Design and realization of control system for automatic setting machine of artificial flower based on PLC

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Abstract. In order to make up for the shortcomings of low production rate and frequent accidents in the production of the traditional hand-made artificial flowers, an automatic setting machine for artificial flowers is developed to effectively increase the efficiency and safety of flower production and meet the increasing demand for artificial flowers. This paper introduces the design and realization of control system for automatic setting machine of artificial flower. In addition, the programmable logic controller (PLC) is used as the core of the control system while LCD touch screen as the human-machine interface to monitor the machine. In the test, the control system shows good stability and practicability, and realizes production of the setting machine with high speed and great safety.

1. Introduction
Artificial flowers, as a substitute for flowers, have the characteristics that flowers do not possess. For example, they are easy to preserve, never fade and have no seasonality, so the demand for artificial flowers is increasing.

The manufacturing process of artificial flowers are divided into material preparation, pull piece, cut pieces, heat setting, gathering flowers, packing and other steps[1]. Heat setting is an important step in the production of artificial flowers. The traditional way of setting artificial petal is to transport the artificial petal by hands and to control the cylinder with a button to make the die close. This method has many problems, such as low efficiency, poor safety, and great labor intensity. Setting automation is an effective measure and main method to improve efficiency and ensure safety. The newly designed automatic setting device takes PLC as the core of control, takes LCD touch screen as the man-machine interaction interface, takes servo motor and cylinder as actuator, and equipped with sensors to detect whether the device is running normally[2]. This device mainly completes the following functions: the petals are sucked from box by suckers and transported to the setting mechanism through the cylinder. The cylinder in the setting mechanism make the die close. After the heat setting finish, the die open and the flower petals are sucked by the sucker and transport to the box. If a fault occurs, the equipment will alarm and stop running.

2. Mechanical design and operational principle
The machine designed by author can once complete storing petals, transporting petals, setting petals, transporting petals and storing petals process, and its structure is shown in Figure 1.
To meet requirements of production, the control system has two working modes, which are single operation and continuous operation[3] Therefore the equipment is divided into two control modes: the automatic control mode and the manual control mode. The manual control mode is applied to the debugging equipment stage, the single point control of the equipment and the adjustment of operating parameters and speed. Maintenance of the equipment is often finished in manual control mode[4].

According to the track of the artificial petals movement on the equipment, the operational principle can be obtained. The track of the artificial petals movement is as follows. In step A→B, if one of the suckers does not suck a unformed artificial flower, the corresponding sucker leaks and the pressure sensor detects that the pressure is too low, then the control system controls the mechanism to suck artificial petal again ;As the same, in step D→E, if one of the suckers does not suck a formed artificial flowers, the corresponding sucker leaks and the pressure sensor detects that the pressure is too low, then the control system controls the mechanism to suck a formed artificial flowers again. The point I is the initial position of the unformed petals which are stored in the box. The point A is the position where the unformed petals are sucked. The point B is the initial position where the petals are transported into the rotation mechanism. Point C is the second work position of the rotating mechanism. The point D is the position of the petals moving out of the rotating mechanism. The point E is the place where the formed petals are placed. The point O is the final position where the unformed petals are stored in the box. In each position, there are three petals of large, medium, and small shapes, increasing the efficiency and improving the production synchronism.

3. The control system of setting machine of artificial flower
A control system platform, by researching the work requirement of machine for setting artificial flowers, is established in the paper. The control system is the key to the design of machine for setting artificial flowers[5].

3.1. PLC selection
According to the analysis of the control requirements, the system needs fifty-four digital signal input, four buttons (start, stop, reset, emergency stop), twenty-six magnetic switches, six photoelectric switch,
one proximity switches, eight temperature detection switch, three servo positioning signals, three servo alarm signal and six suckers leak signal; there are thirty-nine digital signal output, respectively control three servo motors, thirteen cylinders, six suckers. Considering the number of input and output points, the CPU DVP80EH00T3 was used in the control system. At the same time, DVP48HP00T and DVP16HM11N module is used as Digital expansion, which respectively expands forty-eight and sixteen I/O points[6].

3.2. The distribution of input and output
The distribution of I/O is a vital part of the control system. According to the requirements of the control system, the distribution of some important I/O is shown in table 1.

| Input terminal                                              | Output terminal          |
|-------------------------------------------------------------|--------------------------|
| servo-transposition servo positioning                        | X03                      |
| servo-transposition servo alarm                              | X04                      |
| spare                                                        | X05                      |
| servo- lifting servo initial position at inlet                | X06                      |
| servo- lifting servo up limit at inlet                       | X07                      |
| servo- lifting servo down limit at inlet                     | X10                      |
| servo- lifting servo positioning at inlet                    | X11                      |
| servo- lifting servo alarm at inlet                          | X12                      |
| spare                                                        | X13                      |
| servo- lifting servo initial position at outlet               | X14                      |
| servo- lifting servo up limit at outlet                       | X15                      |
| servo- lifting servo down limit at outlet                     | X16                      |
| servo- lifting servo positioning at outlet                    | X17                      |
| servo- lifting servo alarm at outlet                          | X20                      |
| spare                                                        | X21                      |
| sensor- transversal cylinder front limit at inlet            | X22                      |
| sensor-transversal cylinder behind limit at inlet            | X23                      |
| sensor- lifting cylinder up limit at inlet                   | X24                      |
| sensor- lifting cylinder down limit at inlet                 | X25                      |

