Automatic Supervisory Control System of Quenching Temperature in Steel Mill

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***Abstract*—In forging process, quenching temperature is the critical factor on affecting products solidity and wear resistance. In order to guarantee products quality and improve work efficiency, it is very essential to monitor and control quenching temperature automatically. To keep quenching temperature in normal range, a novel automatic supervisory control system based on SCM minimum system was designed. By selecting appropriate sensor and corresponding signal processing, the system realized functions of many furnace temperature supervisory, temperature excursion alarming and temperature regulating. By simulation results, the system can realize automatic and intelligent supervisory, also, the system has characteristics of simple hardware, high reliability, powerful functions and strong practicality.**

Keywords-automatic control; quenching temperature supervisory; signal process; simulation

I. INTRODUCTION *(HEADING 1)*

Temperature is one of most fundamental environmental parameters in industrial production, and the performance of temperature detection and control system affects production status and production quality[1]. As a result, it is crucial importance to research on methods and installations of measurement. In forging process of steel mill, quenching temperature has crucial effect on production quality and work efficiency. In order to guarantee production quality, it is very necessary to monitor quenching temperature. The traditional temperature control methods are discontinuous control based on thermocouple with time relay or potentio-meter[2], and infrared thermometric method[3], and so on. But these methods have defects of low precision, more overshoot, serious delay and so on, so they affect production quality seriously, moreover, they can not meet the requirement of modern technology[4]. While the intelligent supervisory system adopted minimized SMC system is utilized to monitor quenching temperature, this novel supervisory system not only has virtues of powerful functions, simple structure and reliable performance, but also has strong practicality, so can meet technical requirement. This paper will elaborate this novel supervisory control system of quenching temperature.

II. OVERALL DESIGN ON SYSTEM

The supervisory control system designed in this paper is utilized to monitor quenching temperature. The temperature range is 100~650^{o}C, type E thermocouple temperature transmitter SBWR-2160 was adopted in the system, it's temperature range is 0~800 ^{o}C, output signal is current of 0~10 mA or voltage of 0~5 V. The system consisted of signal sampling and process unit, power unit, multi-selection switch unit, SMC minimized system unit, display unit, control unit, alarm unit and so on.

III. DESIGN ON HARDWARE

In this part, the hardware system of automatic quenching temperature supervisory control system based on AT89C52 SCM was introduced. This system was consisted of signal sampling and process circuit, SMC minimized system, display and alarming unit, feedback and implement circuit, and power circuit. This system should accomplish functions as follows. First, sample temperature signal by thermocouple temperature transmitter, then transfer it to ADC. Second, choose one path signal by multi-selection switch, process it by ADC, then transfer it to ATC89C52. Third, transfer the processed signal to display unit, and give different display according to different circumstance, namely normal or abnormal. Finally, SMC send out control signal to implement unit, to control inlet valve of quench furnace, so as to adjust quenching temperature. The framework diagram is shown in figure 1.

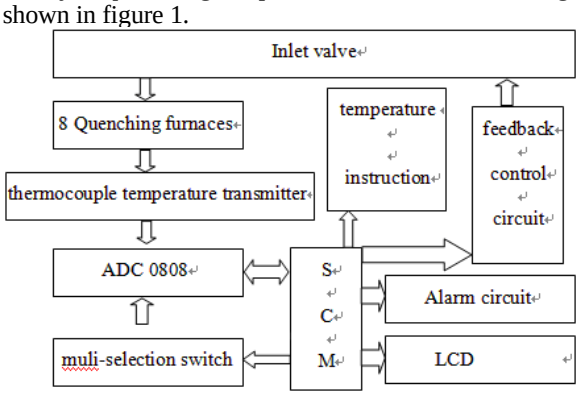

Figure 1. The principle flow chart of hard system.

The main hardware units are introduced as follows:

A. *Temperature signal sampling unit*

In this system, the E type thermocouple temperature transmitter SBWR-2160 is utilized in sampling unit, whose temperature measuring range is 0~800 ^{o}C, output voltage signal is 0~5 V. Thermocouple temperature transmitter is

modularization component, so it can be utilized in circuit, and needs not any other redundant circuits. The framework diagram is shown in figure 2.

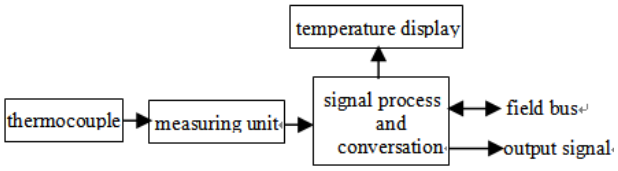

Figure 2. The schematic of temperature transmitter.

B. *Multi-selection switch*

In this system, multi-selection switch is responsible for selecting 8 quenching furnace, and importing switching value into SCM. So 8-channel DIP switch was utilized in this system. It mainly accomplish selecting one of quenching furnace's temperature to be acquired, then importing switching value in SCM. The SCM system will display serial number, temperature value and status of quenching furnace. Because the I/O ports of SCM are limited, we combined multi-selection switch with 8-3 encoder 74HC148.

