strong practical application value.

Keywords: PLC, travel control, position closed loop.

1. Introduction

With the continuous progress of modern science and technology, China's industrial field has gradually turned to the direction of automated control. As an emerging industrial controller, PLC not only has high reliability, but also has more advanced technology in the current industrial field. The PLC control system has been widely promoted and applied in the industrial field. As a relatively advanced technology at present, the PLC control system can fully replace the traditional power control system, so as to fully ensure that the high standards of accuracy, control, and reliability are met. At the same time, it can ensure the efficiency of industrial production and the quality of automated production. Fully increase the practicability of the system and fundamentally reduce the probability of system failure [1]. In the process of industrial production, we often encounter large-stroke, high-precision motion control requirements. The main task of the positioning control system is to precisely control the movement of the tool or material to complete the processing of each positioning point. If a full-function numerical control system is used to realize the positioning control function, although this system has perfect functions, it is expensive, and many functions are redundant for the positioning control of low-end machine tools.

Through the above analysis, it is proposed to use a belt-type magnetic scale displacement sensor to convert the workpiece displacement into a high-speed pulse signal, which is fed back to the PLC in real time, forming a position closed-loop stepping servo system. Set the positioning length and operating parameters through the touch screen to realize single-segment positioning and multi-segment continuous precise positioning of materials.
2. **Analysis of travel control principle and actual travel control algorithm**

2.1. **S-type speed reference curve and its parameter calculation**

The S-type speed reference curve is shown in Figure 1, where $0-t_2$ is the starting section, $t_2-t_4$ is the constant speed section, $t_4-t_5$ is the deceleration section, and $t_5$ is the crawling and stopping section. The basic speed formula in the speed reference curve is as follows. In the formula: $a_1$ is the maximum acceleration in the acceleration stage at the start, $m/s^2$; $a_2$ is the maximum deceleration in the deceleration stage, $m/s^2$; $r_{m1}$ is the rate of change of acceleration in the $0-t_2$ section, $m/s^3$; $r_{m2}$ is the rate of change in the acceleration of the $t_2-t_4$ section, $m/s^3$; $r_{m3}$ is the rate of change in the acceleration of the $t_4-t_5$ section, $m/s^3$.

![Figure 1. S-type speed setting curve](image)

\[
V_1(t) = \frac{1}{2r_{m1}t_2}, 0 \leq t < t_2
\]

\[
V_2(t) = \frac{a_1^2}{2r_{m1}} + a_1(t-t_2), t_2 \leq t < t_5
\]

2.2. **Analysis of stroke control algorithm**

The maximum operating speed is an extremely important parameter in the operating parameters of the hoist, and any change in it will result in a corresponding change in the operating curve. The following is a further analysis of the algorithm of stroke control on the change of $V_{\text{max}}$ value. Set in the deceleration section I, deceleration section II, deceleration section III and crawling section, the stroke distance is $\Delta S_1, \Delta S_2, \Delta S_3$ and $S_p$ respectively, then the total deceleration stroke distance $\Delta S = \Delta S_1 + \Delta S_2 + \Delta S_3 + S_p$. In the actual situation, the $V_{\text{max}}$ value is a variable value, either greater than the maximum given speed, or lower than the maximum given speed. If the $V_{\text{max}}$ value is greater than the maximum given speed, the deceleration point will be advanced; otherwise, the deceleration point will move backward, and the crawling distance will be kept constant by changing the deceleration point [2].

3. **Modification plan**

Our basic idea for the transformation of the original electronic control system is: retain the original electronic control system, add a set of all-digital electronic control system, make the two systems stand by each other, the structure of the entire electronic control system after the transformation is shown in Figure 2.
3

Figure 2. The electric control system diagram of the mine hoist after transformation

1. The original system's operation console, monitor, speed measuring machine, slip measuring device, wellbore head, brake shoe switch, temperature measuring box, hydraulic station, high pressure cabinet, auxiliary machine control cabinet and other equipment are not modified, and only German The 108 adapter of HARDIN Company switches the protection signal of the above-mentioned equipment so that it is shared by the two systems [3].

2. Use PLC to transform the depth control cabinet and master control cabinet to further improve the reliability of the system and the ability of fault diagnosis.

