Control of Powder Material Automatic Batching System based on PLC

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Abstract. Aiming at the characteristics of powder material, such as easy to dust, easy to leakage, polluting the environment and harmful to human body, an automatic batching system for powder material is designed. The system adopts a quantitative weighing device with buoyancy weighing sensor as the core, feeding with electric vibration feeder and 16 small cups. Simatic S7-1200, the latest generation of Siemens PLC, is used to control the system. 2304HS42A1 motor of Hamderburg Company, Germany, is used to control the movement of the cup on the workbench. The software control scheme of the system is designed. Practice has proved that the system runs stably and has good performance, which is worth popularizing.

1. Introduction
The batching process is an important procedure in metallurgy, mining, coking, rubber, ceramics, cement, grain, friction materials and other industries. Some people call it the "throat" in the production process of industrial enterprises. It vividly compares its importance in the whole production process[1].

In industrial production, the measurement and control of powder material is a common problem in continuous production line. Because the powder material has fine particles, strong fluidity, easy to dust, easy to run away, impurities, and will pollute the environment, so the measurement and ingredient of powder material has always been a concern of engineers and scholars. Many Chinese and foreign scholars have done research in this area[2-7].

In the production line of friction materials, as the key link of production, the material pressing workshop is in a backward state with flying dust. The proportioning process has long been stagnated in the state of using manual or semi-automatic weighing and proportioning. The production efficiency is low and the working environment is poor. It is easy to cause mismatch in the proportioning process. The proportioning accuracy is affected by the quality and mood of personnel. Therefore, the emergence of automatic proportioning system is urgently needed. Therefore, we design an automatic batching system controlled by PLC.

2. System Composition
The system consists of two parts: one is quantitative weighing system and the other is automatic batching system.

2.1 Quantitative weighing system
Quantitative weighing system consists of storage bin, feeding system, weighing and measuring system, conveying equipment and central control system. As shown in Figure 1.
The system is driven by a vibration motor, and the feeding quantity is determined by the vibration amplitude of the motor. It is suitable for the occasion where material fluidity is poor and batching accuracy is high, such as powder material. The simple process of quantitative weighing is: starting the feeding device, the material enters the weighing hopper under its own gravity, and the hopper is equipped with buoyancy weighing sensor. The weight signal of the hopper is converted from buoyancy weighing sensor to corresponding voltage signal. The voltage signal is amplified by amplifier and sent to the computer for data processing. When the predetermined value is reached, the feeding is stopped and completed. Weighing once. Buoyancy weighing sensor is the core of the system and the key to ensure the accuracy of quantitative weighing [8].

2.2 Automatic batching system
Sixteen storage cups are designed in this system, as shown in figure 2. The material cup is mounted on a cross slide platform, which drives the material cup to move through the movement of the slide platform. The sliding platform can move in X and Y directions, which are realized by stepping motor driving ball screw pairs. Stepping motor is controlled by PLC.

Fig. 1 Quantitative weighing system block diagram

Fig. 2 Diagram of feeding Sequence
2.3 The control requirement
The system has two working modes: manual mode and automatic mode. The sliding platform can not only run back and forth between 16 stations, but also can be adjusted manually. In automatic mode, press the start button to start the slide, press the stop button, and stop the slide after one step. In manual mode, set four direction control buttons (click), X+, X-, Y+, Y-, press any button slider to move, the loose button slider will stop immediately.

3. The System Design

3.1 Hardware design
Stepping motor is used to control the sliding platform. The system block diagram is shown as Figure 3. The new generation small PLC of SIEMENS S7-1200 is used as our control core. Which has integrated PROFINET interface, powerful integration technology function, strong expansibility and high flexibility design. The fully integrated TIA portal software is used to program. The SIMATIC S7-1200 controller integrates two high-speed outputs, which can be used as the output of pulse sequence and the output of tuning pulse width. It can fully meet the requirements of the system [9].

3.2 Determination the number of I/O points
The system requires the following input signals: a hand/self-switching switch (2 points) to control the working mode of the slide. A start button and a stop button. Four click buttons control the movement of the slide in four directions: X+, X-, Y+, Y- respectively. One origin limit switch, X and Y end limit switches. A total of 11 input points are required.

The system needs the following output signals: two high-speed pulse output terminals are used to drive stepper motors in X and Y directions respectively. Two directional control bits control the direction of the slide (stepper motor steering), one operation indicator and one stop indicator. A total of 6 output points are required.

The I/O allocation table is as follows.

| input | function  | output | Function          |
|-------|-----------|--------|------------------|
| I0.0  | Start Button | Q0.0   | X direction Pulse|
| I0.1  | Stop Button  | Q0.1   | Y direction Pulse|
| I0.2  | Manual mode  | Q0.2   | X direction control|
### 3.3 Software design

#### 3.3.1 Parameter Calculation

Obviously, the displacement of the slider is proportional to the total rotation angle of the stepper motor. Therefore the controlling of the material cup position can be achieved by controlling the angle of stepper motor. The rotational angle of the motor is proportional to the number of pulse input. So you can determine the numbers of pulse output of PLC according to the cup spacing.

#### 3.3.2 Program design

The modular programming method is adopted, which consists of four modules: main program, manual control program, automatic control program and initialization subroutine. The program structure diagram is as follows.

Each subroutine is called in the main program. Initialization subroutine is used to set the starting and stopping speed, maximum running speed, acceleration and deceleration time of stepping motor. Manual program is mainly used to adjust the equipment. Through automatic program, each cup can be controlled to feed under the weighing hopper in turn. The automatic program adopts the sequential control program design method, and its function flow chart is shown as figure 4.
4. Conclusion
It is proven that the system is easy to operate, high reliability and low cost. Which Greatly improve the production efficiency in friction material production line, reducing the labor intensity and avoid dust hazards to workers' health. It is worth promoting the use to the related industries.

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