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Design of Spot Welding Robot

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Abstract

Welding robot has played an extremely important role in the welding production of high-quality, high-efficiency. The paper designed the hardware structure and software of spot welding robot. The hardware design mainly includes the major modules of arm and base; the hardware design includes two parts: manual mode and automatic mode. Manual mode is generally used for the robot system installation, commissioning and troubleshooting, and the major modules are controlled by the start of the corresponding button; automatic mode is mainly used for production stage. The welding robot uses PLC for controlling; the system runs faster and has a short production cycle.

Keywords: *welding robot, PLC control, spot welding*

1. Introduction

According to incomplete statistics, about nearly half of the industrial robots around the world are used in various forms welding process field [1]. Manual welding processing requirements welders have skilled operational skills, a wealth of practical experience and stable welding level; in addition, manual welding is a work with poor working conditions, much smoke, big heat radiation and high-risk. The welding robots can instead of manual welding, reduce welder's labor intensity, ensure the welding quality and improve the welding efficiency. Inside the welding robot, there are specifically designed programs to make it run at predetermined trajectory, but most of the welding robots are constituted through some welding tools fitted on common industrial robots [2-8]. Robot technology is a high-tech intergraded multidisciplinary of computer, cybernetic, Mechanism, information and sensor technology, artificial intelligence and bionics. Current robotics research is very active [9-15].

It can be seen from the current study situation that the welding robot technology research focuses on the seam tracking technology, off-line programming and path planning technology, multi-robot coordination control technology, dedicated arc welding power technology, welding robot systems simulation technology, robotic welding processes and remote welding technology. Welding robot has played an extremely important role in high-quality, high-efficiency welding production. With the continuous development of computer technology, network technology, intelligent control technology, artificial intelligence theory and industrial production systems, welding robot technology field have a lot of issues waiting for us to study, especially the vision control technology, fuzzy control technology, intelligent control technology, embedded control technology, virtual reality technology and network control technology are the main direction for future research. Various countries robot scientists are increasing research efforts to conduct in-depth research on robotics [16-19].

In industrial applications, welding robots are mainly two: spot welding and arc welding. The design object of this paper is spot welding robot. It can conduct welding for positioning points and can also replace the workers operate at high temperatures and dangerous operation area. The welding robot is controlled by PLC, the stored procedures inside the robot can controll the rotate, lift, stretch motion of the robot, and it can accurately capture the joints and weld them.

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2. Overall Design

2.1. System Composition

Welding robot is composed by mechanical system, control and measurement system. Mechanical system includes executing mechanism and driving mechanism. The executing mechanism is used for crawling and moving the workpieces; the driving mechanism is used for driving and locating the executing mechanism. The control system makes executing mechanism to work in accordance with the specified requirements through controlling the driving system, and send an alarm signal when the error or malfunction occurs.

2.2. Mechanical Systems Design Scheme

The robot is controlled through the PLC to complete the movements of arm telescoping, rotation and waist rotation. The three degrees of freedom are as follows: the base can achieve 180° of rotation; the waist enables the arm to achieve 60° rotation, the arm can achieve 800mm telescopic amount. In addition, there are some specific parameters of the robot to be indecate, such as the welding load is 3000N, welding efficiency is 22 points/min and welding cycle time is 2.4 seconds.

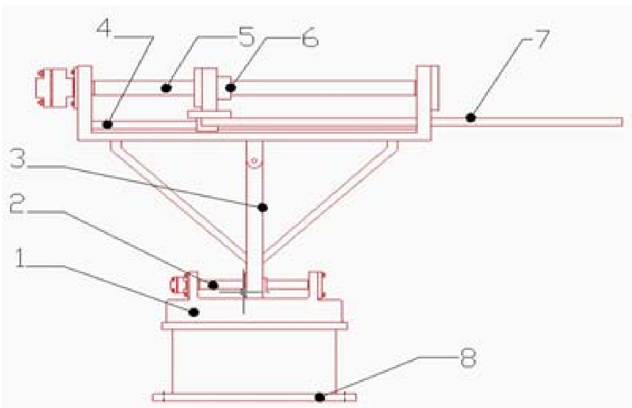
The end-effector: welding manipulator is connected to the arm end, double piston driven by pressure.

