Installation and Debugging of Pneumatic Sorting Station in Flexible Automatic Production Line

Songtao Li¹, Xueguang Zhou²* and Xuxuan Liu²

¹ Dean’s office, Xuchang Electrical Vocational College, Xuchang, Henan Province, 461000, China
²Department of Information Security, Naval University of Engineering, Wuhan, Hubei Province, 430033, China
*Corresponding author’s e-mail: zxg196610@nue.edu.cn

Abstract. Vocational and technical colleges attach great importance to practical teaching. Automatic production line is an important equipment for practical teaching of required courses for mechanical and electrical majors and non-mechanical and electrical majors. On the basis of analyzing the composition of flexible automatic production line and training objectives, this paper gives the structure and workflow of pneumatic sorting station, summarizes pneumatic components, and gives installation and debugging steps.

1. Introduction

Automatic production line is composed of various automatic execution devices (including various execution devices, mechanisms, servo motors, solenoid valves, pneumatic devices, etc.). It is a production line that detects the working process and working state of each device through various detection devices (including various detection devices, sensors, instruments, etc.), and automatically carries out production operations according to the procedures required by the production process. In a word, an automatic production line is a production system that consists of a workpiece conveying system and a control system, connects a group of automatic machine tools and auxiliary equipment according to the process sequence, and automatically completes all or part of the manufacturing process of products.

In the 21st century, driven by computer technology, network communication technology and artificial intelligence technology, automation can produce intelligent control equipment, which will make the industrial production process have certain adaptive ability [1-3]. With the further development of all these related technologies supporting automated production, the functions of automated production technology are more complete, perfect and advanced, to complete more technically complex operations and products with higher production or assembly processes [4-5].

2. Flexible automatic production line

The flexible automatic production line can be divided into six links according to the station action flow: material conveying station A, pneumatic sorting station, pneumatic/servo sorting station, servo/vacuum sorting station, ROBOT multifunctional sorting station and material conveying station B. Seen figure 1.
Figure 1. Flow chart of flexible automation production line

The flexible automation production line mainly includes training bench, mechanical parts of typical mechatronics equipment, PLC module, pneumatic module, robot module, image processing module, MES system, button module, power module, simulation production equipment training module, terminal block and various sensors. The whole structure is open and detachable. The training device is for mechanical parts assembly. We can assemble production equipment according to existing mechanical parts or add mechanical parts to assemble other production equipment so that the whole device can flexibly assemble electromechanical integration equipment with production function according to teaching or competition requirements. This equipment is suitable for the practical training teaching of the compulsory course modules such as Programmable Controller Technology, Electrical, and PLC Control Technology. They are specialized in mechanical and electrical equipment installation and maintenance, electrical operation and control, electrical technology application, electronic appliance application and maintenance, and non-mechanical and electrical majors.

3. Pneumatic sorting station

3.1. Training objectives
Master the functions and characteristics of basic pneumatic components such as linear cylinder, single electric solenoid valve, etc., and be able to form basic pneumatic system, connect and adjust air circuit. Master the structure, characteristics and electrical interface characteristics of sensors such as magnetic switch, photoelectric proximity switch and proximity switch in the production line, and be able to install and debug each sensor in the automatic production line. Master the method of writing single sequence control program with step instruction, and master basic function instructions such as subroutine call. Be able to complete the installation and adjustment of the unit within the specified time, design and debug the control program, and solve the common problems during installation and operation.

3.2. Structure and workflow
The structure of pneumatic sorting station is composed of workpiece tooling plate, workpiece feeding device, support frame, finger cylinder, drag chain, valve group, terminal block assembly, PLC,
emergency stop button and start/stop button, wiring trough, bottom plate, etc. Among them, the structural composition of the mechanical part is shown in figure 2.

