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The Design of Large Packaging Production Line System Based on Embedded Technology

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Abstract

A design of jumbo packaging production line system based on embedded technology, through the STC89C52 microcontroller as the core control chip, rational allocation of the various modules, and the hardware selection and circuit design, system of jumbo packaging production line and the simulation presented in view of the problems in the present jumbo packaging production line of low degree of automation. Through study and design of jumbo packaging line control system, and through the experiment validation were used to collect the test data, verify the theoretical derivation and system design of correctness. Through the analysis of experimental data, test results and theoretical analysis results are consistent, indicating the reliability of the jumbo packaging production line system. At the same time, it is found that the accuracy of the synchronous rotation of the servo motor is compared with that of the fuzzy PID control algorithm and the common control algorithm. Therefore, it is concluded that the fuzzy PID control algorithm in the multi motor synchronous control effect is good, more able to meet the design requirements.

Keywords: *packing line; embedded control system; circuit design; fuzzy PID; multi axis controller*

1. Introduction

The automation of revolutionary change method of manufacturing packaging and control methods. The design of modern automatic packaging machine adopts advanced technology, based on the analysis of the product function, through innovative design, system modeling, dynamic analysis, dynamic optimization, in order to get the optimal design scheme [1]. Jumbo cotton packaging lines are used for a certain type of jumbo cotton packaging production line, which is used to achieve cotton labeling, taped, sealing, end a series of seal. Currently existing packaging method is essentially artificial or semi artificial and semi automatic mechanical way and need to artificial tape, label, loaded with a plastic film bag, terminated, bezel. Only a small part of the packaging line using PLC as control system. PLC is used as controller update lag and the scan cycle is too long, it can not meet the needs of the subsequent function improvement and optimization.

Jumbo cotton packaging lines in the jumbo cotton material thickness tend to be able to achieve a 2-75mm, jumbo roll diameter close to 1m, coil width approximately 1.5-2m, and smaller diameter of the central cylinder of material volume. Due to the thickness of jumbo cotton material large, loose material, larger volume characteristics, once one of the processes is a problem, the entire packaging line need to check and adjust. This will result in the detection of reliability and stability, lower production efficiency, and a lot of work, but the most important is the personal safety of workers there is also a danger. The second paper introduces the contril method of motion of embedded vision [2]. In view of these questions, this article has carried on the thorough research. The control system takes the embedded control system [3-4] as the core to realize the function of collecting, displaying

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and storing the data in real time, and the collected data is transmitted to the controller. The controller adopts the modular design, has the advantages of strong portability, good commonality, easy to manage and maintain, and the corresponding algorithm of multi axis control is also studied.

2. Overall Scheme Design

Jumbo cotton packing line includes five steps, as shown in Figure1.

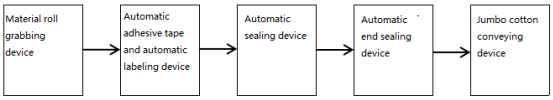

Figure 1. Process Flow Chart

In this paper, the running route of roll material is optimized, so that the material running route is always perpendicular to its axis，at the beginning of the station that is automatically affixed to the tape device can be flipped through the design of the population position to support the production line in the fault can be switched to manual packaging, subsequently, by applying the roll up to the label process, the gravity potential energy which can be used to enhance the height of the lifting height can be used in the following movement. Material roll in after automatic week sealing device, automatic end sealing device decreased height, gravity potential energy for material roll rolling of the kinetic energy conversion, which can reduce to sealing, end sealing in the process of driving device, the device is simplified, and reduces the cost. The automatic loading device can complete the iron frame, a plurality of rolls of material into a rectangular frame work, in the end after completion, which has solved the problem of long - time non - woven cotton large volume material can not realize the full automatic packing [5] . Jumbo cotton automatic packaging line specific. As shown in Figure2.

