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Research Article

Design of Automatic Sorting System of Workpiece Based on Multi-sensor Detection

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Abstract: The sorting system applies multi-sensor technology, PLC technology, pneumatic technology and frequency converter technology to realize the efficient automatic sorting of workpieces and solve the problem of automatic sorting of more complex shaped products. Through running test, the system has high efficiency, reliable operation, strong practicability, and great application value in automatic production lines such as mechanical processing, electronic assembly and article circulation.

Keywords: PLC; Automatic Sorting System; Automatic Control

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1 Introduction

With the increasing social demand for logistics services, sorting as an important part of logistics operations has attracted more and more attention. Studies have shown that the sorting operation is the link that consumes the most labor, time and cost.

The use of manpower accounts for about 50% of the whole logistics center, the operation time accounts for more than 60%, and the activity cost reaches about 40% of the total cost of the logistics center [1-2]. Therefore, the automatic sorting system is a necessary facility of modern advanced distribution center[3-4].

In the automatic production line, the PLC control is generally adopted, which has the advantages of strong resistance to interference, low requirement to environment, high reliability, simple program and the like. Many production lines are related to the classification and processing of items, literature[5-6] proposed the workpiece sorting system composed of PLC, frequency converter, etc., but haven't come up with good solutions to the software design, literature [7-8] proposed visual assistance sorting method, but the visual equipment cost is high, and the algorithm is trouble, literature [5-6] proposed two kinds of automatic sorting system for special purposes. In this paper, a simple and practical automatic sorting system is designed for general situations, the system solves several problems encountered in the establishment of automatic sorting system, and puts forward a scheme based on multi-sensor detection. The designed sorting system is efficient, energy-saving, anti-interference and realizes efficient and automatic control.

2 Composition and Control equireme-nts of Sorting System

2.1 Composition of Sorting System

The main function of the automatic sorting system is to sort the workpiece that has been processed and assembled, and store the workpiece of the same color and material in the corresponding feeding slot. Its main structure includes motor drive and transmission mechanism, workpiece detection mechanism, pneumatic sorting mechanism and PLC control module[3]. The structure and composition of the automatic workpiece sorting system are shown in Figure 1.

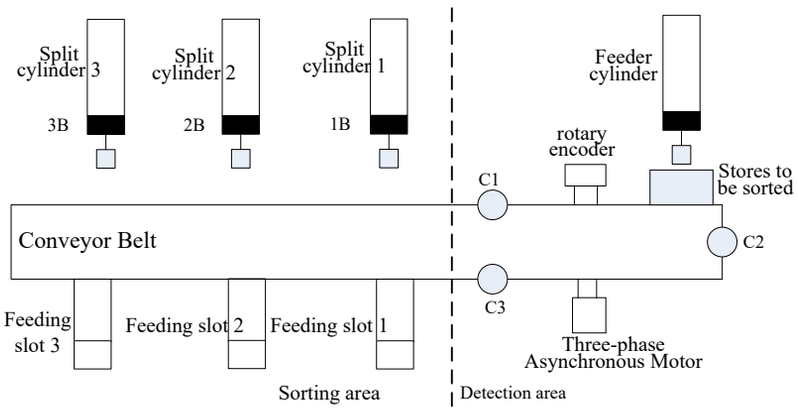

Figure 1. Composition of workpiece sorting system

(1)The motor drive and transmission mechanism are mainly composed of frequency converter, three-phase asynchronous motor, conveyor belt, transmission roller and rotary encoder, etc., whose function is to transport the workpiece to be sorted to the designated position through the conveyor belt, and carry out position detection.

(2) The workpiece detection mechanism is mainly composed of photoelectric sensor, inductive sensor and optical fiber sensor, among which the photoelectric sensor is used to detect whether there is a workpiece, the inductive sensor is used to detect the external material of the workpiece, and the optical fiber sensor is used to detect the color of the core material.

(3) The pneumatic sorting mechanism is mainly composed of three cylinders, including split cylinder 1, split cylinder 2 and split cylinder 3, and three magnetic switches, such as C1, C2 and C3, as well as three solenoid valves controlling the cylinder and related gas circuit accessories. Its function is to use the cylinder to push the sorted workpiece into the relevant feeding slot.

