Control System Design for Feeding Machine of Sound Absorption Board Production Line

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Abstract: This paper introduces a kind of mechanical structure and its control system, with which granular materials can be put into mould with a higher leveling status, the mechanical structure adopts split type arrangement, its function is to achieve the material removal and scraping, its control system is composed of a plurality of Mitsubishi PLC using master-slave control method. The mechanism and control methods can be widely applied in automatic production lines, which needs granular material into the mould quantitatively and passively wiped flatly.

Keywords: Anti interference technology, feeding machine, leveling material accurately, stepper motor.

1. INTRODUCTION

Perlite sound absorption board has these features as list: sound-absorbing, absorb the moisture, fire safety, anti-static, lightweight, environmental friendly etc, in line with the development trend of decorating material with lightweight and environment friendly, in line with the characteristics of sound absorption material contains no fiber and without secondary pollution. When the automatic production line works, four layers of perlite powder are required at the bottom, middle, upper and surface of the mold, and in the two interfaces between two different layers of the middle and bottom, the middle and upper each place a layer of barbed wire, therefore, flatness and thickness of each layer of material powder have strict requirements, can appear otherwise defective or waste products. So it's clear that the feeding system is an important and complex process system that ensure sound-absorbing board quality, and the control system is the core of the whole process, so this paper focuses on the feeding machine's control system.

2. THE STRUCTURE OF FEEDING SYSTEM

The feeding system of perlite sound absorption board production line is designed as a kind of automatic equipment that smooth the material evenly for the perlite products such as sound-absorbing board, this system is also suitable for other small diameter solid particles that need to be strickled with relatively high flatness (for the next process). Fig. (**1**) is a three-dimensional model for feeding system using Pro/E software [1]. Feeding system is mainly composed of RECLAIMER, Scraper and Control System. The main function of RECLAIMER is to take a certain volume of granular from the hopper box and fill in the mold beneath the mechanism; the main function of scraper is to strickle material accumulated in the mold to a relatively smooth stature, no material shortage or stacking in the corners of mold.

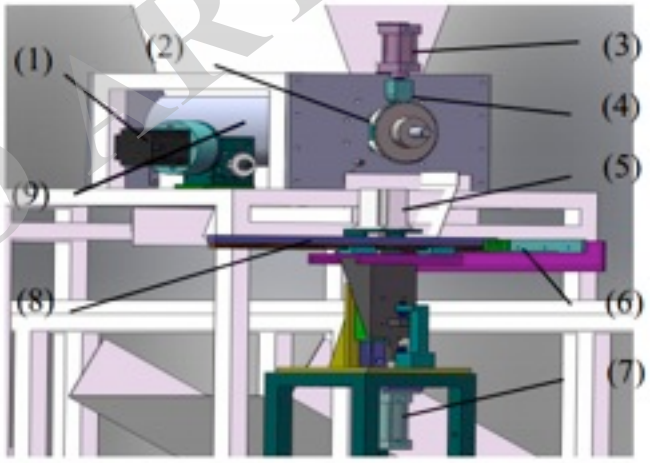

Fig. (1). Feeding system. Legend: (1) RECLAIMER MOTER (2) CONTROL PANEL (3) VIBRATION CYLINDER (4) WEDGR (5) SCRAPER MOTOR (6) STRICKING PLATE (7) LIFTING CYLINDER (8) STRICKING ROD (9) THE BLADE SHAFT.

In reclaiming institutions RECLAIMER MOTER (1) is a stepper motor through reducer connected with sprocket which located in the end of THE BLADE SHAFT (9) and connected by a chain, THE BLADE SHAFT is a cylindrical section which uniformly distributed with four V shaped grooves, the volume of Vshaped groove and the calculated one are equal, the V shaped groove is the foundation to realize accurate leveling [2]; CONTROL PANEL (2) at 90 degrees intervals around the circumference set a U-shaped notch, and connect the end of blade shaft, WEDGR (4) connect with VIBRATION CYLINDER (3); in the scraper mechanism, Motor scraper (5) is a stepper motor, the gear is connected with the rack which is fixed with the Strickling Rod (8), the STRICKING ROD is provided with a induction sensor block, STRICKING PLATE (6) is fixed at the end of the strickling rod, SCRAPER MOTOR, STRICKING ROD and STRICKING PLATE are connected through the bracket

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with the top of Lifting Cylinder (7), which can move up and down, support is provided with four sensors as Limiting, Strickling, Cleaning and the Return. Scraper trajectory diagram\med as shown in Fig. (**2**), h in the figure is strickling height which could adjusted by mechanical structure;STRICKING PLATE from the origin to start moving along the direction of the arrow, and back to the origin ultimately.