Arm telescopic mechanism: the arm is connected to the screw, the stepper motor drives screw to realize the arm telescopic movement. In order not to make the arm occur migration in the stretching process, adopts the linear guide rail to fix the arm.

Waist rotation mechanism: the arm bracket is connected with the waist screw pair, using the stepper motor to drive screw rotation, which can drive the arm rotation movement.

The base rotation mechanism: the transmission mode is using the stepper motor to drive the worm.

As shown in Figure 1 is the schematic diagram of the robot.



1-waist; 2-screw; 3-bracket; 4-screw; 5, 6-screw nut pairs; 7-arm; 8-base

Figure 1. The Schematic Diagram of the Welding Robot

2.3. Control Systems Design Scheme

In robot motion control, there are mainly two ways: point position control and continuous path control. In point position control, the end actuator only acts on some specified point and the trajectory is not required. It is easy to implement, but not easy to achieve accurate location accuracy; continuous path control requires the end actuator moving at a predetermined trajectory and speed, it is hard to implement but can get good accurate location accuracy. Comprehensive consideration, this paper chose point position control, and its control flow is shown in Figure 2, in addition, Siemens S7-200 PLC is choose to control the robot.

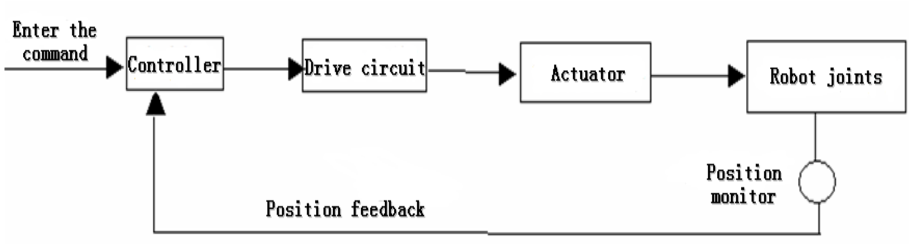
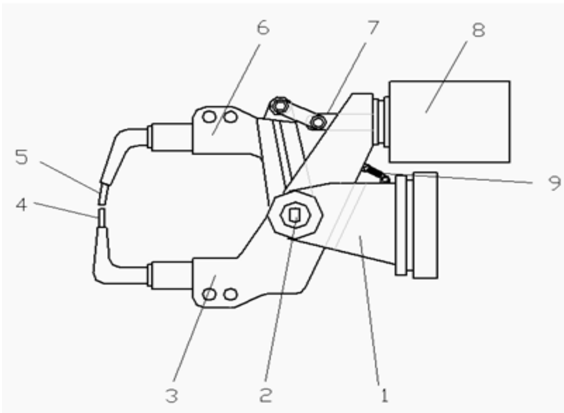


Figure 2. Robot Control System Diagram

3. Mechanical System Design
3.1. Welding Clamp Design

Welding clamp is composed of power source cylinder, floating mechanism, limiting mechanism, clamp body, the upper and lower pole arms and electrodes. Welding robot needs to go deep into the complex structure like fixture and conveying equipment to weld, and the load is rated, therefore, the welding clamp structure design requires light weight, compact structure, good approaching and small size. To this end, designed X-type welding clamp, and its structure is shown in Figure 3.



