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The Design of Intelligent Repair Welding Mechanism and Relative Control System of Big Gear

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Abstract: Effective repair of worn big gear has large influence on ensuring safety production and enhancing economic benefits. A kind of intelligent repair welding method was put forward mainly aimed at the big gear restriction conditions of high production cost, long production cycle and high-intensity artificial repair welding work. Big gear repair welding mechanism was designed in this paper. The work principle and part selection of big gear repair welding mechanism was introduced. The three dimensional mode of big gear repair welding mechanism was constructed by Pro/E three dimensional design software. Three dimensional motions can be realized by motor controlling ball screw. According to involute gear feature, the complicated curve motion on curved gear surface can be transformed to linear motion by orientation. By this way, the repair welding on worn gear area can be realized. In the design of big gear repair welding mechanism control system, Siemens S7-200 series hardware was chosen. Siemens STEP7 programming software was chosen as system design tool. The entire repair welding process was simulated by experiment simulation. It provides a kind of practical and feasible method for the intelligent repair welding of big worn gear. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Big gear, Intelligent repair welding mechanism, Control system, Repair welding process, Experiment simulation.

1. Introduction

Gear drive mechanism was applied in modern mechanical equipment. Gear has the advantages of big power transmission, high efficiency, steady drive and long work cycle. Gear has the disadvantages of high manufacture cost, high manufacture precision and high installation precision. The manufacture cost of big gear is higher.

Gear plays an important role in national production. But gear abrasion is a big and difficult problem in industrial production. How to accomplish gear repair so as to prolong gear service life is an important problem. When gear surface was worn, gear can not work normally. Gear work precision was affected. Vibrations and noises may be caused [1]. Entire gear part was scrapped because of gear surface abrasion. Equipment utilization rate and work efficiency were cut down greatly [2]. The repair of worn gear has important significance on enhancing production efficiency and decreasing production cost [3]. Gear can be used again by proper repair on worn gear surface. It can ensure normal equipment running. It can save big enterprise cost. It can bring distinct economic benefits [4]. Big gear is important part in modern industrial production. The normal big

gear work affects the running of entire equipment or production line directly.

Repairing gear can save more cost than manufacturing gear. Big gear repair has the advantages of short processing cycle and low work intensity. The purpose of gear repair on abnormal gear is to recover original property and precision of gear. Thereby normal production can be recovered. Unnecessary economic loss can be avoided. Current gear repair method mainly has several kinds. In adjustment and position conversion method, worn gear position was converted. Unworn and light worn gear was utilized to work continually. The method is suitable for single sided worn gear repair caused by unidirectional work load [5]. Position conversion was utilized on both big gear and small gear in position conversion processing method to realize gear repair [6]. Bead weld repair is a gear repair method of melting and depositing a special alloy layer on worn gear surface by bead weld. After bead weld, alloy layer was processed so as to recover gear service character [7]. Thermal spraying is a general name of modern various spraying depositing and spraying melting technology. Thermal spraying repair as a ripe technology has been applied in many fields successfully. Thermal spraying technology is a technology with melting, atomizing, accelerating and depositing silk or powder material on part surface so as to form cover layer [8]. The method can repair gear and enhance gear abrasion performance. In inlay repair, aiming at bad gear teeth loss, gear teeth was manufactured according to the size of loss gear teeth. It was installed in original gear groove. Then it was fixed by bolts. Finally, welding was used to fix.

Researches were made mainly on designing big gear repair welding mechanism, designing big gear repair welding mechanism control system and relative experiment simulation.

2. Big Gear Repair Welding Mechanism Design

In this paper, big gear repair welding mechanism mainly contains clamp plate mechanism, welding wire transport system, welding gun and ball screw mechanism. For the big volume and quality of big gear, it is difficult in designing special work platform. So, in this paper, big gear was level placed. Then big gear was adjusted with level status and fixed. Big gear repair welding mechanism was placed on fixed big gear. Repair welding was made based on big gear axis hole position determination. Gear shape of big gear is involute. Motions on three dimensional directions need to be realized in repair welding process. Welding gun was located on worn gear position by collective straight line motions of X axis lead screw pair, Y axis lead screw pair and Z axis lead screw pair. Then welding gun moves straight and repeatedly along gear width direction so as to realize gear repair welding. The three dimensional mode of big gear repair welding mechanism was constructed by Pro/E three dimensional design software. The assembly diagram of big gear repair welding mechanism and big gear is shown as Fig. 1.

