Design of continuous automatic wire-feeding device based on electric explosive wire

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Abstract. Continuous automatic wire-feeding device is a device that delivers metal wires required for electric explosion spraying to the designated position in vacuum environment, thus replacing manual wire-feeding on the equipment. The control system of the continuous automatic wire-feeding experimental device designed in this paper mainly includes three parts: the main control system, the man-machine interface and the upper computer. The main control system is composed of a single-chip microcontroller c8051f020, which realizes the control of components such as the motor drivers, relays, sensors and etc. outputs the collected signals and communicates with the human-machine interface. The human-machine interface consists of an LCD display and an IO expansion board, which can respond to the operator's instructions and display the experimental data. The host computer communicates with the main control system, sends commands and receives the feedback information of the main control for analysis and processing. The experimental results show that the device realizes automatic wire-feeding control with high degree of automation, which improves the efficiency and reliability of the electric explosion spraying experimental device.

1. Introduction

Automatic wire-feeding is an important part of electric explosive wire spraying. At present, there are two problems in general spraying equipment. One is that the spraying material of the metal wire explosion is not high in utilization; the other is that the spraying material cannot be automatically replaced, and it needs to be manually completed before spraying, which has high labor intensity and low efficiency\textsuperscript{[1-2]}; As the center of the automatic control system, single chip computer plays a key role in the automatic control system. The connection between the single-chip microcomputer and the external equipment is usually realized through a serial communication interface\textsuperscript{[3]}. The upper computer of the experimental device communicates with the single-chip microcomputer through RS485. The interface has a simple structure, long communication distance and strong anti-interference ability\textsuperscript{[4]}. On the basis of existing experiments, an automatic wire-feeding spraying device was designed and manufactured in this paper. Based on the spraying equipment, the material utilization rate and reliability of the wire and the length control of the wire at both ends of the electrode tip are improved and optimized.
2. Design of Continuous Automatic Wire-feeding Device

The automatic wire-feeding experimental device is mainly composed of three parts: an XY moving platform, a continuous wire-clamping integrated device and a main control circuit. As is shown in Figure 1, the two motors on the XY platform control the workpiece mounting plate under the XY platform to move on a horizontal surface to ensure that each spray can cover the specified area, and then achieve repeated spraying, which can make the thickness of the metal coating more uniform.

![Figure 1. XY mobile platform](image)

1-X axis motor; 2-Y axis motor; 3-Workpiece mounting plate;

As is shown in Figure 2, the main components of the continuous wire clamp device consists of a moving component mounting plate, a moving chuck insulating mounting plate, an electrode chuck, an electrode wire guide pipe socket, an upper roller mounting plate, a lower roller mounting plate, a mounting bottom plate, the linear guide rail mounting plate, the left and right chuck insulating mounting brackets and the fixed chuck insulating mounting plate, etc. Installation of the bottom plate is mainly used to build the whole wire-feeding fixture in order to provide support for the device. Linear guide rail mounting plate fixes moving parts mounting plate through slide rail, and can drive it back and forth by stepping motor. The moving parts are used to fix the insulation mounting plate of the movable chuck; the movable chuck mounting plate is used to fix a left fixed chuck mounting bracket and a left movable chuck mounting bracket which can move longitudinally; the circular groove under the left fixed chuck mounting bracket will place permanent magnet, and the left movable chuck mounting bracket will place an adjustable voltage electromagnet. By changing the voltage and electrode direction of the electromagnet, The magnet's attraction and push-off can be realized. The electrode chuck is fixed on the left and right chuck insulating mounting brackets, and the electrode chucks at both ends of the wire are controlled to be pulled or pushed open by the back and forth movement of the left and right movable chuck insulating mounting brackets. Insulation mounting plate with fixed chuck is equipped with right movable chuck and right fixed chuck mounting bracket, on which the principle of right chuck mounting bracket is the same as that of left chuck mounting bracket. The upper roller mounting plate and the lower roller mounting plate fix the upper and lower rollers respectively. The movement of the wire between the upper and lower rollers is realized by the stepping motor driving the lower roller to rotate while driving the upper roller.
The main control system of the automatic wire-feeding device uses the c8051f020 single-chip microcomputer as the control board to collect sensor information and control motor drive, relay switch and high-voltage reed relay, and perform data transmission with human-machine interface.

The schematic diagram of the main control system is shown in Figure 3.

**Figure 3. Schematic diagram of master control system**

### 3. The Realization Process of Automatic Wire-feeding Device

The automatic wire-feeding device transports the wire through the motor-controlled roller to the left and right chucks for fixing, in order to realize the electric explosion spraying. The automatic wire-
feeding includes the current automatic wire-feeding mechanism, control circuit, high-voltage terminal, etc. and the control circuit adopts the 8051f020 core board. The work flow is shown in Figure 4.