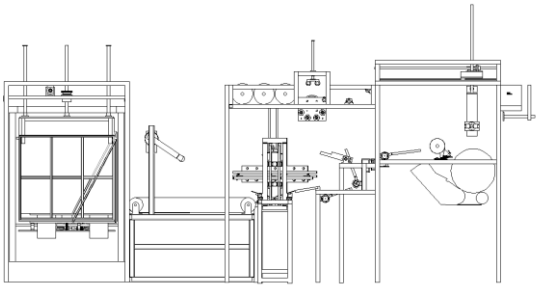

Figure 2. Jumbo Cotton Automatic Packaging Line

3. System Hardware And Software Design

According to the general requirements of the system function，the control task of this system is mainly the application of the cylinder and the control of the motor. The output port of the single chip through control relay links off to control on-off of the electromagnetic valve, control the cylinder and the extended and retracted, clamping or loosening. The single chip microcomputer sends different period and the number of pulses to the motor driver to control the motor speed and the stroke. This system chooses STC89C52 single chip microcomputer as the core controller. Because the control object of the system is more, each part is basically a magnetic switch as the detecting element, which constitutes the control system, which is composed of servo system and relay as the executive component. At the same time, the need for adequate I/O ports, in order to meet

the specified requirements, preliminary consideration to the system programming of simple circuit and accurate, simply select the STC89C52 microcontroller I/O port pin is far from enough, so in order to increase the number of I/O port pins, using 8255 as the expansion of the chip, the whole system control flow chart. As shown in Figure3.

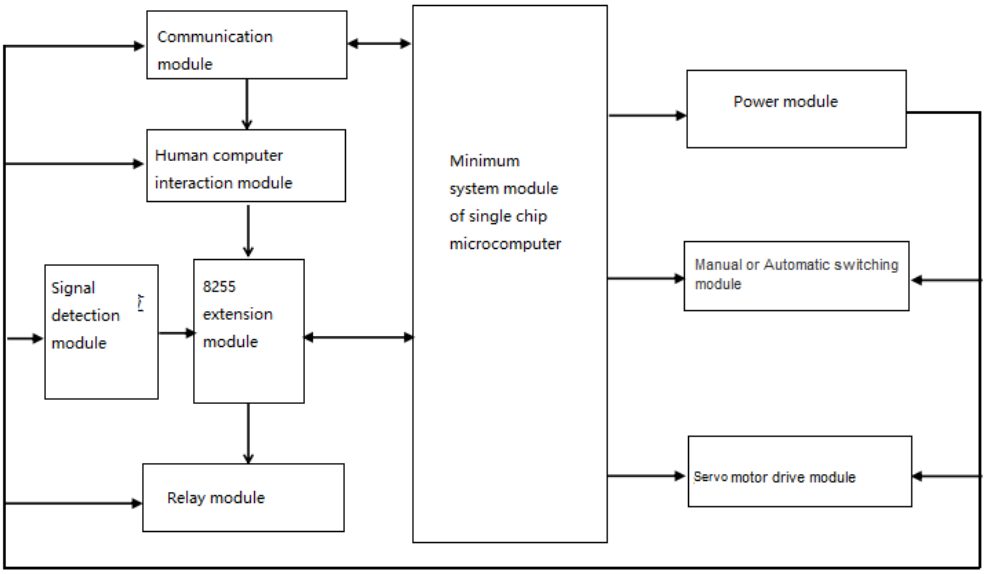

Figure 3. Flow Chart of System Control

The system uses the modular design method[6], where the interface of the electric appliance on the substrate is consistent with each function block. It is the carrier of the function connection, the main function of which is to provide each function block in the above fixed position and the base of all kinds of electrical appliances. The upper and lower base plate is connected by DuPont line, power line design in the respective substrate according to the principle of electromagnetic compatibility design, arrangement of lines. And then I made the embedded control system according to the similar design method. As shown in Figure4.