4. Centralized Control System

The sampling machine centralized control system is mainly composed of two parts: hardware system and software system. The basic structure of the system is composed of sampling machine, control circuit and control setting software. The control software can read the operating status of each sampling machine in real time [4]. When the sampling machine fails, it will flash an alarm and display the malfunctioning sampling machine on the display screen, which is convenient for maintenance personnel to repair and troubleshoot in time. As shown in Figure 3, it is the circuit diagram of the centralized control system. The automatic sampling machine process control system uses the travel switch as the detection signal, through the "event trigger" method, combined with the programmable controller "precise timing" system and powerful "logical reasoning" function, to achieve 24h for the pulp sampling machine Full process control. It is composed of core controller, power supply system, actuator and input and output channel processing, etc., and is installed in the control cabinet. When the automatic sampling machine is turned on regularly, all the working processes of sampling are completely under the automatic control of the control system.

Figure 3. Control circuit
4.1. Control circuit design and PLC program design
The control principle is very simple, realizing the forward and reverse rotation of the motor. Set when increasing the setting to make the motor act once in a certain period of time to realize automatic sampling. Due to the large number of sampling points, the single-point electrical device control failure rate is relatively high. In order to facilitate the monitoring of equipment operation and achieve centralized control, the PLC control scheme is adopted to reduce the device control links and reduce the frequency of failures. Do a simple design communication for single control design [5].

4.2. Analysis of control requirements
The controlled object's control requirements: as shown in Figure 4, the sampling slider waits at the limit switch X4. After the sampling set time, it starts sampling on the right line, and stops and continues to wait for the same time interval after encountering X3, Sampling in the left row, stop and continue to wait after encountering X4, so that it keeps working in a loop until the stop button X2 is pressed. Buttons X0 and X1 are used to start the right and left travel of the car respectively.

4.3. Program analysis and design
Suppose the car is empty when starting, press the left row start button X1, Y1 is powered, sampling starts to go left, when it touches the left limit switch, the normally closed contact of X4 is disconnected, making Y1 de-energized and sampling stops Go left. The normally open contact of X4 is turned on, so that the coils of Y2 and T0 are energized, and the delay starts. After the set time interval, the normally open contact of T0 is closed, so that Y0 is energized, and the sample is taken to the right. After the slider leaves the left limit switch, X4 becomes "0", the coils of Y2 and T0 lose power, stop delay, and T0 is reset. The analysis of the right-hand and delayed waiting process is basically the same as the above. If the stop button X2 is pressed while the car is running, the car will stop moving and the system will stop working. If the car stops at SQ1 or SQ2, even if the stop button is pressed once, the car will still start by itself. Solution: Add auxiliary relay to memorize the start signal.

4.4. Hardware analysis
When the system starts to work, it needs a start switch, occupying an input point. After the system is started, the system resets the robot to the initial position and waits for the signal to prepare for work, occupying an input point. When the robot successfully grabs the injection moulded part and moves to
the gas shear, the robot sends a signal to the gas shear through the PLC. The gas shear starts and waits for the arrival of the injection part, and the gas shear starts occupying an input point. When the robot grabs the injection moulded part and reaches the air shear cutting station, the PLC sends a cutting signal, the air shear starts to prepare for cutting, and controls the cutting to occupy an input point. After receiving the robot signal, the rotating cylinder moves, occupying an input point. Because the gate position on the injection moulded part is irregular, the guide rod cylinder and the rotary cylinder are required to adapt the air shear to a variety of stations to compensate for the insufficient stroke of the robot. The extension and contraction of the guide rod cylinder each occupy an input point. There are two input points. When the rotating cylinder needs to be rotated to 0° and 90° according to the position of the gate of the injection moulded part, each occupies one input point for a total of two input points [6]. When the cutting operation is completed, the PLC sends a signal to the robot, and the robot returns to the completion signal to occupy an input point. There are 10 input points in total, and the detailed input contact distribution is shown in Table 1.