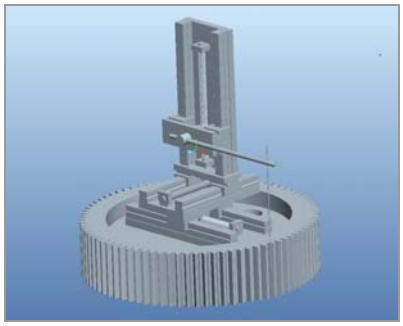

Fig. 1. The assembly diagram of big gear repair welding mechanism and big gear.

Welding gun moves along X axis longitudinal lead rail straightly is shown as Fig. 2. Welding gun moves along Y axis transverse lead rail straightly is shown as Fig. 3. Welding gun moves along Z axis lead rail straightly that is positive gear width direction is shown as Fig. 4. Welding gun moves along Z axis lead rail straightly that is inverse gear width direction is shown as Fig. 5. When a weld bead was completed, Welding gun was adjusted to next position. Inverse straight line motion was made by welding gun next to previous weld bead. After reciprocating straight line motion of welding gun a weld layer was welded well. By the same mode, next weld layer was welded well. Finally, a worn gear tooth was welded well.

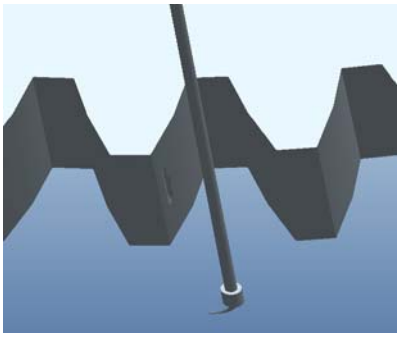

Fig. 2. Welding gun moves along X axis longitudinal lead rail straightly.

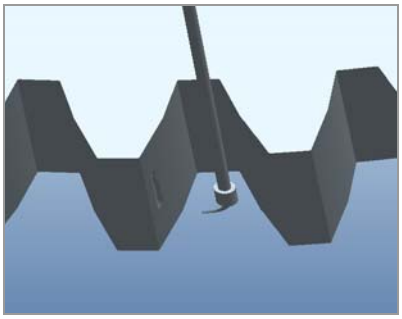

Fig. 3. Welding gun moves along Y axis transverse lead rail straightly.

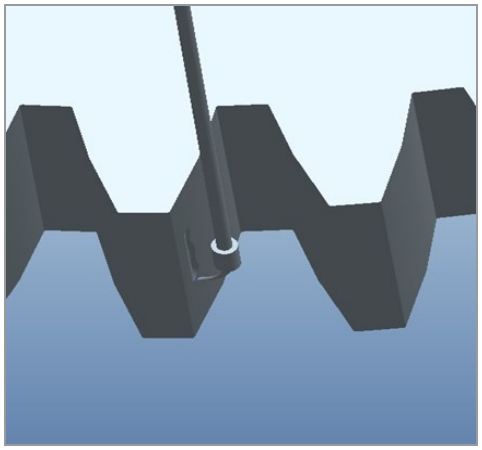

Fig. 4. Welding gun moves along Z axis lead rail straightly that is positive gear width direction.

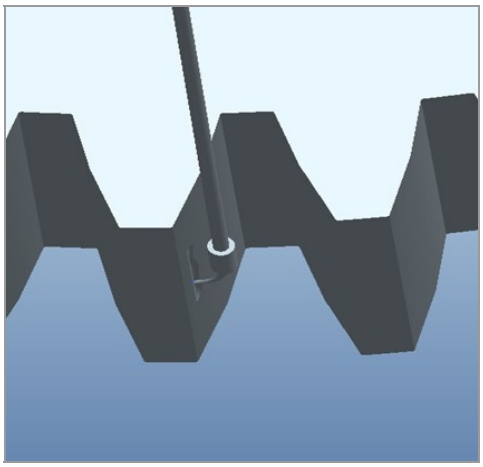

Fig. 5. Welding gun moves along Z axis lead rail straightly that is negative gear width direction.

3. Big Gear Repair Welding Mechanism Control System Design

3.1. Siemens S7-200 and V4.0 STEP7-Micro/WIN Software

Siemens S7-200 is a kind of miniaturization PLC appreciated by broad user deeply. It mainly contains CPU module and other abundantly expanded modules. It can accomplish flexible configuration according to user need. Its powerful instruction system can satisfy control requirement of small scale system absolutely.

