Design of the Highest Surface Temperature Test System for Explosion-Proof Electrical Appliances

Yukun Wang [1, 2, 3], Hongkui Zhang [1, 2, 3, *]

[1] Fushun CCTEG Inspection Center Co. Ltd, Fushun Liaoning 113122, China

[2] CCTEG Shenyang Research Institute, Fushun Liaoning 113122, China

[3] State Key Laboratory of Coal Mine Safety Technology, Fushun Liaoning 113122, China

* Corresponding author Email: 18940021505@126.com

Abstract. Based on the analysis of explosion-proof electrical appliances use places and the status of the highest surface temperature test, the design method of the highest surface temperature test system of explosion-proof electrical appliances is proposed, the functions of each part of the system are clarified, the circuit of the voice alarm unit is designed, and the automatic test and result determination of the highest surface temperature test of explosion-proof electrical appliances are realized.

Keywords: Explosion-proof Electrical Appliances; Maximum Surface Temperature; Test System; Voice Reminding Unit.

1. Introduction

Explosion-proof electrical equipment refers to the electrical equipment such as explosion-proof electromagnetic starter, explosion-proof high-voltage power distribution device, explosion-proof junction box and explosion-proof lighting comprehensive protection device used in explosive places, which are widely used in coal mines, chemical industry, petroleum and other flammable and explosive places. The flameproof shell structure not only prevents the electric spark inside the explosion-proof electrical appliance from igniting the external explosive gas, but also prevents the explosion of the external environment from damaging the explosion-proof electrical appliance, thus ensuring the safe operation of the explosion-proof electrical appliance in an explosive place. However, the heavy weight of the flameproof shell structure limits the mobility of the explosion-proof electrical appliances, and also limits the internal heat transfer of the explosion-proof electrical appliances, resulting in the temperature of the explosion-proof electrical appliances being much higher than that of the electrical equipment of the same grade on the ground. Explosion-proof electrical appliances are shown in Figure 1.

Fig 1. Physical diagram of explosion-proof electrical appliances

The national standard GB/T 3836.1-2021 "Explosive atmospheres-Part 1: General requirements for equipment" clearly stipulates that the maximum surface temperature of explosion-proof appliances shall not exceed 150℃. At present, the highest surface temperature test of explosion-proof electrical appliances uses infrared point thermometer to test the temperature data, and the test point selection is inaccurate (explosion-proof electrical appliances have complex structure and large

maximum surface area, and the point thermometer can only select the test point according to experience). At the same time, it is necessary to manually judge whether the test results and the ambient temperature meet the test requirements, which leads to heavy workload, low accuracy of test data and poor reliability of test results, and brings hidden dangers to the safe operation of explosion-proof electrical appliances in explosive places.

2. Temperature Test System

The explosion-proof maximum surface temperature test system of electrical appliances includes PLC, thermocouple group, regulated power supply, thermal imager, temperature test power supply, temperature and humidity sensor, temperature control device, data memory card, electrical parameter test unit, voice reminding unit and touch screen. The structural diagram of the explosion-proof maximum surface temperature test system for electrical appliances is shown in Figure 2. PLC is the core of the test system, which is used for the control, data acquisition and processing of the whole test system. Thermocouple group is used to test the highest surface temperature data of explosion-proof electrical appliances. The regulated power supply is used to provide control power for PLC, touch screen, explosion-proof electrical appliances, etc. Thermal imager is used to find the highest surface temperature point of explosion-proof electrical appliances. The test power supply is used to provide test current for the highest surface temperature test of explosion-proof electrical appliances. The temperature and humidity sensor is used to test the temperature and humidity data of the environment. The temperature control device is used to adjust the temperature of the experimental environment. The data memory card is used to store the test data of the highest surface temperature and the information of explosion-proof appliances. The electrical parameter test unit is used to test the voltage and current of the highest surface temperature test. Touch screen is used to set test parameters and display test data.