1-base; 2- rotation axis; 3-lower clamp body; 4-lower electrode; 5-upper electrode;6-upper clamp body; 7- piston rod; 8-power cylinder; 9- spring

Figure 3. The Composition of the Welding Clamp

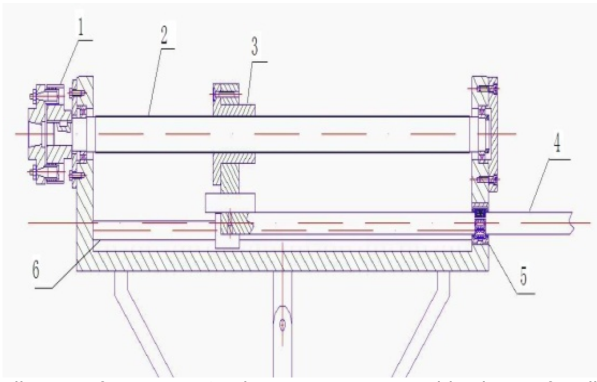
The workpieces to be wielded are often thin pieces of stampings with poor rigid, which are easy to produce irregular deformation and lead its position unstable. in order to obtain a satisfactory welding effect, designed a unique floating mechanism with automatic compensation function to compensate for the function which the robot can not reach and automatically adjust to the electrode wear.

Welding clamp uses two-stroke cylinder to push rod, which drives the upper and lower clamp bodies rotating around the hinges, so the upper and lower electrodes on the clamp bodies can clamp the workpieces. If one of the two electrodes first contact with the workpiece, it will stop, the other then will be rotated around the shaft, until it contacts the workpiece to achieve the effect of the automatic tracking of the workpiece; immediately it is energized for welding, and after welding the electromagnetic threshold changes over, the air source intakes to make the two electrodes loose out, the robot resets to wait for the next cycle.

In order to make the welding clamp keep a fixed position during the robot operation of moving, rotating, in place, back position, etc, there is stopper mechanism on it to prevent collision or interference with the location and the other. The welding clamp is fixed by spring.

3.2. The Design of the Arm Mechanism

The arm uses ball screw to achieve telescopic movement, also designed two guide posts to prevent the arm rotating on the ball screw and ensure that the arm and the end actuator rotate together. Figure 4 shows its structure.



1-coupling; 2- ball screw; 3- screw nut pairs;4- arm; 5-arm guide sleeve; 6- rolling linear guide

Figure 4. The Structure of the Robot Arm

3.3. Structure Design of the Base

The base uses an annular bearing support structure. The motor drives the worm gear to make the base shell connected together the base rotate, so the robot gets the rotational movement.

4. Control System Design

4.1. The Workflow

The welding robot has three degrees of freedom: one linear movement and two rotational movements, and all movements are driven by motors. The initial position of the welding clamp is in situ, after pressing the start button, and the robot will complete movements in sequence: dextral → backspin → elongation → welding → contraction → topspin →sinistral.

Figure 5 shows the workflow of the robot. The rotation and movements conversion of welding clamp is controlled by limit switches, and the welding time is controlled by the time relay.

To meet the production requirements, the control modes have manual mode and automatic mode, and the automatic mode have single-step, single-cycle and continuous operation mode.

Manual mode: every step of action is controlled by the button; for example, press the "up" button, welding robot arm will raise; press the "down" button, welding robot arm will decline. Such a way can set the arm in situ.

Single-step mode: starting from the situ, according to the automatic cycle process, per-click the Start button, the arm completes a step action and then stops automatically.

Single-cycle mode: Press the start button, the arm will automatically complete a cycle action from the origin, and then stops in situ.

Continuous operation mode: when the arm is in situ, press the start button, the arm will automatically and continuously execute cycle action. When the stop button is pressed, the welding robot will stoop in their current state, and when regain, the welding robot will run according to the action before stop.