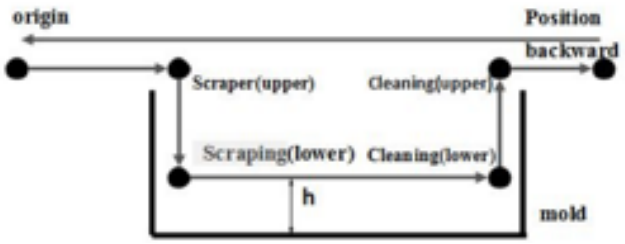

Fig. (2). Schematic for scraper trajectory.

3. THE PROCESS OF FEEDING SYSTEM

Feeding system is a subsystem of perlite sound absorption board automatic production line, only cooperate with the main line can ensure that the entire production process security and stability; in addition, feeding machine could finish leveling technology independently, and is therefore an independent system. Whole process of feeding system the as shown in Fig. (**3**). Process as shown in Fig. (**3**): When the mold positioning on the main line is completed, the main line sent to the feeding machine a "feeding start signal", reclaiming motor starts to rotate 90 degrees; when the sensor detects the reclaiming completed signal the VIBRATION CYLINDER extends, WEDGR impact the gap of CONTROL PANEL, and then the cylinder retracts, this action can make powder remaining in THE BLADE SHAFT shock and drop, thus ensuring a constant volume for the next reclaiming; after this reclaiming, the strickling mechanism start from the Upper, with the SCRAPER MOTOR rotates forward to Strickling Position (just above the edge of the mold) and then stop; STRICKING PLATE down into the mold, the motor restart, scraping on the material, and the material is restricted by the mold frame become smooth; by limiting the LIFTING CYLINDER stroke can adjust the strickling thickness, to ensure no material shortage and accumulation in the mold; when the scraper plate reaches to the Cleaning Position (the other side of the mold edge), the motor stopped; with the LIFTING CYLINDER rising up the scraper left the mold, the motor continues to rotate to arrive at the Backward Position, this process can release the excess material at the mold edge to facilitate recycling; then the motor reverse back to the limit switch (initial position).

4. THE CONTROL OF FEEDING SYSTEM

4.1. The Hardware of the Control System

According to the mechanical structure and process requirements, the overall design of the control system as shown in Fig. (**4**).

The core controller of feeding machine control system is Mitsubishi FX3U-36M, this model PLC includes 16 input and 16 output points [3]. RECLAIMER MOTER and scraper motors using Kinco series 2S110Q- 047F0 and 2S86Q-069B8 these two-phase stepper motor [4]. Other electrical component comprises an electromagnetic valve, a magnetic switch, proximity switch, limit switch, AC contactor, air switches and relays etc.. According to the process, statistics on all the electrical components and assign I / O ports, as shown in Table **1**.

The Y00 to Y02 terminal of the FX3U-36M are high speed pulse output ports, specially used for motor control, the two stepping motors in this system are used "pulse and direction" control mode. Stepper motor is connected with corresponding driver which is controlled by the PLC. 2S110Q-047F0 stepper motor matches the 2M2280N driver, the driver has over voltage protection, under voltage protection, over-current protection, overheat protection, fault phase protection and alarm function, high reliability and easy to use. For real-time monitoring the working status of the motor, the set of alarm output terminal ERR+ and ERR- of driver is assigned to the PLC X03 port. PLS is the pulse signal receiving end of the driver, this port is connected with Y00 of PLC, Y14 and Y15 are respectively used for direction of motor control and axle control; the 2M530 driver is matched with the 2S86Q-069B8, the working voltage is DC24V, because of the need of torque is small when STRICKING ROD working, so use this type of stepping motor driver, compared with 2M2280N, 2M530 does not have alarm output function, the function and usage of the other terminals are the same with 2M2280N, the connection method as shown in Fig. (**5**), according to the driver's interface principle diagram, in each set of control port connection circuit a resistor with a value for 2K is connected, in order that the interface current limited to the safe current range of 12 mA.