![Figure 2. Structure composition of pneumatic sorting station](image)

Action flow of pneumatic sorting station: when the tooling plate flows to this station, the Z-axis cylinder moves down to the chute, the finger cylinder clamps the gear, the Z-axis cylinder moves up, the Y-axis cylinder extends out, and the Z-axis biaxial cylinder moves down again, placing the gear in hole position 1 on the tooling plate, the Z-axis cylinder extends back and then returns to the initial position; Repeat the fetching action, put the second gear in hole position 2 of the tooling plate, then move the tooling plate once, repeat the fetching action, put the 3rd and 4th gears in hole positions 3 and 4 of the tooling plate respectively, then move the tooling plate once again, repeat the fetching action, put the 5th and 6th gears in hole positions 5 and 6 of the tooling plate respectively, and then the tooling plate flows to the next station.

4. Pneumatic components of pneumatic sorting station

4.1. Standard double-acting linear cylinder

Standard cylinders refer to cylinders whose functions and specifications are universally used, whose structure is easy to manufacture, and which manufacturers usually supply to the market as general products. According to the different number of directions controlled by air pressure, the two directions of cylinder movement can be divided into single-acting cylinder and double-acting cylinder.

The single-acting cylinder inputs compressed air into the air-port at one end of the cylinder head to extend (or retract) the piston rod, while the other end restores the piston rod to its initial position by spring force, dead weight or other external force. The single-acting cylinder only needs compressed air in the action direction, so it can save half of the compressed air. It is mainly used in clamping, material returning, blocking, press in, lifting and feeding operations.

According to the position of the return spring, the acting cylinder is divided into a pre-retracted cylinder and a pre-extended cylinder, seen in figure 3. When the spring is installed in the rod cavity, the initial position of the piston rod of the cylinder is in the retracted position due to the acting force of the spring, which is called the pre-retracted single-acting cylinder. When the spring is installed in the rodless cavity, the initial position of the cylinder piston rod is the extended position, which is called the pre-extended cylinder.
Figure 3. Schematic diagram of single-acting cylinder

Double-acting cylinder is the most widely used cylinder. The action principle is that compressed air is input from the air-port at the end of the rodless cavity. If the force of air pressure acting on the left end of the piston overcomes various reactive forces such as motion friction and load, when the piston advances, the air in the rodless cavity is exhausted through the air-port at the end and the piston rod extends out. Similarly, when compressed air is input into the air-port at the end of the rod cavity, the piston rod retracts to the initial position. Through the alternate intake and exhaust of the rodless cavity and the rodless cavity, the piston rod extends and retracts, and the cylinder realizes reciprocating linear motion. Seen in figure 4.

Figure 4. Schematic diagram of double-acting cylinder

Double-acting cylinder has the advantages of simple structure, stable output force and selectable stroke based on requirements. However, because compressed air acts alternately on the piston to realize telescopic movement, the effective action area of compressed air during retraction is small, so the force generated is smaller than the thrust generated during extension.

To make the movement of the cylinder stable and reliable, the moving speed of the cylinder should be controlled, and the common method is to use one-way throttle valve. One-way throttle valve is a flow control valve formed by parallel connection of one-way valve and throttle valve, which is often used to control the movement speed of cylinder, so it is also called speed control valve.

The function of one-way valve is realized by one-way sealing ring. Figure 5 shows a sectional view of a one-way throttle valve. When the air is exhausted from the exhaust port of the cylinder, the one-way sealing ring is blocked and the one-way valve is closed. At this time, the throttle lever can be moved up and down by adjusting the handwheel to change the opening of air flow, thus achieving the throttling effect. On the contrary, during air intake, the one-way seal ring is swept away by air flow, the one-way valve is opened, compressed air directly enters the air intake port of the cylinder, and the throttle valve does not work. Therefore, this throttling mode is called exhaust throttling mode.
Figure 5. Sectional view of one-way throttle valve in exhaust throttling mode

Figure 6 shows the connection schematic diagram of two exhaust type one-way throttle valves installed in the double-acting cylinder. When compressed air enters from the A end and exhausts from the B end, the one-way valve of the one-way throttle valve A opens and quickly inflates the rodless cavity of the cylinder; Since the one-way valve of the one-way throttle valve B is closed, the air with rod cavity can only be exhausted through the throttle valve. Adjusting the opening of the throttle valve B can change the moving speed of the cylinder when it extends out. On the contrary, adjusting the opening of throttle valve A can change the moving speed of the cylinder when it retracts. This control method can ensure the stable operation of the piston, and this is the most commonly used method.