C. *SMC main control unit*

In this system, the SCM ATC89C52 was utilized to measure and control temperature of quenching furnace. The SCM measuring system has strong intelligence, and can measure temperature of multi quenching furnaces. In consideration of the optimization of system, the SCM ATC89C52 was utilized as main control unit, the circuit of this unit is shown in figure 3.

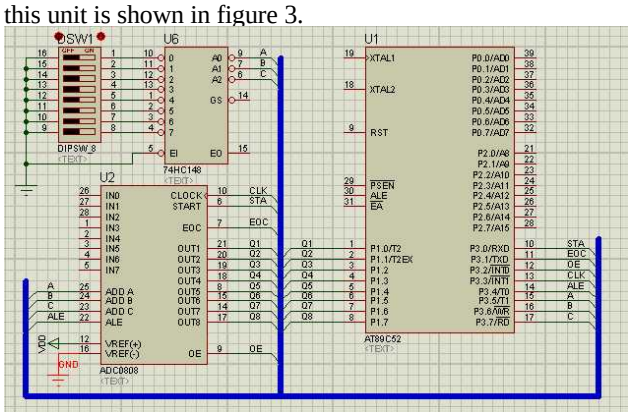

Figure 3. The interface circuit of SCM unit.

D. *Feedback implement control unit*

This unit mainly accomplish functions as follows. First, SCM sends out control signal to control electric relay if temperature of quenching furnace is out of normal range. Second, electric relay controls air inflow of quenching furnace, so as to increase or decrease temperature. As a result, the purpose of controlling temperature of quenching furnace automatically can be realized.

IV. DESIGN ON SOFTWARE SYSTEM

This part introduced the software system of automatic quenching temperature supervisory control system based on AT89C52 SMC. According to the functions of supervisory control system, software system can be divided into signal acquisition and process subprogram, ADC conversion subprogram, display subprogram, implement subprogram. The main software flowchart is shown in figure 4.

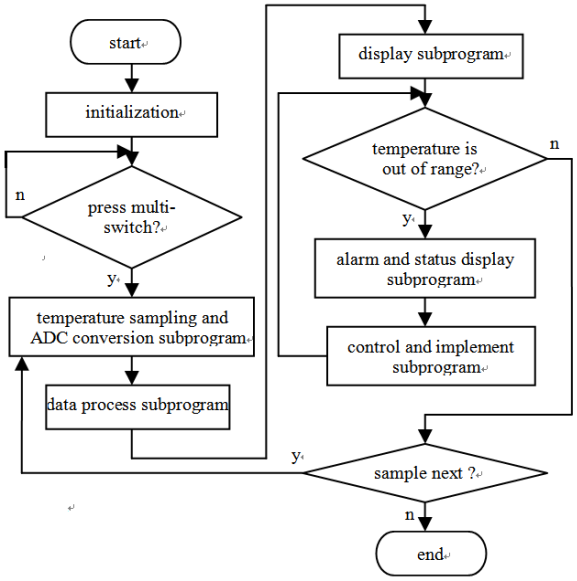

Figure 4. The main software flowchart of software system.

A. *Temperature sampling and ADC conversion subprogram*

This subprogram accomplish functions of sampling voltage signal converted by thermocouple temperature transmitter, and converting it into digital signal, then transfer it to SCM system to be processed. The software flowchart is shown in figure 5.

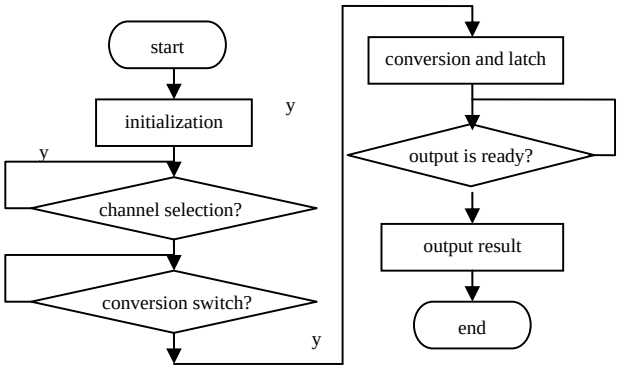

Figure 5. The software flowchart of sampling and ADC conversion.

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B. *Alarming and status display subprogram*

This subprogram accomplish functions of displaying temperature status of chosen quenching furnace, and alarming if temperature is out of range. The concrete functions are as follows: First, if temperature of quenching furnace is in the range of 100~650°C, blue LED is on, alarm does not ring. Second, if temperature of quenching furnace exceeds 650°C, red LED is on, alarm rings three times. Third, if temperature of quenching furnace is less than 100°C, yellow LED is on, alarm rings two times. In this part, SCM control LED and alarm according to different judgment. The software flowchart is shown in figure 6.