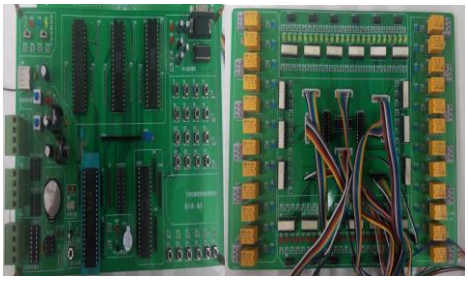

Figure 4. Embedded System Real Photos

3.1. Minimum System Module and Peripheral Circuit of Single Chip Microcomputer

The minimum system module and the core chip of the peripheral circuit are: STC89C52, LM7812, LM7805, MAX232.

The minimum system of single chip microcomputer, the most important part of the single chip microcomputer, generally includes single-chip chip, power circuit, clock circuit, reset circuit, *etc.* Microcontroller chip is a micro controller produced by Shenzhen macro crystal company, including high performance, low power consumption and so on.

Besides it has a capacity of 8KB size in the system programmable Flash memory. The 40 pin dual in line package, according to pins function, can be devided into three parts: power supply and clock pin, a control pin, I / O pins. Power circuit is the fortieth pin connected to the +5V power supply VCC, and the twentieth pin ground GND. Clock circuit is used to generate the control clock signal, MCU's internal clock circuit is by the combination of the internal high gain inverting amplifier with a quartz crystal, clock circuit with two ceramic capacitors, capacitor and the crystal should be as maximum demand and the chip installed recently, reduce the interference of parasitic capacitance and ensure the reliability of the oscillator, a solid. At the same time there will be the impact of temperature. The reset circuit is a single chip initialization process, so that the reset pin is higher than two machine cycles, you can make it reset. Not included into the normal initialization of the system, due to run the program error or the operation error the system into the dead cycle, in order to get rid of the deadlock state and need to with the reset button to make the RST pin is high level, so that this chip can restart[7].

Power conversion module can be said to be an indispensable part of the MCU application system, its main function is to supply power for the whole system. Power conversion circuit in addition to ensure low power consumption, but also must be stable and anti-interference. Using external 24V power supply, through the chip LM7812 and LM7805 conversion, to meet the requirements of power supply. In the power circuit, the capacitors C1 and C2 belong to the decoupling capacitor, and the function is to eliminate the high frequency signal and the noise signal on the power line. Capacitors C3, C4 and C6, C5 belong to the bypass circuit, the role is to eliminate interference and stabilize the power supply voltage. In the power supply interface to install the power indicator D1, the role is to detect whether the system has power supply, but also to the resistance R3, used to protect the circuit; Finally, a total power switch, the role is to control the total system power supply. At the same time we should pay attention to a particularly important issue. When the temperature is too high voltage chip and its regulator will become worse and worse, and even burned, need to add heat sink to ensure chip does not overheat of their cause adverse effects. The hardware circuit is shown in Figure5.

Hand / automatic switching module can achieve manual control and automatic control of the switch, in which the manual control is to rely on the operation of the keyboard to control each action individually; Automatic control is the ability to control, to achieve the continuity of action. Through the communication module can realize the online program download and related data information transmitted to the microcontroller, the microcontroller to save the data information.

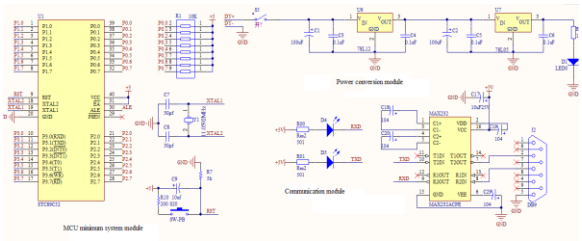

Figure 5. Minimum System and Peripheral Circuit

3.2. 8255 Extension Module

Due to the process requirements of the control system, need to extend four 8255, used to expand the pin , the signal acquisition circuit, the relay control module and the keyboard control circuit are used to transmit the information, which is highly versatile and flexible [8]. Each of the 8255 most important is CS, A0, A1. Only these three lines connected to the address line. The four 8255 chip selection terminal of the CS