Figure 6. Schematic diagram of throttle valve connection and adjustment principle

The throttle valve is provided with a quick connector of the air pipe, and the pipe can be connected by inserting the air pipe with a proper outer diameter into the quick connector, which is very convenient to use. Figure 7 is the cylinder with the throttle valve of the limit cylinder with quick connector.

Figure 7. Cylinder with throttle valve installed
4.2. Single-control electromagnetic reversing valve and solenoid valve set
The so-called “position” refers to the different working positions of the valve core relative to the valve body to change the air direction. Seen in figure 8.

![Figure 8. Working principle of single electric control electromagnetic reversing valve](image1)

The meaning of “way” refers to the communication port between the reversing valve and the system, and the number of communication ports means the ways of the working position. There are only two working positions with air supply port P, working port A and exhaust port R, so it is a two-position three-way valve.

Figure 9 shows the graphic symbols of two-position three-way, two-position four-way and two-position five-way single-control electromagnetic reversing valve, in which there are several squares, and the “┷” and “┯” symbols in the squares indicate that the interfaces are not connected with each other.

![Figure 9. Graphical symbols of some single electric control electromagnetic reversing valves](image2)

The two solenoid valves are centrally installed on the bus bar. Mufflers are connected to the ends of the two exhaust ports in the bus bar, and the function of the muffler is to reduce the noise of compressed air when it is exhausted to the atmosphere. This integration of a group of control valves composed of multiple valves, muffler, bus plate and other components is called valve group, and the functions of each valve are independent of each other. The structure of the valve group is shown in Figure 10.

![Figure 10. Solenoid valve set](image3)

![Figure 11. Working principle of pneumatic control circuit of feeding unit](image4)
4.3. Pneumatic control circuit
The channel which can transmit compressed air and make various pneumatic components act according to certain rules is called pneumatic control loop. The control logic control function of pneumatic control loop is realized by PLC. Working principle of pneumatic control circuit is as shown in Figure 11. 1A and 2A are the pushing cylinder and the ejecting cylinder, respectively. 1B1 and 1B2 are magnetic induction proximity switches installed at two extreme working positions of the ejector cylinder, and 2B1 and 2B2 are magnetic induction proximity switches installed at two extreme working positions of the ejector cylinder. 1Y and 2Y are the electromagnetic control ends of the electromagnetic valves for controlling the ejector cylinder and ejector cylinder, respectively. Generally, the initial positions of these two cylinders are set in the retracted state.

5. Commissioning and Operation
- Adjust the pneumatic part, and check whether the air circuit is correct, the air pressure is reasonable, and the movement speed of the cylinder is reasonable.
- Check whether the installation position of the magnetic switch is in place and whether the magnetic switch works normally.
- Check whether I/O wiring is correct.
- Check whether the installation of photoelectric sensor is reasonable and the distance setting is appropriate to ensure the reliability of detection.
- Run the program to check whether the action meets the task requirements.
- Debug various possible situations, such as whether the system can work reliably under the condition of insufficient workpieces in the chute; If there is no workpiece in the chute, can it meet the control requirements?
- Optimize the program.

6. Summary
This paper is an attempt of bilingual practice teaching. Firstly, it proposes the teaching goal of pneumatic sorting station in flexible automatic production line. On the basis of analyzing the composition, workflow and pneumatic components of this station, the debugging and operation scheme of pneumatic sorting station is given.

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