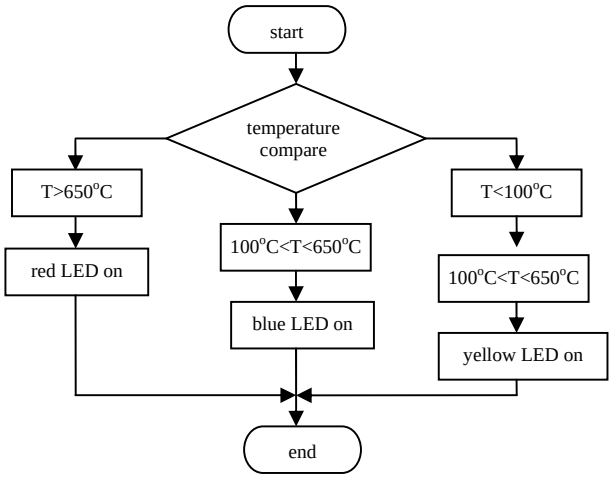

Figure 6. The software flowchart of alarm and display subprogram.

C. *Core control main program*

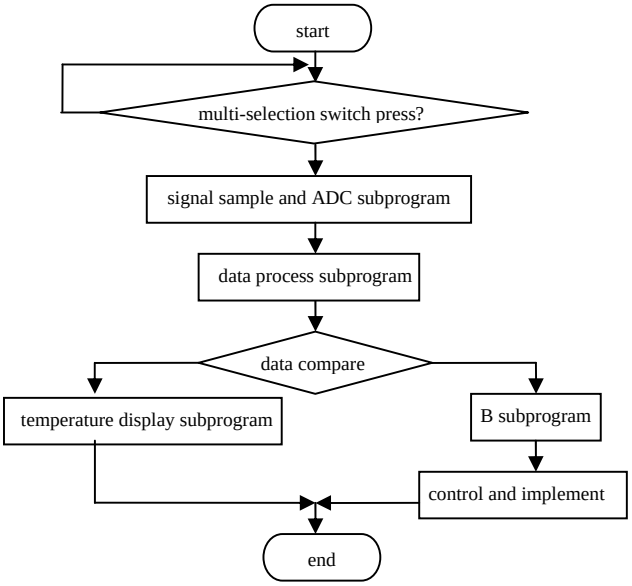

Figure 7. The software flowchart of alarm and display subprogram.

Core control main program is critical part in the whole system, also is the foundation of realizing system function. The core control program mainly accomplish following functions. a). Detect the status of multi-selection switch, then choose channel of signal sampling and conversion; b). Process received data, and control LCD display temperature value and status of temperature of quenching furnace. c). control alarm circuit according to status of temperature of quenching furnace. d). Control valve air inflow of quenching furnace according to feedback control signal, so as to control temperature of quenching furnace. The software flowchart is shown in figure 7.

V. SIMULATION OF SYSTEM

The system was designed and simulated by Keil uVision4 and Proteus, by simulating system actual environment, achieved simulation result. Take number 1 furnace as example, if voltage sampled by system is 2.23V, the result is shown in figure 8.

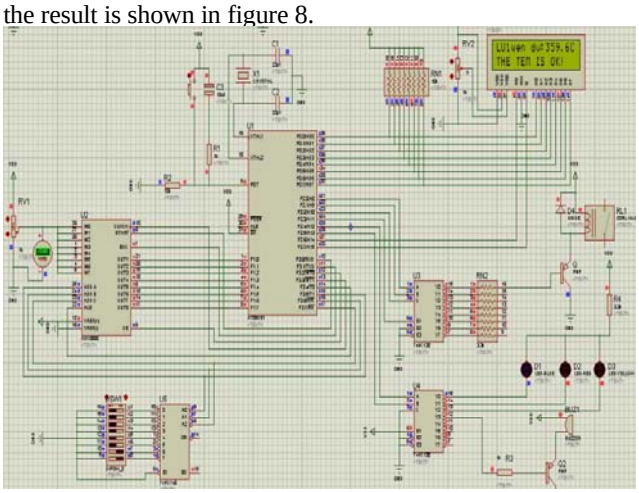

Figure 8. The simulation result of furnace 1.

When temperature is in the range, blue LED is on, and LCD displays “THE TEM IS OK!”, alarm does not ring. When temperature exceeds 650°C, red LED is on, and LCD displays “THE TEM IS HIGH!”, and alarm rings three times. When temperature is less than 100°C, yellow LED is on, and LCD displays “THE TEM IS LOWER!”, and alarm rings two times.

VI. CONCLUSION

This paper designed a automatic quenching temperature supervisory control system based on AT89C52 SCM. By simulation result we can draw a conclusion that this system can accomplish automatic supervise on quenching furnace, display temperature value and status of temperature, and can control it's temperature automatically. This system has merits of simple hardware, plentiful function, strong practicality and advancement, more important, it meet intelligent control of present industrial production.

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