The operation and configuration of V4.0 STEP7-Micro/WIN software was based on Windows system. It is designed by Siemens especially for S7-200 series PLC. This software has powerful function and friendly interface. Various programming operation can be made by this software expediently. The user program performance status can be monitored in real time by this software. Big gear repair welding mechanism control system design can be realized by S7-200 and V4.0 STEP7-Micro/WIN software.

3.2. Control Requirement

After pressing start button, work indicating lamp was lighted. Two limited position limit switch were placed on both sides of worn gear surface to limit welding gun position. When welding gun reaches scheduled position, Z axis motor was started. Welding gun was opened simultaneously. Welding gun moves straightly along positive gear width direction to accomplish repair welding. When signal was emitted by position limit switch, welding gun was closed. Z axis motor was closed simultaneously. Then X axis motor and Y axis motor were started. Welding gun was adjusted to next weld bead position. Afterwards, X axis motor and Y axis motor were closed. Z axis motor was started again and reversed.

Welding gun was opened simultaneously. Welding gun moves straightly along inverse gear width direction to accomplish repair welding. When signal was emitted by position limit switch, welding gun was closed. Z axis motor was closed simultaneously.

3.3. Control Analysis

In order to realize the control of PLC on repair welding mechanism, a system start button, a system stop button, a positive direction start button, a negative direction start button, a X axis start button, a Y axis start button, four relay coils, two position limit switches, seven start display lamps and three ball screws were regarded as output control objects.

3.4. PLC Type Selection and Resource Configuration of Repair Welding Mechanism Control System

According to control requirement, CPU224 of S7-200 series PLC was adopted in this paper. Seven input points and seven output points were required by system.

The distribution addresses of seven input points and seven output points are shown as Table 1 and Table 2 respectively.

3.5. Program Design

According to control system requirement, ladder diagram was adopted in this paper to design gear repair welding mechanism control system program. Gear repair welding mechanism control system program ladder diagram is shown as Fig. 6.

Table 1. The distribution addresses of seven input points.

Sequence number	Symbol	Address	Annotation
1	SB1	10.0	System start button
2	SB2	10.1	System stop button
3	S1	10.3	Positive direction welding gun movement position limit
4	S2	10.4	Inverse direction welding gun movement position limit
5	S3	10.5	Welding gun movement position limit along X axis lead screw
6	S4	10.6	Welding gun movement position limit along Y axis lead screw
7	ST1	10.7	Welding gun stop along X axis and Y axis

Table 2. The distribution addresses of seven output points.

Sequence number	Symbol	Address	Annotation
1	KM1	Q0.0	System start show
2	KM2	Q0.1	System stop show
3	YV1	Q0.3	Positive direction welding gun movement and welding along Z axis
4	YV2	Q0.4	Inverse direction welding gun movement and welding along Z axis
5	YV3	Q0.5	Welding gun movement adjustment along X axis lead screw
6	YV4	Q0.6	Welding gun movement adjustment along Y axis lead screw
7	HA	Q0.7	Welding gun stop show along X axis and Y axis