respectively connected to the microcontroller p2.7, p2.6, p2.5, P2.4. Other P2 port address lines all vacant; address selection end A0 and A1 are respectively connected with the SCM P0 mouth. When CS is low, the selected 8255; when A0, A1 is 00, the selected is 8255 of the A port, and the rest of the useless side are all set to 1. So the first 8255 of the A port, B port, C port and control port address are 7FFCH, 7FFDH, 7FFEH, 7FFFH; The second 8255 of the A port, B port, C port and control port address respectively BFF3H, BFF7H, BFFBH, BFFFH; the third 8255 of the A port, B port, C port and control port address respectively DFCFH, DFDFH, DFEFH, DFFFH; the fourth 255 of the A port, B port, C port and control port address respectively for EF3FH, EF7FH, EFBFH, EFFFH. The hardware circuit is shown in Figure6.

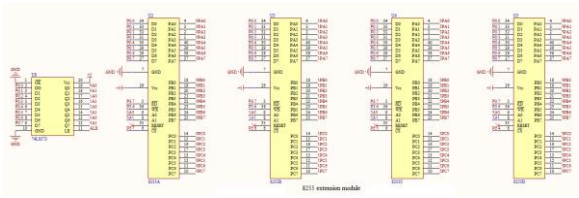

Figure 6. 8255 Extension Module

3.3. Input Circuit Module

Input circuit module includes signal acquisition circuit and keyboard control circuit. The role of the signal collection circuit is checking the cylinder piston and conveyor belt's running condition. Magnetic sensor switch is used to check the function of cylinder piston. When the cylinder slowly close to the magnetic switch, magnetic switch will gradually be interacted, at this time contact point will close and signal can be found. When the magnetic of the cylinder deviate from induction switch area, magnetic reed gradually lose the magnetic induction at this time, and then make off contact, won't produce signal. In a similar way, proximity switch sensor detection is made to ensure the conveyor belt in place. When the large volume of cotton to the induction area for proximity switch, proximity switch will lose the ability of contact anything, No pressure, no spark, and sending electrical instruction quickly, reflecting the position of the large volume of cotton accurately, output the signal and large volumes of cotton at the same time. hardware circuit as shown in Figure7.Due to there is too much input command and data, the function is relatively complex, so choosing matrix keyboard is a great way to complete the product line of manual control.

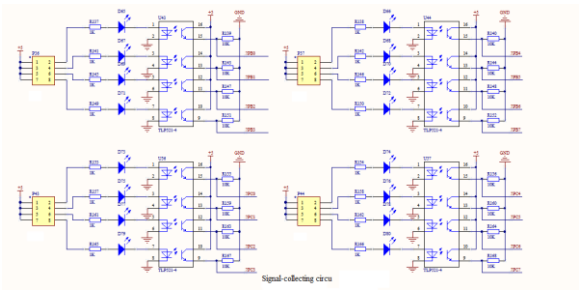

Figure 7. Signal Acquisition Circuit

3.4. Output Circuit Module

The output circuit module includes an electric motor drive module, a relay module[9] and a liquid crystal display module. Relay module comprises a total of 31 channels, each

channel is connected to a relay. A relay control electromagnetic valve of a cylinder, by controlling the cylinder solenoid valve, and then control the corresponding cylinder to complete the corresponding action; Relay is actually a small current to control an automatic switch to run large current, and the relay module is the use of relay on-off control solenoid valve fault and control of the corresponding cylinder is extended and retracted. Through the liquid crystal display circuit, the state of each action is displayed, so that the operator knows the current operation state of the packing line, and is convenient for control.

3.5 Software Design

This paper use C language to write the large volume of packaging production line control system by adopting the idea of modularization. We could finish MCU program initialization after connecting the power supply circuit, control circuit and pressing the power switch. Then judge if it could run automatically. Then judge detection fault, if there are faults, we should raise the alarm, then after troubleshooting, return to the single-chip microcomputer program initialization. If no fault is detected, the implement process should be conducted, if it do not run automatically, we could execute the specified action manually. As shown in Figure8.