Cylinders, magnetic switches, proximity switches, limit switches, relays and other devices are common I/O devices, the remained I/O ports of PLC are in turn allocated, the unused ports as a reserved port. Calculating power and current of each device, besides, selecting suitable wires and connecting according to the electric principle diagram.

4.2. Designing the Software of Control System

After the hardware circuit design and installation completed, then design the control program. The program written using the Mitsubishi GX Developer [5]. This control system must be independently complete the feeding process and also receive the mainline control (mainline is controlled by Mitsubishi Q00 series PLC), for master-slave control the usual practice is to use fieldbus [6] control, but if the field-bus is used, undoubtedly make the system more complex and the cost increases, so the ordinary I/O ports are used for master-slave communication instead of field-bus, the control mode as shown in Fig. (**6**).

In this control mode, firstly of all the Slave Machine (feeding machine controller PLC) boot, program scan the system to normal and send communication test request signal (Y04 port set) to the Master Machine (mainline controller PLC), and then timing for 5 seconds, in this time detecting feedback signal (port X04 detection level change) from the

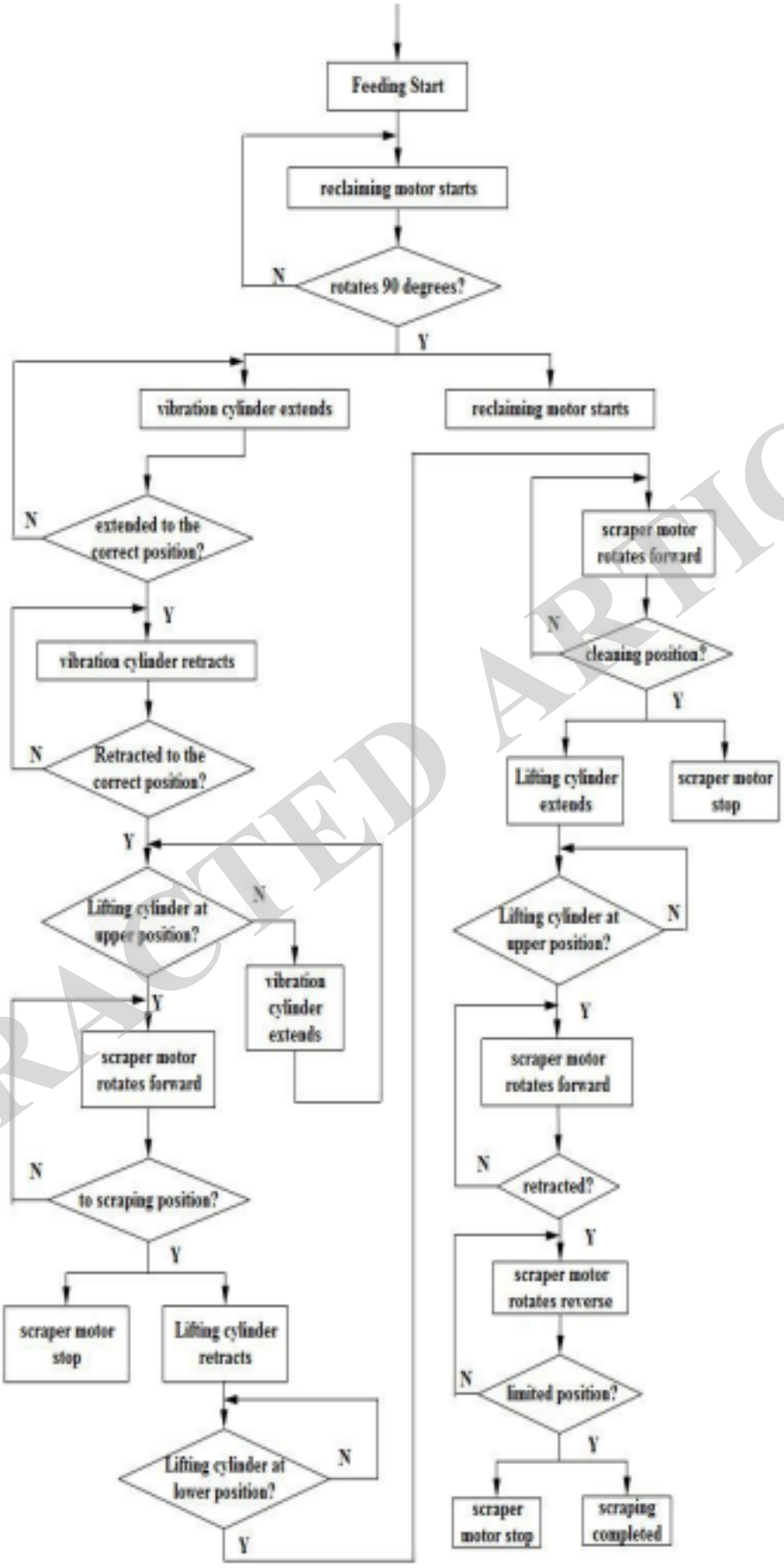

Fig. (3). The process of feeding system.

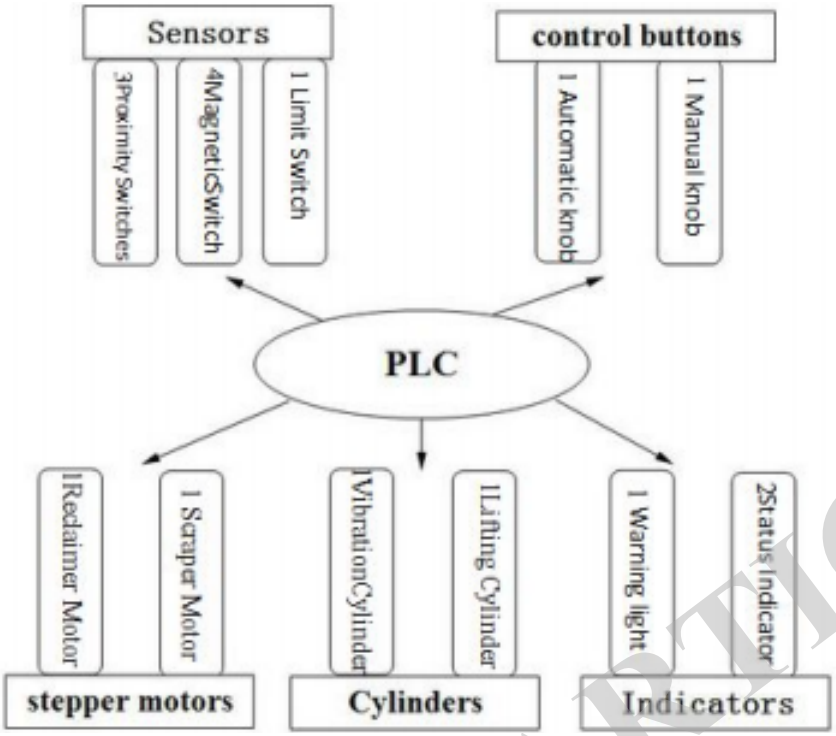

Fig. (4). Control system hardware components.

Table 1. Allocation table of I/O ports for feeding system.