(4) The PLC control module is mainly composed of Siemens CPU224XP host, operation buttons and indicator lighst, whose function is the control core of the whole system.

2.2 Control requirements for the sorting system

There are two zones on the conveyor belt of the automatic sorting system, namely the detection zone and the sorting zone. When the combined workpiece to be sorted is placed on the conveyor belt, the conveyor belt starts to run, and the rotary encoder starts to record the operating position of the workpiece. Only when the workpiece runs to the position of the optical fiber sensor S1 and the inductive sensor S3 will the two sensor signals be effective for the detection of core materials' color and external workpiece materials' detection. When the core material of the workpiece is white and the external material is metal, and when the workpiece runs to the position of feeding slot 1, the conveyor belt stops running, and the pushing cylinder 1 acts to push the combined workpiece into the feeding slot 1; Similarly, when the core material is white and the external material is plastic, the combined workpiece will be pushed into the feeding slot 2; When the core material is black, the combined workpiece will be pushed into the feeding slot 3. The rotary encoder converts the position information of the workpiece into high-speed pulse signal and sends it to the PLC digital input port, and the high-speed counter (HSC) function is used for position detection.

3 Design of sorting system

3.1 Analysis of sorting process

According to the automatic sorting process of workpiece, after the power is turned on, the stand-by indicator light is on, the air pump starts to work, and if the cylinder is not reset, it will wait for the cylinder to reset. After pressing the start button, the start button transmits the signal to PLC, and the PLC controls the corresponding solid-state relay to work, the solid-state relay controls the motor to power on, the motor drives the drum through the coupling, and the drum drives the conveyor belt to work.

After starting to place the workpiece to the conveyor belt, the workpiece of different height triggers the photoelectric switch of different height which transmits the signal to PLC, and the PLC controls the corresponding solid-state relay which controls the corresponding electromagnetic reversing valve to work. When the electromagnetic reversing valve works, the direction of outgassing is changed to make the cylin-

der work. After the cylinder working, it is based on the speed of the cylinder to set the working time of the electromagnetic reversing valve, which ensures that the cylinder is fully extended to pushed out the workpiece. After the workpiece is pushed out, the electromagnetic valve is cut off, the electromagnetic reversing valve is reset, the outgassing's direction is changed, and the cylinder is reset under the action of air pressure. The sorting of the workpiece is completed, and the control flow is shown in Figure 2.

Figure 2. Control low chart

3.2 Design of pneumatic control circuit

The sorting mechanism of the automatic sorting system is composed of three linear cylinders as the actuator of pushing action, which are respectively controlled by three single-acting and two-position five-way electromagnetic reversing valve. When the solenoid valve is electrified, the cylinder extends. The rate at which the cylinder extends or retracts is controlled by a one-way throttle valve in the form of exhaust throttling. The magnetic switch is used to detect the position of the cylinder piston. When the cylinder is detected to be in position, it sends a signal in position to the PLC. The pneumatic control circuit of the automatic workpiece sorting system is shown in Figure 3.

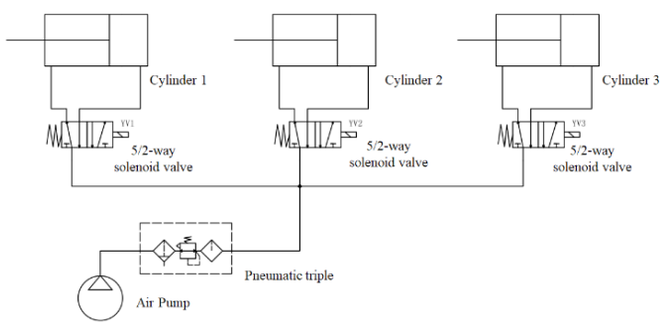

Figure 3. Aerodynamic schematic diagram of the sorting device

3.3 Software Design of Control system

Mitsubishi FX1N-32MT of CPU224XP type is selected as the controller of the automatic sorting system. The host unit has 16 digital input ports and 12 digital output ports, as well as 2 analog input ports and 1 analog output ports. During the connection of analog output ports, terminal V and M are connected to the analog input AIN 1+ and AIN 1 end of MM440 frequency converter respectively, to output the voltage signal of 0~ 10v, corresponding to the output frequency 0~ 50Hz of the frequency converter, thus realizes the high and low speed operation of the inverter. The I/O distribution of the automatic workpiece sorting system is shown in Table 1.