Table 1. PLC input contact allocation table

| Input | name | Comment | Input | name | Comment |
|-------|------|---------|-------|------|---------|
| I0.0  | Switch: start | Start switch | I0.5  | Magnetic switch: the guide rod cylinder extends in place | The guide rod cylinder extends into place |
| I0.1  | Switch: reset | System reset | I0.6  | Magnetic switch: the guide rod cylinder retracts into position | The guide rod cylinder retracts into position |
| I0.2  | Air shear start | Robot controlled air shear start | I0.7  | Magnetic switch: rotary cylinder 0° position | Rotating cylinder 0° in place |
| 10.3  | Cut preparation | Robot controlled cutting preparation | 11.0  | Magnetic switch: rotary cylinder 90° position | Rotating cylinder 90° in place |
| 10.4  | Rotating cylinder action | Robot controls the action of the rotating cylinder | 11.1  | Cut complete | Robot return complete signal |

When the system starts, there is a start light for signalling, occupying an output terminal. When the robot grabs the parts successfully, the PLC will give a signal to the air shear to control the air shear to start, occupying an output port. When the air shear cooperates with the cutting gate, PLC controls the extension or retraction of the guide rod cylinder, and then sends a signal to the robot through the PLC, and the robot moves the workpiece to the cutting position. The extension and retraction of the guide rod cylinder are required Occupies two output ports. Similarly, after the rotating cylinder rotates to the 0° position or 90° position, the PLC sends a motion signal to the robot, and the robot moves the workpiece to the cutting position. The rotating cylinder rotates to the 0° position or 90° position to occupy two output ports. When the robot stroke is insufficient, the guide rod cylinder or the rotary cylinder alone cannot successfully cut the gate, so the guide rod cylinder and the rotary cylinder need to move together until the guide rod cylinder extends, the 0° position of the rotary cylinder or the guide rod cylinder extends. When the air shear reaches the guide rod cylinder extension, the rotation cylinder 0° position or the guide rod cylinder extension and the rotation cylinder 90° position, the PLC will give the robot a signal and the robot will move the workpiece to the cutting position. The coordinated movement of the guide rod cylinder and the rotary cylinder until the guide rod cylinder extends, the 0° position of the rotary cylinder, or the guide rod cylinder extends, and the 90° position of the rotary cylinder requires two output ports. Production safety in the factory is very important. When the system fails, an alarm indicator is needed to remind the operator that the alarm indicator occupies an output port. There are 9 output points in total.
5. Conclusions
The single-point and multi-point positioning control system of the feeding table is realized by using magnetic scale and PLC basic commands. Although it is not a closed-loop feedback system in the true sense, it can achieve higher positioning accuracy and operating speed, resulting in a larger stroke positioning control the technical threshold and development cost of the GS are greatly reduced, and it can replace the original expensive CNC system in many occasions. The design has been successfully applied to the development of the control system of the sawing centre for plastic steel profiles, achieving satisfactory positioning accuracy, and has good promotion value.

References
[1] Ahmad, H., Arya, A., Agrawal, S., Mall, P., Samuel, S. S., & Sharma, K., et al. Rutin phospholipid complexes confer neuro-protection in ischemic-stroke rats. RSC Advances, 6(99) (2016) 96445-96454.
[2] Crowson, C. S., Rollefstad, S., Ikdahl, E., Kitas, G. D., Riel, P. L. C. M. V., & Gabriel, S. E., et al. Impact of risk factors associated with cardiovascular outcomes in patients with rheumatoid arthritis. Annals of the Rheumatic Diseases, 77(1) (2018) 48-59.
[3] Ennis, K., Dotterman, H., Stein, A., & Rao, R. Hyperglycemia accentuates and ketonemia attenuates hypoglycemia-induced neuronal injury in the developing rat brain. Pediatric Research, 77(1) (2015) 84-90.
[4] Xiaonan, M. Vinpocetine inhibits nf-κb-dependent inflammation in acute ischemic stroke patients. Translational Stroke Research, 9(4) (2017) 1-11.
[5] Mendyk, A. M., Duhamel, A., Bejot, Y., Leys, D., Derex, L., & Dereeper, O., et al. Controlled education of patients after stroke(ceops)- nurse-led multimodal and long-term interventional program involving a patient's caregiver to optimize secondary prevention of stroke: study protocol for a randomized controlled trial. Trials, 19(1) (2018) 137-148.
[6] Li-Ming, L, Kuan-Hung, L., Li-Ting, H., Mei-Fang, T., Hou-Chang, C., & Ray-Jade, C., et al. Licochalcone a prevents platelet activation and thrombus formation through the inhibition of plcγ2-pkc, akt, and mapk pathways. International Journal of Molecular ences, 18(7) (2017) 1500-1508.