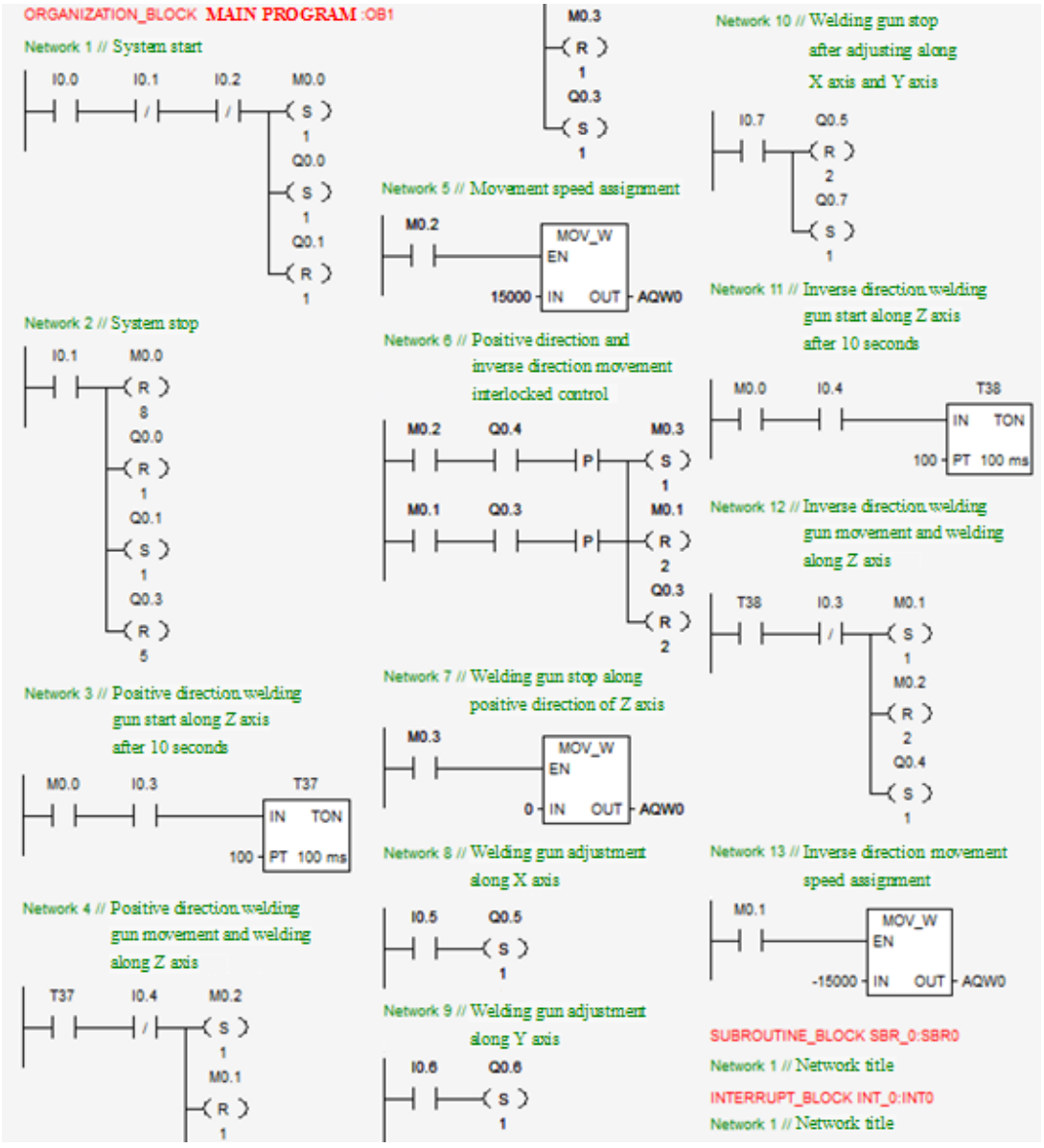

Fig. 6. Gear repair welding mechanism control system program ladder diagram.

4. Experiment Simulation

Firstly, S7-200 Simulation software was opened. CPU type was chosen as CPU224 under configuration menu instruction. Program codes of programming software can not be received by simulation software directly. Program codes of programming software were led out and transformed as ASCII text file with extension name awl in this paper. The file was led in simulation software to simulate. File and lead out menu instruction were carried out in programming software. File was named as gear repair welding mechanism control system. File and load program menu instruction were carried out in simulation software. Entire, logical block, data block and CPU configuration were selected in shown dialog box. Microwin V3.2, V4.0 was selected in lead in file version option. Then determination button was clicked. *.awl file was selected and opened in shown open dialog box. Afterwards, program was loaded by system. After program load success, loaded file name was shown on CPU module. Program code was shown simultaneously.

PLC and run menu instruction were carried out. Program loaded by system was started and carried out. Small switch of switch panel under CPU module was clicked to simulate signal input. The status change of output point can be observed by led lamp on CPU module so as to check the status of requirement satisfaction of program. After pressing system start button, system start was shown. Work pilot lamp was lighted. It is shown as Fig. 7.

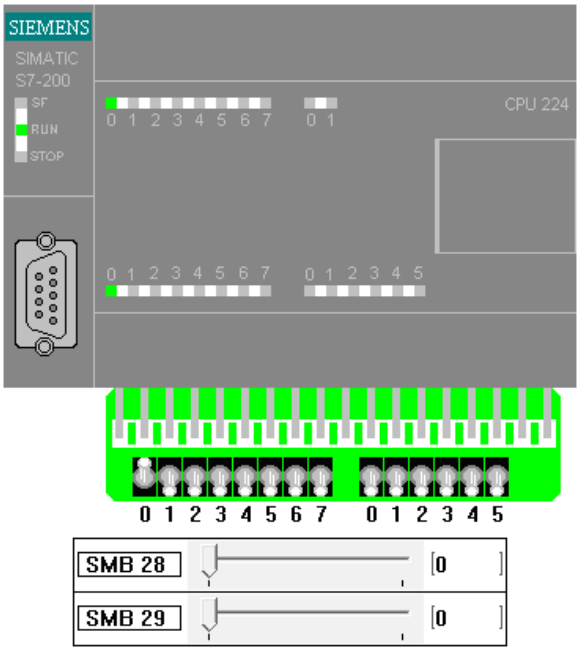

Fig. 7. System start.