Address	Function	Address	Function
X00	Reserved	Y00	Pulse of reclaimer motor
X01	Reserved	Y01	Pulse of Scraper Motor
X02	Cleaning	Y02	Reserved
X03	Reclaimer Motor alarm	Y03	Reserved
X04	Main line sig	Y04	Sub-line signal
X05	Vibration front	Y05	Vibration front
X06	Rear vibration	Y06	Rear vibration
X07	Lifting front	Y07	Lifting front
X10	Rear Lifting	Y10	Rear Lifting
X11	Position of material	Y11	Alarm
X12	Scraping	Y12	Run Mode
X13	Return	Y13	Reserved
X14	Limit	Y14	direction of reclaimer motor
X15	Emergency Stop	Y15	axle control of reclaimer motor
X16	Automatic mode	Y16	direction of Scraping motor
X17	Debug mode	Y17	axle control of Scraping motor

master machine, if it received the feed back signal, the communication is normal, otherwise is abnormal and alarm output; but when communication is normal, Slave Machine waiting for the start signal form the host machine, and when completed the feeding process sent a signal to the host, then enter the next loop. This control method is simple, with high reliability, and widely used in this production line with stable operation. Fig. (**7**) shows the process control program of "scraper rod reaches the strickling position - LIFTING CYLINDER retracts (scraper into the mold) - SCRAPER MOTOR rotates (began strickling) - arrived at sweep position (motor stopped) In the automatic mode, when the STRICKING ROD reaches the starting point, the M35 touched off the next process (LIFTING CYLINDER retracted) start flag M36, Y10 is set and the LIFTING CYLINDER retracts, detect lifting retracted signal X10 within the the period of M36 efficient, when the X10 signal is detected, the completed flag M37 of lifting retracted set, M37 disconnected lifting retracted startup flag M36, scraper retracting process to complete; using the rising edge signal when M37 conducted to start a process of "strickling", thus the process of "LIFTING CYLINDER retracts" is completed and automatically disabled after starting the next process.

When the process of "strickling" starts, set the motor operating speed and direction by transition registers D10 and M39, the timer T4 as the "pause before start strickling", whose role is twofold: One is for the mechanical structure of the buffer time, the other is for the stepper motor starting a buffer time, this two together to ensure the smooth response of mechanism. Fallowing the pause is booting stepper motor which controlled by M41, detect the return signal X13 after the starting of stepper motor, when the signal is detected means "strickling" is finished, make strickling complete flag

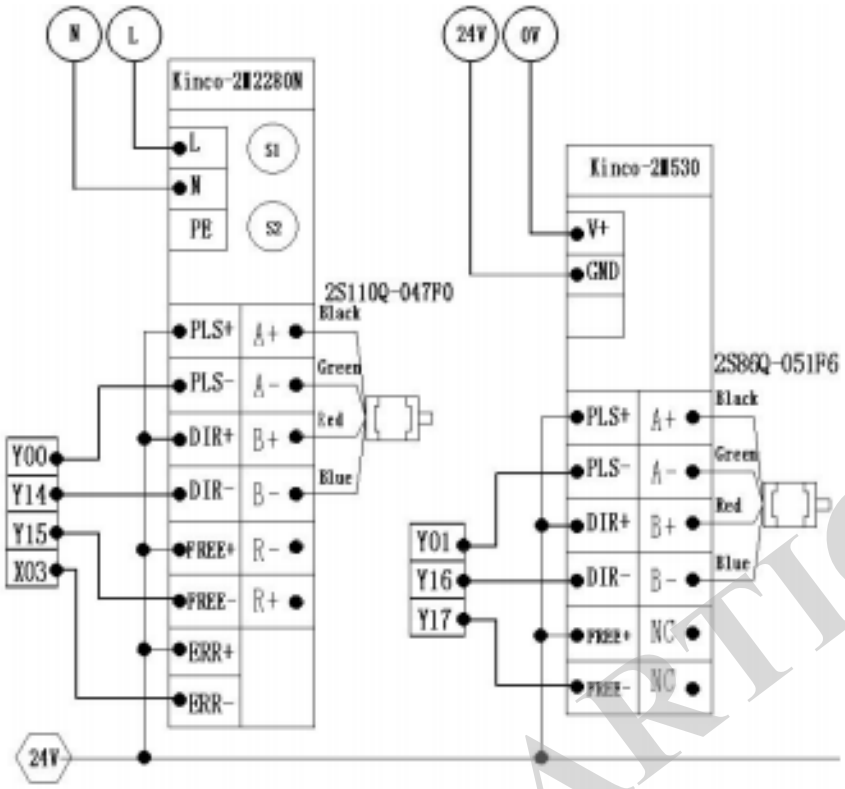

Fig. (5). The connection method of reclaimer moter and strickling motor.