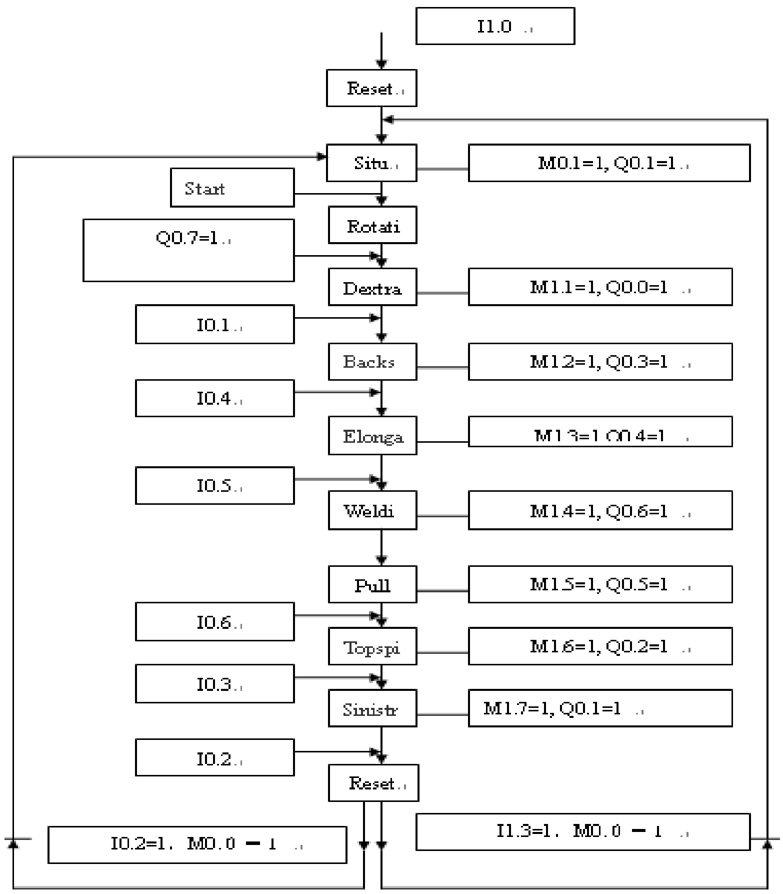


Figure 5. The Workflow of the Welding Robot

4.2. Input and Output Point Statistics

The system needs 22 input points and 8 output points, which can be seen in Table 1. In addition, Table 1 shows the I / O address assignment, which can guide wiring I / O terminals of Siemens S7200.

Table1. I/O Address Assignment

Input			Input		
Signal Name	Signal symbol	Address	Signal Name	Signal symbol	Address
Start button	SB1	I0.0	Continuous button	SA3	I1.3
Dextral limit	SQ1	I0.1	Single-cycle button	SA4	I1.4
sinistral limit	SQ2	I0.2	Stop button	SB3	I1.5
Topspin limit	SQ3	I0.3	dextral button	SB4	I1.6
Backspin limit	SQ4	I0.4	Sinistral button	SB5	I1.7
Elongation limit	SQ5	I0.5	Topspin button	SB6	I2.0
Contraction limit	SQ6	I0.6	Backspin button	SB7	I2.1
Element detection	SP1	I0.7	Elongation button	SB8	I2.2
Reset button	SB2	I1.0	Contraction button	SB9	I2.3
Manual	SA1	I1.1	Welding button	SB10	I2.4
Single-step	SA2	I1.2	Welding end button	SB11	I2.5
output			output		
Signal Name	Signal symbol	Address	Signal Name	Signal symbol	Address
dextral motor	Y1	Q0.0	Elongation motor	Y5	Q0.4
Sinistral motor	Y2	Q0.1	Contraction motor	Y6	Q0.5
Top spin motor	Y3	Q0.2	Welding motor	Y7	Q0.6
Backspin motor	Y4	Q0.3	Situ display	HL	Q0.7

4.3. PLC Programming

The main program is show in Figure 6. When the work mode is manual work, the 1.1 is turned on, and the system perform manual work procedures; When chose automatic mode (Single-step, single circle, continuous), I1.2、I1.3、I1.4 is turned on respectively, the system perform automatic procedure.

The manually control program is shown in Figure 7. Manual button I1.6, I1.7, I2.0, I2.1, I2.2, I2.3, I2.4 respectively controls the actions of dextral, sinistral, topspin, backspin, elongation, shrinkage, welding and over. In order to maintain the safe operation of the system, set the necessary interlock protection, I0.5 is set as an upper limit for contraction and welding control chain.