After pressing positive Z axis motor start button, welding gun moves straightly along positive gear width direction to accomplish repair welding. It is shown as Fig. 8.

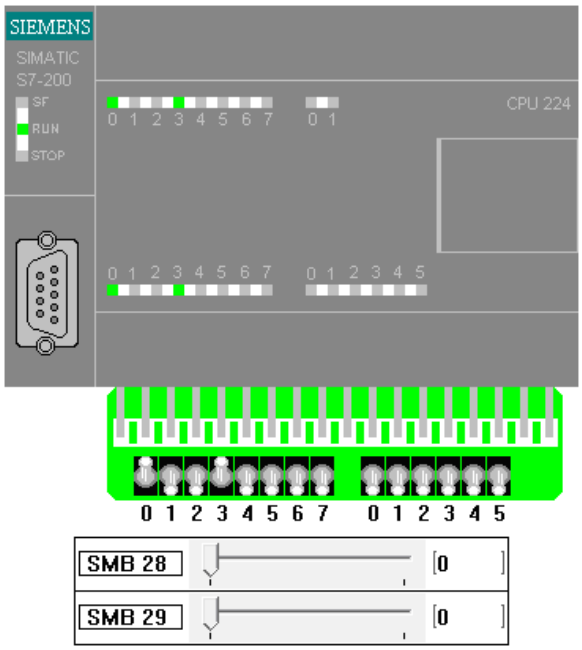

Fig. 8. Welding gun moves straightly along positive gear width direction to accomplish repair welding.

When welding gun reaches limit position, the straight motion of welding gun along positive gear width direction was stopped. X axis motor was opened. It is shown as Fig. 9.

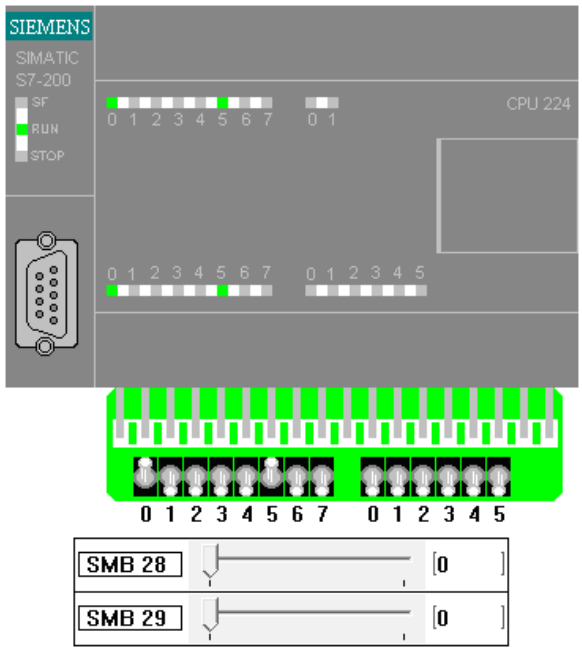

Fig. 9. The straight motion of welding gun along positive gear width direction was stopped.

When welding gun reaches limit position, Y axis motor was opened to adjust welding gun position. It is shown as Fig. 10.

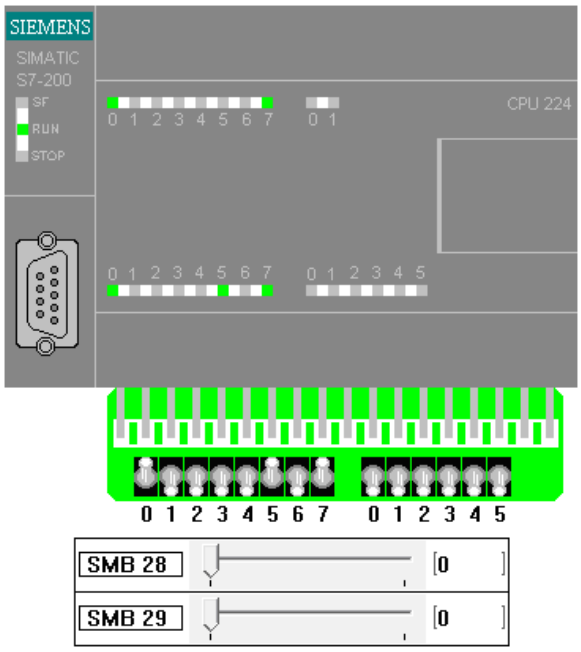

Fig. 10. Y axis motor was opened.

