

Research on Temperature Rise Testing Technology of Explosion-Proof Low-Voltage Feeder Switches in Coal Mines

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Abstract. Based on the analysis of the operating environment and protective functions of explosion-proof low-voltage feeder switches in coal mines, this paper proposes a temperature rise test data processing method for these switches. A temperature rise testing system for coal mine explosion-proof low-voltage feeder switches is designed to accurately measure the temperature rise at different points of the switches. This provides a reference for the development of intelligent inspection technologies for these switches in coal mines.

Keywords: Low-voltage electrical equipment; interrupting test; arc; image enhancement.

1. Introduction

Explosion-proof low-voltage feeder switches for coal mines are designed for environments with methane and coal dust explosion hazards. These switches are used as main distribution switches or branch switches in three-phase, ungrounded power systems with rated frequencies of 50 Hz, rated voltages of 1140V and 660V, and rated currents up to 400A. They also provide protection for power supply lines. The switch features a quick-opening door structure and uses vacuum circuit breakers for its main interrupting components. The system incorporates a microcomputer-based comprehensive monitoring device with a full Chinese-language display and menu-based operation, offering a user-friendly interface with rich display information. With a human-machine interface keyboard, it allows for modification of protection set values and various operations without power interruption. The switch can measure and display parameters such as grid voltage, three-phase current, insulation resistance, zero-sequence voltage, zero-sequence current, active power, reactive power, and power factor, and it shows equipment fault types, fault parameters, and fault times, with a fault memory and query function. Protection functions include overload, short circuit, leakage, leakage interlock, overvoltage, undervoltage, phase failure, three-phase imbalance, and overvoltage absorption.

To ensure the explosion-proof capability of these switches, they are housed in explosion-proof casings to prevent internal sparks from propagating to the external explosive environment. This explosion-proof structure ensures the safety of the equipment but affects the dissipation of internal heat, leading to a temperature rise higher than similar devices in surface installations. Temperature rise testing is a critical test item for type testing of coal mine explosion-proof low-voltage feeder switches and serves as an important indicator of product performance. According to the coal industry standard MT/T 871-2011 for explosion-proof low-voltage AC vacuum feeder switches, Clause 7.2.1 specifies the maximum temperature rise limits for terminal connections, insulating coils, and easily accessible components. The current automation level of the temperature rise testing system is low, and the level of data processing automation is poor, which affects the efficiency and accuracy of the temperature rise testing process.



Figure 1: Explosion-Proof Low-Voltage Feeder Switch for Coal Mines

2. Temperature Rise Testing System

The temperature rise testing system for explosion-proof low-voltage feeder switches in coal mines consists mainly of a PLC, thermocouple group A, analog expansion module A, thermocouple group B, analog expansion module B, switching power supply, display screen, communication module, control panel, warning module, data storage, humidity sensor, barometric pressure sensor, wind speed sensor, and the coal mine explosion-proof low-voltage feeder switch, as shown in the schematic diagram in Figure 2. Thermocouple group A and analog expansion module A are used to collect the temperature data of the coal mine explosion-proof low-voltage feeder switch. Thermocouple group B and analog expansion module B are used to collect the ambient temperature data during the temperature rise test. The humidity sensor, barometric pressure sensor, and wind speed sensor are used to collect environmental parameters such as humidity, atmospheric pressure, and wind speed during the temperature rise test. The display screen is used to show data such as voltage, current, temperature, and humidity during the temperature rise test. The switching power supply provides power for the PLC, display screen, control panel, etc.

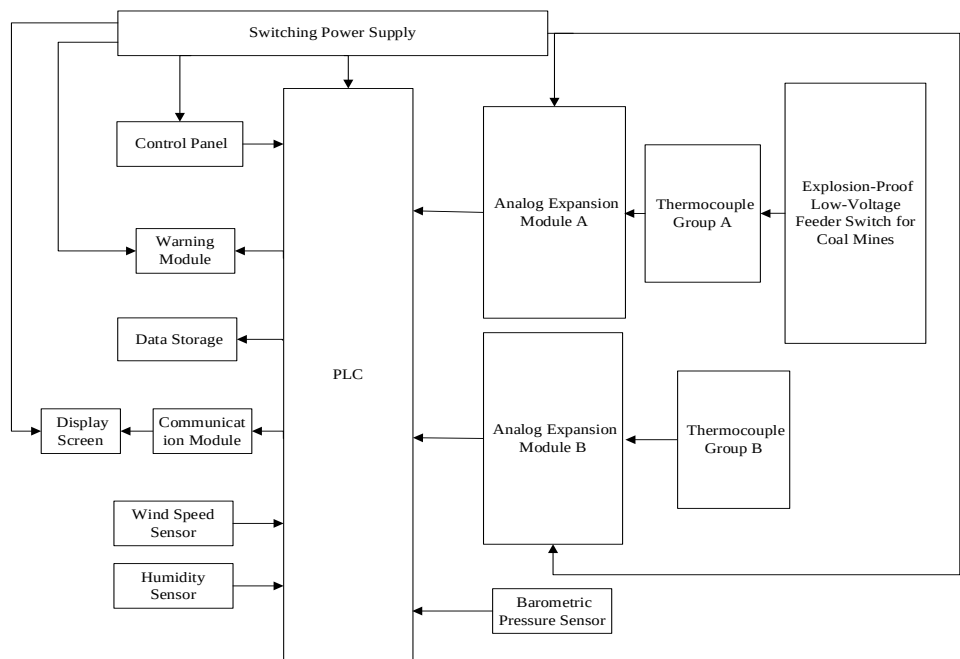


Figure 2: Schematic Diagram of the Temperature Rise Testing System for Explosion-Proof Low-Voltage Feeder Switches in Coal Mines