Automatic control program is shown in Figure 8. Automatic operating program contains single circle and continuous movement, which depends on the mode select switches. When you select continuous way, I1.3 makes M0.0 set "1", and when the mechanism comes back into place, the shift register is automatically reset and make M1.0 set "1", at the same time I1.3 close to get a shift signal, so the sequence is repeatedly executed; when you select the single-cycle mode, I1.4 makes M0.0 set to "0", when the mechanism comes back into place, press the start button and the mechanism will automatically act a movement cycle then stops in situ.

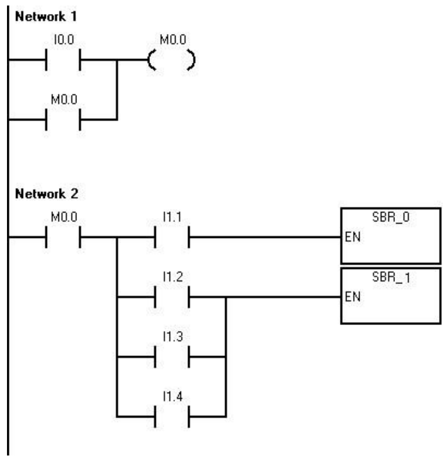


Figure 6. The Main Program

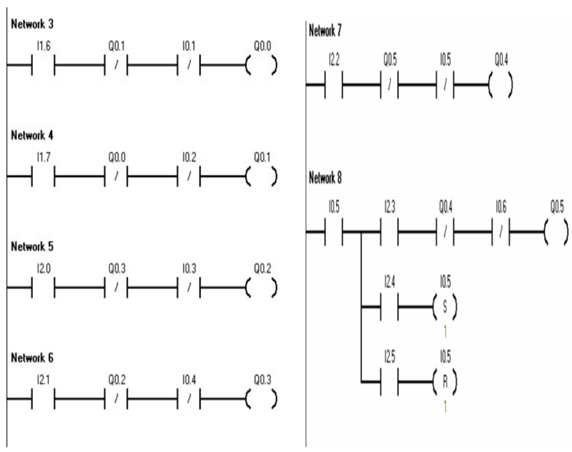


Figure 7. The Manually Control Program

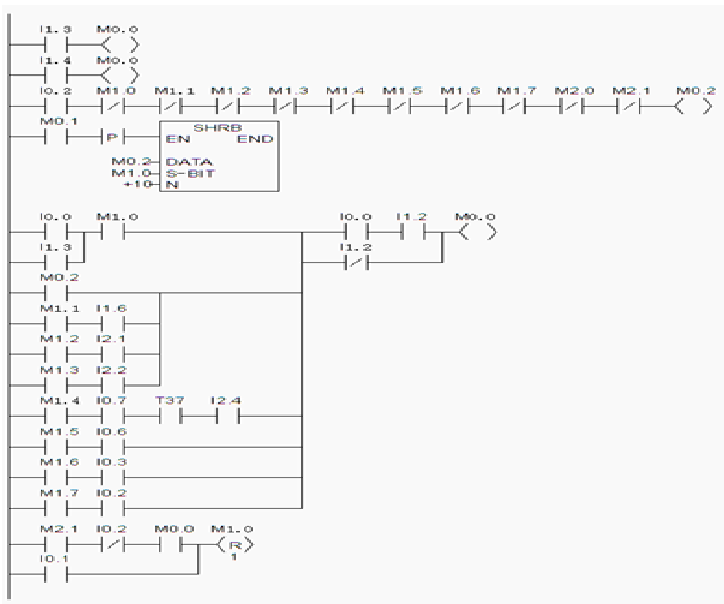


Figure 8. Automatic Control Program

5. Conclusion

The paper designed a type of three degrees of freedom industrial welding robot. The robot can complete the actions of rotating, lifting and elongation; it can accurately capture the solder joints and welding them.

Acknowledgment

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