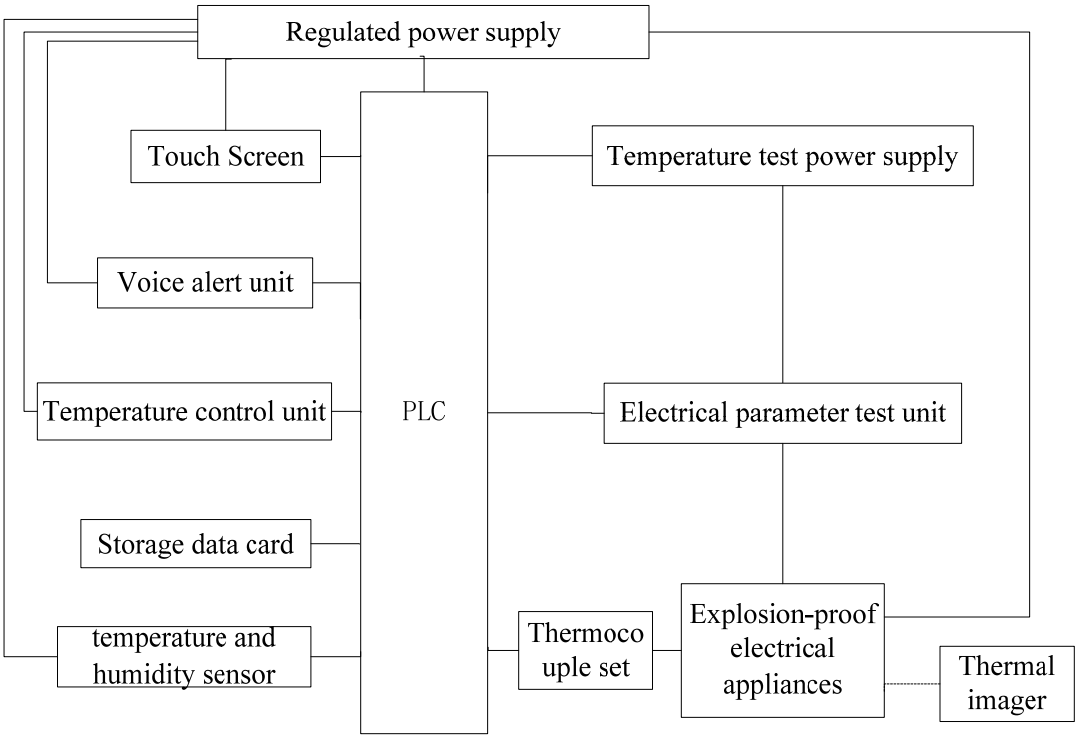

Fig 2. Structure diagram of test system for maximum surface temperature of explosion-proof electrical apparatus

The voice reminding unit circuit is mainly composed of a voice chip SC8120B, a capacitor C1, a capacitor C2, a power supply VCC, a grounding terminal GND1, a grounding terminal GND2 and a

speaker LSQ. The voice reminding unit is used for reminding system status and faults. The circuit diagram of voice reminder unit is shown in Figure 3.

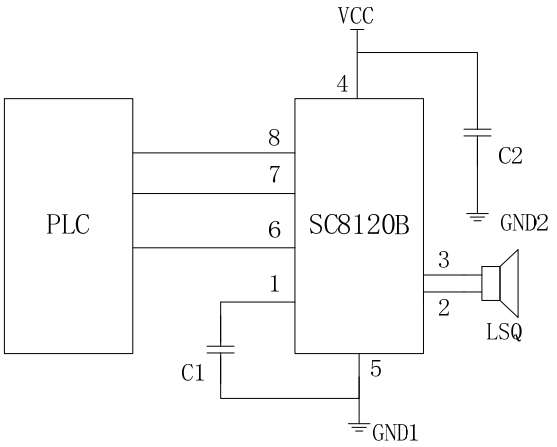

Fig 3. Circuit diagram of voice reminder unit

The working process of explosion-proof electrical appliances is mainly caused by current, so the highest surface temperature of explosion-proof electrical appliances is tested using the simulation method, using a high current generator to generate test current, and the three phases of explosion-proof electrical appliances are connected in series in turn and then passed into the test current. The highest surface temperature test of explosion-proof electrical appliances is shown in Figure 4. This is the description of the working process of the highest surface temperature test system for explosion-proof electrical appliances.

(1) Set the explosion-proof electrical test current through the touch screen, and then send the current adjustment command output through the touch screen control PLC, and the temperature test power supply receives the current adjustment command and adjusts the current output (increase from zero).