The warning module in the temperature rise testing and inspection system for explosion-proof low-voltage feeder switches in coal mines receives the PLC digital output signals, and the warning lights display the system's working status through different colors. Green indicates that the system is functioning normally after self-check and is ready for temperature rise testing; red signals a system failure; yellow indicates that temperature data collection is ongoing; blue means the temperature data collection is complete and the temperature rise calculation is in progress; blue also indicates that the temperature rise test has concluded.

Description of the Working Process of the Temperature Rise Testing System:

1. Turn on the power switch on the control panel. After the system powers on, it performs a self-check, and if any abnormalities are detected, the warning module triggers an alarm.
2. The control panel sends a system start-up command, and the temperature acquisition system begins its operation. The PLC starts collecting temperature data for the explosion-proof low-voltage feeder switch and the environment.
3. The PLC processes the collected data to determine whether the temperature rise test is complete. If the test is complete, the system halts further temperature data collection.
4. After data collection is completed, the instruction input unit turns off the data collection system, and the collected temperature data is retrieved for temperature rise calculation.
5. Once the temperature rise value is calculated, it is compared with the standard requirement data to determine whether the measured temperature rise at the test points of the explosion-proof low-voltage feeder switch is acceptable.
6. The PLC transmits the calculation result to the display screen through the communication module, and the warning module indicates that the temperature rise test has ended.

Judging the Completion of the Temperature Rise Test (Step 3): The PLC continuously collects temperature data for the explosion-proof low-voltage feeder switch, with a data collection cycle of 1 minute. After the data collection time exceeds 1 hour, the temperature data is compared with the data collected 1 hour ago. The comparison process is as follows:

$$\Delta T = T_n - T_{n-60}$$

Where:

- ΔT is the temperature change in Kelvin (K),
- T_n is the temperature at the current test time in Celsius (°C),
- T_{n-60} is the temperature 60 minutes prior to the test time in Celsius (°C).

According to national standards, if the temperature rises between two points taken 1 hour apart is less than 1 K, it is considered that the temperature has stabilized, and the temperature rise test is completed. When $\Delta T \geq 1$, if the temperature change has not yet stabilized, temperature data collection will continue. When $\Delta T < 1$, if the temperature has stabilized, the temperature rise test is concluded.

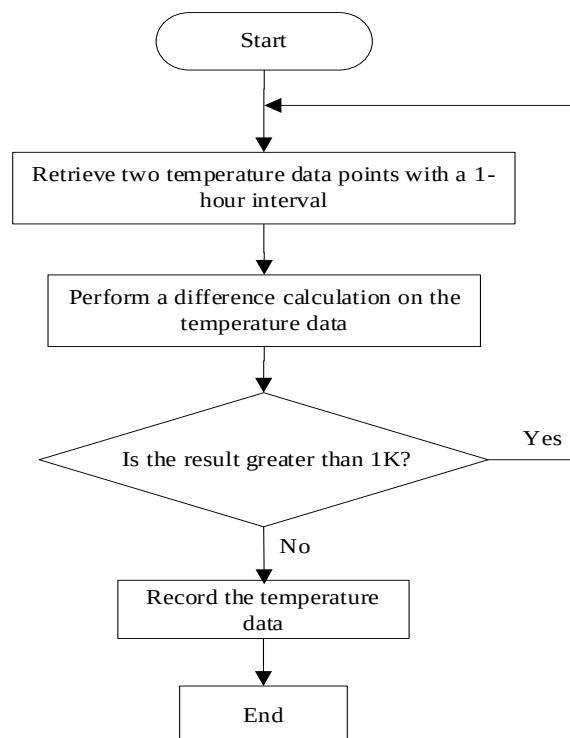


Figure 3: Flowchart for Determining the Completion of the Temperature Rise Test for Explosion-Proof Low-Voltage Feeder Switches in Coal Mines

3. Conclusion

By utilizing a PLC, a temperature rise testing and inspection system for explosion-proof low-voltage feeder switches in coal mines have been designed, and a data processing method for the test results has been proposed. This enhances the testing capabilities, increases the technological content of the products, and provides experimental validation support for the material and component selection in the research and development of new products. This guarantees the quality of the explosion-proof low-voltage feeder switches and promotes the ongoing healthy development of the testing and electrical equipment industry.

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