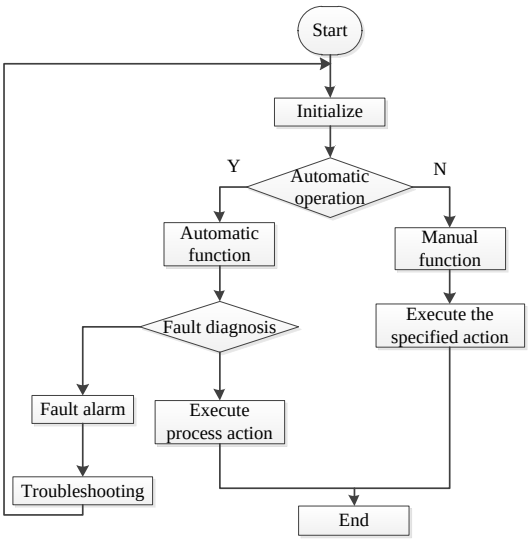

Figure 8. Main Program Flow Chart

4. The Test

4.1. Debug of SCM System Module

Minimum system's stability is a prerequisite for work throughout the system, In the case of electricity to ensure that the minimum system to carry out the test. The measure of the crystal is the most key of the normal vibration work of Minimum test system, the method used is to measure the voltage between two pin detection crystal. Since the minimum system power supply voltage is +5V, two pin voltage normal operation of the crystal value at about 2V. Simultaneous detection of two pin waveform judgment between crystal. As shown in Figure9.Crystal pin voltage display 2.01V, the crystal is 11.11MHz, similar to the actual oscillator frequency, prove that the minimum system is normal.

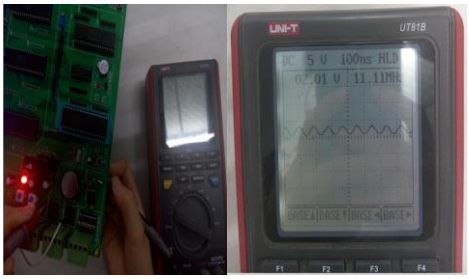

Figure 9. Minimum System Debugging

4.2. Research on Multi Axis Control Algorithm Based on Fuzzy PID

The test is after the sealing of jumbo, labeling, transported jumbo to the shifting plate at the specified location by manipulator, the dial plate and the blanking plate combined with exercise, the jumbo smoothly through the curtain shape plastic film completed part of the jumbo coating.

In this step the switch plate is static, the blanking plate to rotate clockwise, when transferred to a certain angle, the blanking plate began to make contact with the plastic film, and push the plastic film together in a clockwise rotation, complete the large part of the coating. At present, the common method is the independent control of the single machine, By detecting the signal in place of the jumbo, At the same time monitoring the respective line speed for end seal, the main advantage of this is that the method is simple. However, due to the inertia of the motor itself and the impact of the hysteresis of the sensor in the detection in place, the control effect of the line speed is not good enough. The multi axis synchronization control proposed by this control system is very good to eliminate the influence of these factors.

4.2.1 Multi Axis Synchronous Control Method

In the control algorithm, there are the traditional PID control algorithm, fuzzy control [10], sliding mode variable structure algorithm [11], robust H^{∞} control, *etc.*

Although the latter two kinds of algorithms are better than the first two kinds of results, but the algorithm is complex and to achieve a certain difficulty in the application. Through consulting the related literature, the control precision of the PID control algorithm is very high, but it can not guarantee the speed. The dynamic performance of the fuzzy control algorithm can meet the requirements of the system, but there is a systematic error. The fuzzy PID control algorithm combines the advantages of the two, in order to meet the dynamic performance and has a high control accuracy [12].

Multi axis synchronous control requires there synchronous control of the servo motors, due to the three motor rotation so that the discharge plate membrane, blanking plate, dial plate are moving at the same time. There is to ensure speed of three servo motors that can not have a big deviation in the whole process of movement, when the shifting plate or others servo motor disturbance and the two other of the servo motors need to follow the motor disturbance corresponding detection, and to make the corresponding adjustments. Using velocity compensation principle of the servo motor speed compensation, that is to carry out the automatic detection through the of three sets of servo motor output , by modulating the feedback is to adjust the servo motor of the input pulse, so that the command speed of three servo motors to achieve the purpose of the synchronous rotation of the servo motor.