Table 1. The distribution of I/O.
| Sensor Description                                      | X Coordinate | Y Coordinate |
|---------------------------------------------------------|--------------|--------------|
| Sensor - second transversal cylinder right limit at inlet| X26          | Y23          |
| Sensor - second transversal cylinder left limit at inlet | X27          | Y24          |
| Spare                                                   | X30          | Y25          |
| Spare                                                   | X31          | Y26          |
| Sensor – first sucker leak at inlet                     | X32          | Y27          |
| Sensor – second sucker leak at inlet                    | X33          | Y30          |
| Sensor – third sucker leak at inlet                     | X34          | Y31          |
| Sensor - third transversal cylinder right limit at inlet | X35          | Y32          |
| Sensor - third transversal cylinder right limit at inlet | X36          | Y33          |
| Spare                                                   | X37          | Y34          |
| Spares                                                  | X30          | Y35          |
| Sensor - first stamping cylinder up limit                | X41          | Y36          |
| Sensor - first stamping cylinder down limit              | X42          | Y37          |
| Sensor - second stamping cylinder up limit               | X43          | Y40          |
| Sensor - second stamping cylinder down limit             | X44          | Y41          |
| Sensor - third stamping cylinder up limit                | X45          | Y42          |
| Sensor - third stamping cylinder down limit              | X46          | Y43          |
| Sensor - fourth stamping cylinder up limit               | X47          | Y44          |
| Sensor - fourth stamping cylinder down limit             | X50          | Y45          |
| Sensor - temperature detection of upper set mould 1      | X51          | Y46          |
| Sensor - temperature detection of lower set mould 1      | X52          | Y47          |
| Sensor - temperature detection of upper set mould 2      | X53          | Y50          |
| Sensor - temperature detection of lower set mould 2      | X54          | Y51          |
| Sensor Description                                                                 | X/Y   |
|-----------------------------------------------------------------------------------|-------|
| Sensor-temperature detection of upper set mould 3                                 | X55   |
| Sensor-temperature detection of lower set mould 3                                 | X56   |
| Sensor-temperature detection of upper set mould 4                                 | X57   |
| Sensor-temperature detection of lower set mould 4                                 | X60   |
| Sensor - transposition positioning cylinder original point                          | X61   |
| Sensor - transposition positioning cylinder end point                              | X62   |
| Spare                                                                              | X63   |
| Spare                                                                              | X64   |
| Sensor-transposition detection                                                     | X65   |
| Sensor- transversal cylinder right limit at outlet                                 | X66   |
| Sensor-transversal cylinder left limit at outlet                                    | X67   |
| Sensor- lifting cylinder up limit at outlet                                         | X70   |
| Sensor- lifting cylinder down limit at outlet                                       | X71   |
| Sensor –first sucker leak at outlet                                               | X72   |
| Sensor –second sucker leak at outlet                                              | X73   |
| Sensor –third sucker leak at outlet                                               | X74   |
| Sensor-second transversal cylinder right limit at outlet                           | X75   |
| Sensor-second transversal cylinder left limit at outlet                            | X76   |
| Spare                                                                              | X77   |
| Spare                                                                              | X100  |
| Sensor-third transversal cylinder front limit at outlet                            | X101  |
| Sensor-third transversal cylinder behind limit at outlet                           | X102  |
| Spare                                                                              | X103  |
| Button-start button                                                                | X104  |
| Button-stop button                                                                 | X105  |
| Button-reset button                                                                | X106  |
| Button-urgent stop button                                                          | X107  |
3.3. Software design of control system
The software program mainly completes ladder diagram and HMI program. The whole PLC program includes a main program and three subroutines. Three subroutines mainly include initialization, automatic and manual part[6]. The automatic program flow of control system is shown in Figure 2. The first page of HMI program is shown in Figure 3.

4. The installation and debugging of the machine
After completing the manufacturing process of each parts, according to design ideas of the machine, the device is assembled. The whole assembly effect picture of the automatic setting machine is shown in Figure 4.
In order to ensure the stable and reliable of the operation and to improve the correctness of the run of the program, the PLC program must be debugged. In the process of debugging, each action is operated separately, and the whole is debugged. If misoperation occurs, the interlock circuit protection need to be added to protect the machine.

After the completion of the debugging, the machine can set the petals very well. At the same time, compared with artificial setting, the efficiency and safety are greatly improved.

5. Conclusion
The automatic setting machine of artificial flower designed in this study is based on PLC, which solves the logical control of storing petals, transporting petals, setting pills, transporting petals and storing petals process, and realizes the accurate and efficient setting of the artificial flower. The control system has a smooth operation, stable performance and high reliability after running and debugging. The machine has many advantages compared with the manual setting method. It has many advantages: high production efficiency, stable product performance, high operation safety, reduced production cost and reduced production accidents.

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