As is shown in Figure 4, after the experimental device is built and detecting whether each module is powered on, power on the PC and the main control chip, and turn on the upper computer, and send the command with it to the main control chip to test whether the main control module can be used. After testing, instructions are sent to the main control chip through the function module of the upper computer. The main control module sends the execution commands to the specified module end, observes the operation status of the module and the data sent by the sensor module displayed on LCD in real time. After all the modules have been tested correctly, adjust the wire to the appropriate position through the step-by-step debugging section on the host computer. Start the continuous wire-feeding button on the upper computer, and then the roller drive motor starts and begins to feed. When the length of the wire exceeds the length of the left fixed chuck to reach a predetermined length, the roller drive motor stops, the electromagnet installed in the left movable chuck mounting bracket (slidable) is forwardly guided, which is attracted by the opposite sex of the permanent magnets fixed in the left fixed collet mounting bracket. And then the two chucks clamp the wire. The reciprocating motor starts and pushes the right chuck closer to the left chuck. When the distance between the left and right chucks reaches the preset value, the reciprocating motor stops. The electromagnet installed in the right-moving chuck mounting bracket is directed. The right-moving chuck and the right-setting chuck clamp the wire beyond a part of the left chuck. The electromagnet installed in the left-moving chuck mounting bracket is directed in the opposite direction, and the two chucks bounce off. The reciprocating motor starts and drives the right chuck away from the left chuck. When the wire reaches

![Work flow chart](image_url)
the set length, the reciprocating motor stops. The electromagnet in the installation bracket of the left-moving chuck is in forward direction. The left-fixed chuck and the left-moving chuck are closed and clamped with metal wire. The dry-reed relay switch is opened to test whether the metal wire is clamped by the two chucks. If it is not clamped, read back check and repeat the above steps. On the contrary, the left and right chucks are electrically sprayed and discharged, and one spray is completed. Repeat the above steps to complete multiple sprays.

4. Requirements for Control System of Automatic Wire-feeding Device

The control system consists of main controller, upper computer, conventional relay, high-voltage dry-reed relay, stepper motor driver, sensor and other modules. The functions of the system are as follows:

- The working mode of the control system: Three switchable working modes are set up, including manual mode, automatic mode and single-step mode. The single-step mode and manual mode are mainly used to detect faults, debug the whole working process, whether the wire is clamped or not, and the execution of a single action. The automatic mode is mainly used in the actual research and testing process to realize the cooperative work of the moving parts of the automatic wire-feeding control system and continuous wire-feeding.

- Fault detection function: firstly, the automatic wire traveling system can automatically detect the failure of each module; secondly, it can detect whether the wire is clamped or not, and when the wire breaks or does not clamp, the signal received by the single-chip microcomputer is fed back to the upper computer to display the alarm information; thirdly, it can detect whether the main executing device is working normally. When abnormal happens, the system automatically alarms and stops, and displays abnormal information.

- Emergency stop function: In case of abnormal situation, you can click the emergency stop button on the host computer to stop all movement of the device.

- Debugging function: In the case of failure or before the device is ready to run, the debugging plate can be activated by the debugging button on the host computer to test whether the moving parts and the control chip can work normally.

5. Safety Design of Automatic Wire-feeding Device

Since the automatic wire-feeding device involves high voltage and strong current, and there is a complicated electromagnetic environment inside, which will generate strong electromagnetic interference to the low voltage control circuit, the safe operation of the whole system should be guaranteed when designing the control system of the experimental device. The measures taken include good grounding system, shielding of low voltage circuits, and isolation of high and low voltage.

- Grounding: The whole automatic wire-feeding device uses metal cabinet to surround it, isolate the inside and outside, except that, the metal cabinet is grounded; Other devices and circuitry that need to be grounded are centrally installed with grounded copper bars to connect the ground to ensure that high voltage capacitors can discharge outside the isolation network using buttons completely isolated from the cabinet.

- Shield: In the cabinet where the automatic wire-feeding device is located, there is strong electromagnetic interference, in order to ensure the reliability of the main control circuit. The main control circuit is placed outside the metal cabinet, and the data communication between the main control system and the automatic wire-feeding device is realized through the air plug.

- Isolation: In order to ensure the reliable operation of high and low voltage equipment, the circuit control signals and trigger signals are isolated by optocouplers. The power supply of the trigger circuit and the human-machine interaction terminal circuit is isolated and powered by an isolation transformer.

6. Conclusion

In this paper, an automatic wire-feeding device is designed for the research on electric explosion of mental wire. The device has the following characteristics:
• The execution efficiency is high, and the entire automatic wire-feeding is in the closed vacuum metal container, which is higher than the speed of manual wire-feeding, and meanwhile, the spraying efficiency is improved.
• The use of MCU collaborative control saves cost and manpower, and improves work efficiency. It has high degree of automation, strong execution and simple operation.

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