The principle of synchronous control of three servo motors is shown in Figure10. N indicates the set speed value, N_1 indicates the output of the servo motor 1, N_2 indicates the

output of the servo motor 2, N_3 indicates the output speed of the servo motor 3. V_1 indicates the actual speed of the servo motor 1, V_2 Indicates the actual speed of the servo motor 2, V_3 indicates the actual speed of the servo motor 3.

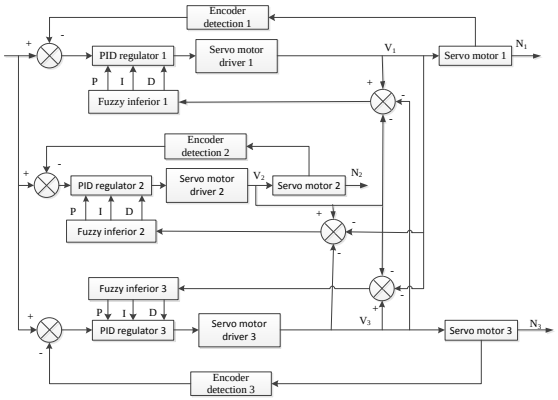

Figure 10. Principle of Synchronous Control of Three Servo Motors

4.2.2. Fuzzy PID Control System

The core of the fuzzy PID control system is the combination of PID controller and fuzzy controller. On the basis of the fuzzy logic reasoning method, According to the variation rate of the deviation, the three parameters K_P, K_i and K_d of the PID control system are adjusted to make dynamic control. PID controller according to the latest three parameters, output control quantity to meet the different stages of control parameters, the control system remained relatively stable. The fuzzy PID controller is precisely to avoid the disadvantages of the fuzzy control and PID control algorithm, and make full use of the advantages of the control algorithm. Compared with the digital control system, the control algorithm is implemented by software. Fuzzy control is the imitation of human thinking, the use of fuzzy language to simulate people's operating habits and common sense reasoning. The input of the fuzzy control system is the output deviation and the rate of change of input, so as to realize the control of the industrial process. Fuzzy control system including fuzzy, knowledge base, fuzzy reasoning and fuzzy, etc[11]. The basic structure is shown in Figure11.

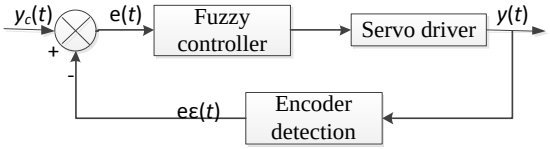

Figure 11. Structure of Fuzzy Controller

The control principle of fuzzy control algorithm is that: The encoder real-time acquisition the angular velocity value of switch-plate, blanking plate and release axis. The value compared with the expected value, the input variables are fuzzy reasoned. feedback to the microcontroller, every once in a while, calculate the number of pulses, achieve the speed of motor. The fuzzy control principle diagram is shown in Figure12. The fuzzy control rule base is composed of a series of "if-and-then" statements, and its general control principle is that: When the error of the angular velocity increases, the frequency of the pulse signal is reduced, and the error should be reduced quickly; When the angular velocity error is reduced, in addition to eliminating the error, but also to preventing

unnecessary overshoot of the generating system to singlechip ensure the stability of the system.

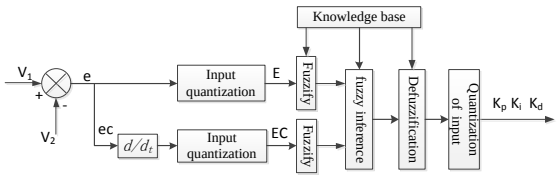

Figure 12. Schematic Diagram of Fuzzy Control

In the figure, $y_c(t)$ for the desired angular velocity; $e(t)$ for angular velocity error; $ec(t)$ E for the angular velocity error variation (That is, the current detection of angular velocity minus the previous sampling time feedback angular velocity deviation), The decreasing pulse frequency signal $\Delta p(t)$ is obtained by the two inputs of $e(t)$ and $ec(t)$. Angular velocity error e, angular velocity error variation ec as the input variable of the fuzzy controller, which are defined as follows:

$$e(t) = y(t) - y_c(t) \tag{4.1}$$

$$ec(t) = y(t) - y(t-1) \tag{4.2}$$

Among them: $y_c(t)$ for the desired angular velocity; y for the encoder detection value.