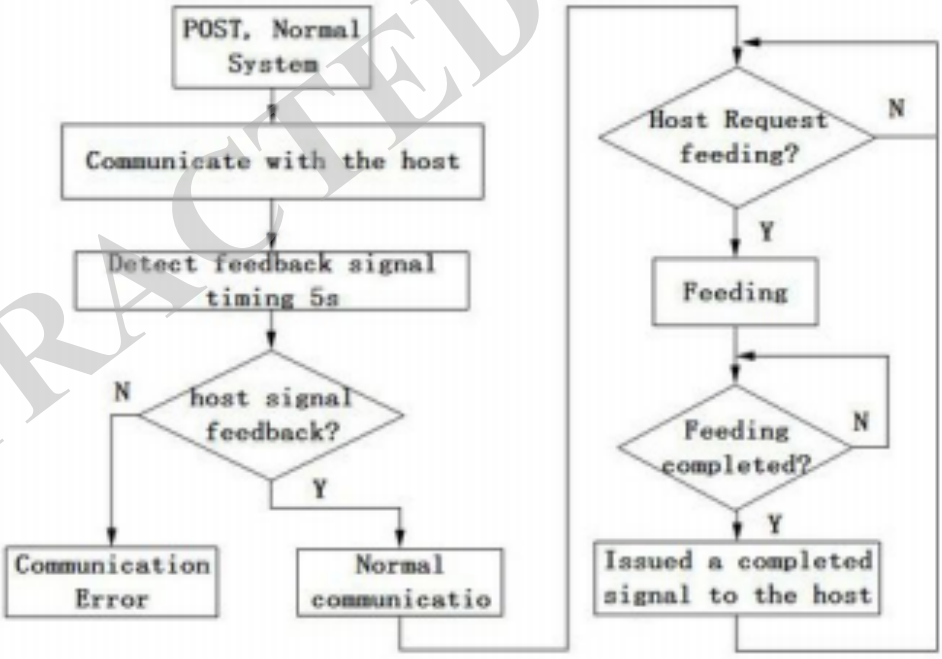

Fig. (6). Master-slave control schematics offeeding system.

M41 set, and if the process protecting time out also makes M41 set, meaning the "strickling" process came to an end.

In the "strickling" process, use strickling starting flag M38 to monitor the "strickling" process, and use timer T13 to the whole process for timing protection, in case of accidents cause motor long time blocked and damaged, and some unexpected situations can be directly stopped by pressing the emergency stop button on the feeding mechanism (connected with X15 of PLC), the process is not limited by time, this approach can reduce the number of stops in the continuous production, and improve production efficiency.

This control method guarantees that the process in the whole process of uniqueness, effectively preventing the system exception caused by interference signal. This program design method improves the reliability and