When welding gun reaches limit position, the straight motions of welding gun along X axis and Y axis were stopped. Z axis motor was opened and reversed. Welding gun moves straightly along negative gear width direction to accomplish repair welding. It is shown as Fig. 11.

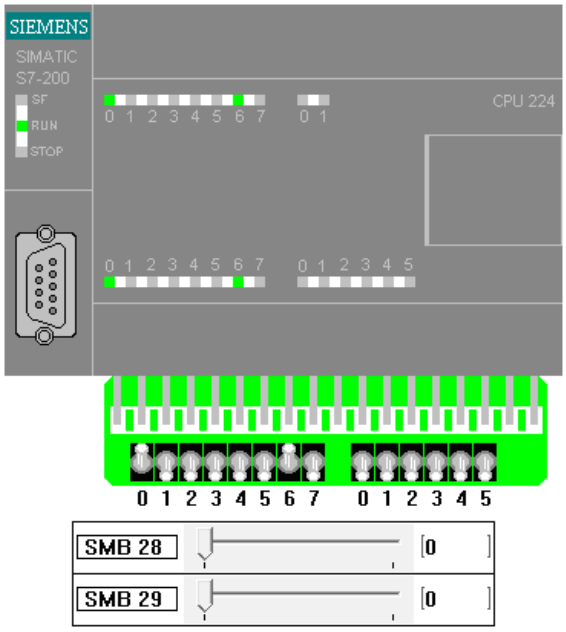

Fig. 11. Welding gun moves straightly along negative gear width direction to accomplish repair welding.

When the repair welding along negative gear width direction was accomplished, system stop button was pressed. Entire repair welding mechanism was stopped. It is shown as Fig. 12.

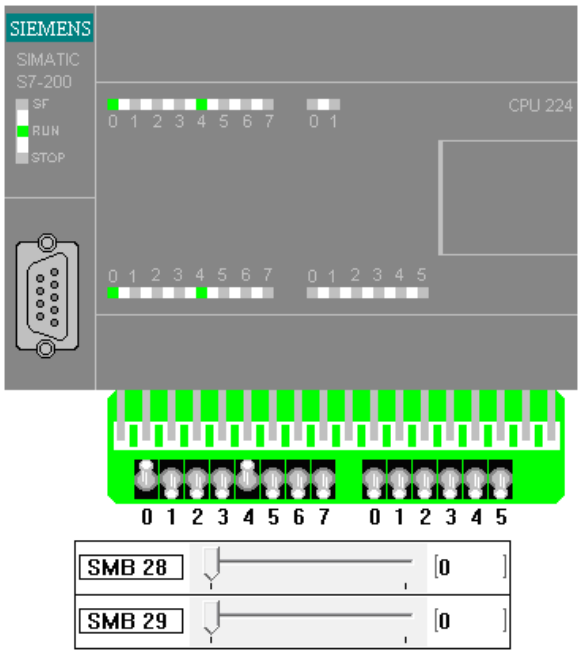

Fig. 12. Entire repair welding mechanism was stopped.

Experiment simulation results shows that big gear repair welding mechanism control system can satisfy control requirement.

5. Conclusions

A kind of intelligent repair welding method was put forward mainly aimed at the big gear restriction conditions of high production cost, long production cycle and high-intensity artificial repair welding work. Big gear repair welding mechanism was designed in this paper. The work principle and part selection of big gear repair welding mechanism was introduced. The three dimensional mode of big gear repair welding mechanism was constructed by Pro/E three dimensional design software. Three dimensional motions can be realized by motor controlling ball screw. According to involute gear feature, the complicated curve motion on curved gear surface can be transformed to linear motion by orientation. By this way, the repair welding on worn gear area can be realized. In the design of big gear repair welding mechanism control system, Siemens S7-200 series hardware was chosen. Siemens STEP7 programming software was chosen as system design tool. The entire repair welding process was simulated. The design of big gear repair welding mechanism and relative control system is practical and feasible.

Acknowledgements

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