5. The Results of the Experiment

In the control system, by testing shaft seal device of the three processes, using normal algorithm and fuzzy PID algorithm respectively, get the following data, as shown in Figure13.

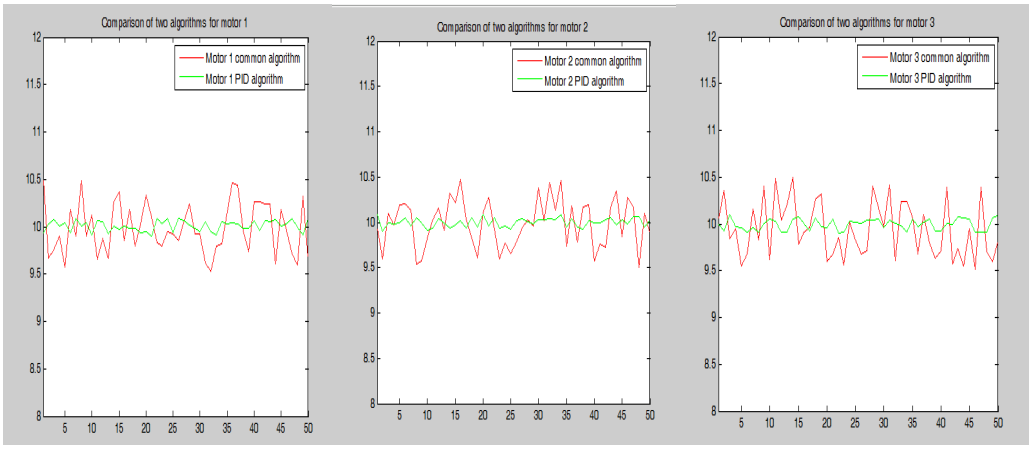

Figure 13. Test Data Distribution Curve

As can be seen from Figure13, the range of data obtained by the common algorithm is very large, which is beyond the range of control speed, but the test data obtained by the fuzzy PID algorithm is relatively stable, and meet the requirements of the control speed. In order to further evaluate the effect, calculate the standard deviation of the several groups of the test data respectively.

$$s_m = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{4.3}$$

Where: n for the measurement of the number of times; x_i for the measured value of the i's times ; $\bar{x}$ for the average value of the 10 measurements.

By calculation, the standard deviation of the common control algorithm of the motor 1, 2, 3 are 0.0598, 0.0553, 0.0541; the standard deviation of the fuzzy PID control algorithm are 0.2695, 0.2649, 0.3000. Compared with the fuzzy PID control algorithm, the standard deviation can be accurately obtained by comparing the standard deviation, and it is not stable and can not satisfy the requirement of the control system. In summary, the fuzzy PID algorithm proposed in this paper is better than that of the general algorithm, further proved the validity of the method.

6. Conclusion

This paper presents a jumbo packaging production line system which is based on embedded technology jumbo, reasonably configured modules, and the selection and design of the hardware circuit, system of jumbo packaging production line and is verified by simulation, and the general algorithm and fuzzy PID algorithm of coating volume in the process of multi axis synchronous control. The results show that the standard deviation of the fuzzy PID algorithm is 0.0598, 0.0553 and 0.0541, respectively, and the standard deviation is 0.2695, 0.2649 and 0.3000, respectively. It can be known that the fuzzy PID control algorithm and the common algorithm of high precision servo motor synchronous rotation. At the same time, it is concluded that the fuzzy PID control algorithm in the multi motor synchronous control effect is good, can meet the design requirements. Through this based on Embedded Technology Jumbo packaging production line system, can effectively improve the automation level and production efficiency of the enterprise.

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