Table 1. I / O distribution table of PLC for automatic workpiece sorting device

Serial Number	Input Address	Notes	Serial Number	Output Address	Notes
1	X0.0	Start button (green)	1	Y0.0	Start indicator (green)
2	X0.1	Stop button (red)	2	Y0.1	Standby indicator (red)
3	X0.2	Optical fiber sensor S1	3	Y0.2	Electromagnetic valve YV1
4	X0.3	Optical fiber sensor S2	4	Y0.3	Electromagnetic valve YV2
5	X0.4	Inductive sensor S3	5	Y0.4	Electromagnetic valve YV3
6	X0.5	Cylinder 1 magnetic switch C1	6	Y0.5	DIN1 terminal of inverter
7	X0.6	Cylinder 2 magnetic switch C2	7	AQW0	Frequency setting of inverter
8	X0.7	Cylinder 3 magnetic switch C3			

3.4 Design of the control circuit

The circuit of the control system is designed according to the control flow of the automatic sorting device, the I / O distribution table of PLC and the electrical components used, as shown in Figure 5.

Combined with the control flow of the automatic workpiece sorting device, the I/O distribution table of PLC and the electrical components used, the circuit of the control system is designed, as shown in Figure 4.

4 Conclusion

This sorting system applies multi-sensor technology, PLC technology, pneumatic technology and frequency converter technology to realize the efficient automatic sorting of workpieces and solve the problem of automat-ic sorting of more complex shaped products. Through running test, the system has high efficiency, reliable op-eration, strong practicability, and great application value in automatic production lines such as mechanical pro-cessing, electronic assembly and article circulation.

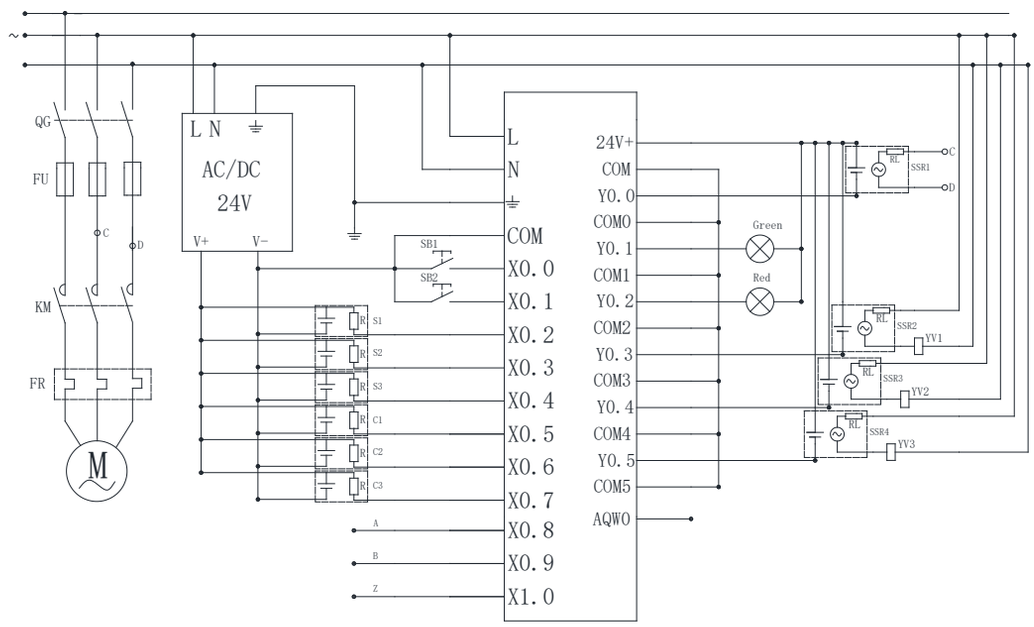

Figure 4. Sorting device control circuit diagram

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