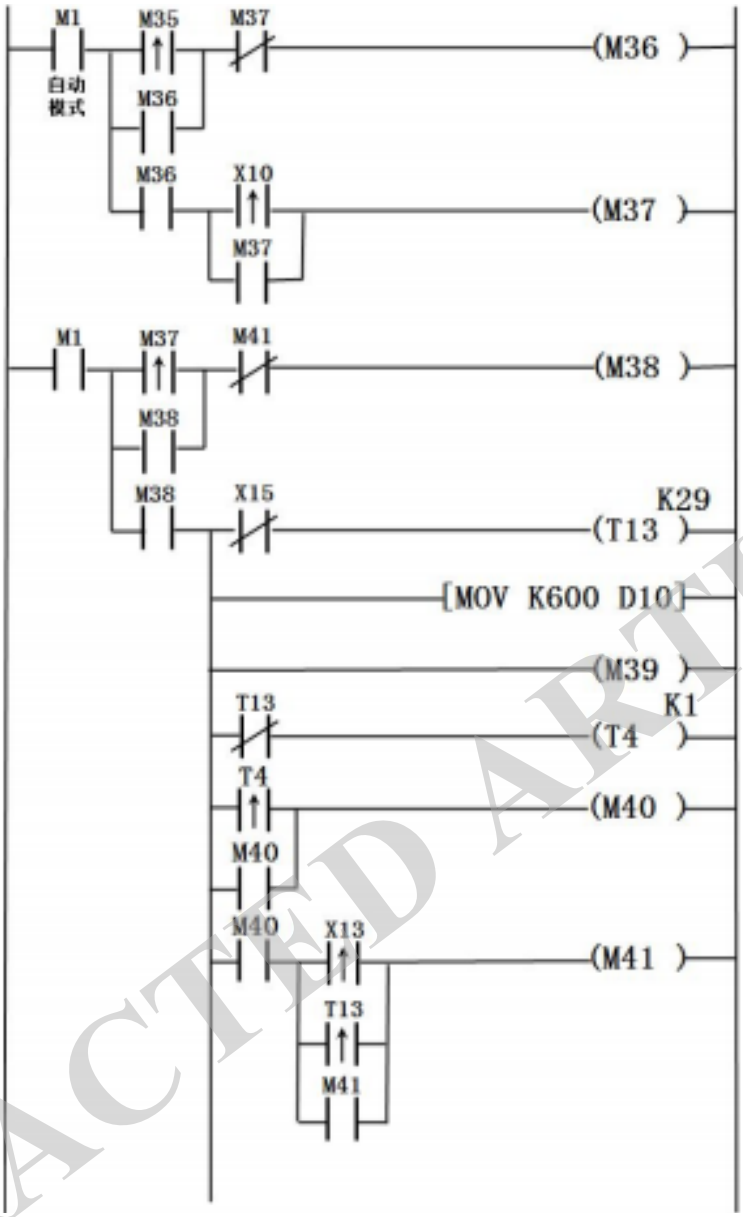

Fig. (7). Part ofthe feeding process program. Legend: M1:Automatic mode M35:scraper starting place M36:Lifting retracted start M37:Lifting retracted completed M38: Strickling start flag M39:strickling direction control M40:strickling motor start M41:strickling complete X10: Lift rear X13: Return signal X15： Emergency Stop D10： Speed of SCRAPER MOTOR T4:Pause before the scraper start T13:Timing protection.

maintainability, while using strict process control design method [7], can guarantee that each process has an unique execution condition and unique perform action, because the signal that will be effective only in the corresponding process, in any other non corresponding process are invalid.

The output instructions of device in this program are finally unified listed by the transitional soft component, will not be covered here.

5. THE DEBUGGING OF FEEDING SYSTEM

When the program is wrote and compiled will be downloaded to the PLC, for insurance, the mold under the feeding machine will be removed, no-load debugging.

Firstly, use the special motor control commands from Mitsubishi programming software to the stepper motor forward, reversion and stop control, to determine whether the motor is normal, and observe whether the rotate direction is consistent with design in order to modify the program; with the motor testing completed, utilize online monitoring of Mitsubishi programming software combined with the process to carry on test, when the test is normal then test the reliability:

In the surveillance state, trigger the sensor manually to generate a interference signal, to test the whether the process could be affected by external disturbance [8]. After several tests proved that the program can be strictly executed in accordance with the process. But when the sensor out of its sensing range and found that this stage of process would not

obtain the stop signal and sustained action, which is not allowed in the production process [9], so in the program for each process set a timing protection, that is during debugging monitoring the execution time of each action, and based in this time defining the execution time for insurance, once the time protection signal is triggered it may be considered that the corresponding sensor signal to the abnormal status, and alarm [10]. This control method not only can ensure the safe of process, rapid troubleshooting, convenient to use and maintain, it has been proved in practical application.

CONCLUSION

Automatic production line has significance in improving the efficiency and reducing the cost. For complex automated production line, each executive agency must has highly reliability, in order to ensure the reliability and stability of the whole production line. This paper introduces a feeding system of perlite sound absorption board in automatic production line, ensuring the system stability and reliability the common I/O are used in lieu of field-bus control, using procedural programming methods to improve the program's stability and anti-interference and achieve cost savings.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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Declared none.

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