(2) PLC collects and processes the test current data of explosion-proof electrical appliances in real time, and compares it with the set value. When the actual current reaches the test current, PLC stops outputting the current adjustment instruction, and the current adjustment of the temperature test power supply stops.

(3) After the explosion-proof appliance is energized for half an hour, use the thermal imager to find the highest surface temperature point of the explosion-proof appliance (in order to ensure the accuracy of the test, choose the n points with the highest temperature, n usually takes 5), then fix the thermocouple group at the highest surface temperature test position with glue, and PLC collects the highest surface temperature data of the explosion-proof appliance in real time, and performs calculation processing.

(4) PLC collects the temperature and humidity data of the temperature and humidity sensor in real time, and calculates it. If the temperature change data is greater than 2℃, PLC sends a control signal to start the temperature control device, and stops the temperature and humidity control device when the temperature change data is less than 2K. If the temperature data changes more than 3℃, stop the maximum surface temperature test of explosion-proof electrical appliances.

(5) When the ambient temperature changes less than 3℃, the PLC processes and stores the data of the thermal resistance group. If the temperature data measured twice at the same thermocouple interval of 1 hour is less than 1℃, it is determined that the test of the highest surface temperature of the thermocouple circuit is finished.

（6） When the temperature data of all thermocouple circuits measured twice at an interval of 1 hour are less than 2K, it is considered that the test of the highest surface temperature of explosion-proof electrical apparatus is finished.

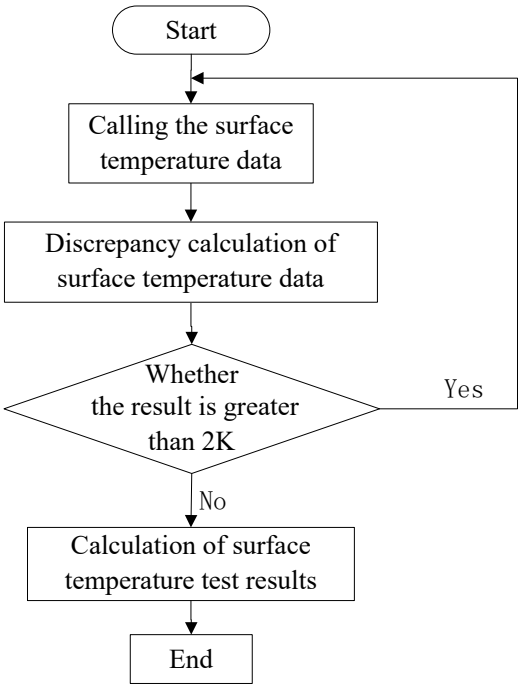

Fig 4. Test judgment process of maximum surface temperature of explosion-proof electrical apparatus

3. Temperature Data Processing

The test results of the explosion-proof maximum surface temperature test of electrical appliances are the test data of the highest surface temperature under the test environment. The maximum surface temperature required in the national standard GB/T 3836.1-2021 "Explosive Environment Part 1: General Requirements for Equipment" is the temperature under the most unfavorable underground conditions, so it is necessary to convert the test data of the highest surface temperature under the test environment. The conversion method is as follows:

$$T=T_s-T_h+T_k \tag{1}$$

T is the highest surface temperature of explosion-proof electrical appliances under the most unfavorable conditions, in degrees Celsius (℃); T_s is the highest surface temperature test data under the test environment (taking the highest temperature of n test points), in degrees Celsius (℃); T_h is the test environment temperature, in degrees Celsius (℃); T_k is the ambient temperature under the most unfavorable conditions, in degrees Celsius (℃), T_k usually take +40 ℃.

National standards require temperature tests around the air temperature change cannot exceed 3 ℃. The highest surface temperature test system for explosion-proof electrical appliances collects ambient temperature in real time, and PLC processes and stores the temperature data, and performs calculations and judgments.

4. Conclusion

We designed the highest surface temperature test system for explosion-proof electrical appliances in combination with the requirements of national standards, which solved the technical problems of large workload, difficult operation and low test accuracy of the highest surface temperature test for explosion-proof electrical appliances, and improved the efficiency of the highest surface temperature test, providing test verification technical support for the selection of explosion-proof enclosures and components in the R&D process of new products of explosion-proof electrical appliances.

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