Research on Stroke Detection Technology for High-Voltage Distribution Devices in Coal Mine

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Abstract. The continuous advancement of intelligent technology in coal mines has raised increasingly high demands for the reliability and safety of power grids. Based on an analysis of the structure and voltage levels of coal mine power supply systems, a stroke detection system for high-voltage distribution devices in coal mines has been designed, centered around a PIC microcontroller and linear displacement sensors. This system enables real-time monitoring of the movement of the dynamic contacts in high-voltage distribution devices, providing valuable reference for the design of such equipment in coal mines.

Keywords: Coal mine; High-voltage distribution device; Stroke; Detection.

1. Introduction

With the continuous development of intelligent technology in China's coal mines, the variety and quantity of underground electrical equipment have continually increased, leading to higher demands for the safety and reliability of power systems. The maturation of electrical technology and detection methods has provided new directions for the development of mining equipment. On one hand, the control precision and automation level of coal mining equipment are continuously improving; on the other hand, online monitoring technologies for both mining equipment and underground environments are rapidly advancing. Explosion-proof high-voltage distribution devices used in mining shown in Figure 1 are among the most critical switching devices within coal mine power grids. They possess the capability to connect, carry, and interrupt normal operating currents while also being able to connect, carry, and interrupt short-circuit currents within specified time frames according to standard requirements.

Figure 1. Explosion-proof high-voltage distribution devices used in mining

The reliability of high-voltage circuit breakers has been a hot spot of research at home and abroad, and the International Conference on Large Power Grids has carried out two large-scale investigations on them, and some domestic institutions have also carried out a large number of statistics and analyses

of high-voltage switch accidents. The relevant results show that the failures caused by mechanical reasons account for 80% of the total failures, most of which are caused by the failure of the operating mechanism. Usually in the power grid outage of high-voltage circuit breakers for maintenance and preventive testing, but the number of high-voltage circuit breakers in mining is large, the maintenance work lacks relevance and the cost is high. Therefore, the coal mine high-voltage power distribution device trip to detect and understand the operating status of the equipment can reduce unnecessary blackout test and overhaul, reduce the failure rate of the coal mine power grid, improve the reliability and safety of the coal mine power grid, which is of great significance to ensure the safe operation of the coal mine power grid and the safety of the personnel.

2. Coal Mine Power Supply System

Due to the complex underground environment and harsh geological conditions in coal mines, it is essential for the coal mine power grid to have two independent circuits. In the event of a fault in one working circuit, the power grid must be able to quickly switch to the other circuit, with each circuit capable of independently bearing the entire load of the mine. High-voltage distribution devices in coal mines are crucial equipment within the power grid, performing dual roles of control and protection. On one hand, they connect or disconnect lower-level transmission and distribution equipment under normal conditions; on the other hand, they rapidly isolate faulty circuits during grid failures and switch to backup power circuits, ensuring the normal operation of both the coal mine power grid and electrical equipment.

The two independent power supply circuits in the coal mine grid should not be connected to any loads. The dual power supply operates in a parallel mode; if one circuit is operational, the other must remain energized as a backup to ensure continuity and safety in power supply. The mining area's electrical network consists of two parts: the surface network and the underground network. The surface network includes the coal mine area grid and surface transformers, which convert grid voltage into 10kV for underground use. The first-level underground network comprises high-voltage distribution devices, mobile transformers, low-voltage protection devices, low-voltage feed switches, and electrical equipment. It converts the 10kV voltage entering underground into working voltages such as 3.3kV, 1140V, and 660V, supplying power for various safety production equipment including lighting, drainage, and gas extraction throughout the mine. A structural diagram of the coal mine power grid is shown in Figure 2.

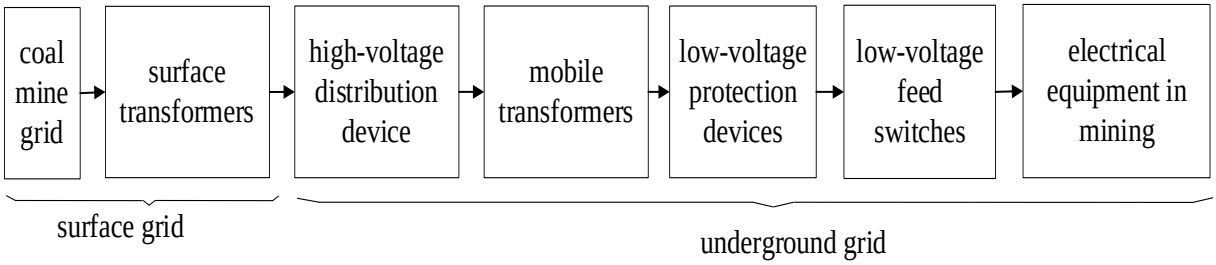

Figure 2. Structural block diagram of coal mine grid

3. Stroke Detection System

The operating mechanism is the main action element of the whole coal mine high-voltage power distribution device, which is used to drive the movement of the moving contact to achieve the opening and closing operation of the coal mine high-voltage power distribution device. The travelling of movable contact is the main signal collected during the opening and closing process of coal mine high-voltage power distribution device, which is used to characterize the operation status of coal mine high-voltage power distribution device. Coal mine high-voltage power distribution device travel detection system adopts high-precision linear displacement sensor, through the PIC microcontroller on the dynamic contact travel signal acquisition, calculation and storage. Coal mine high-voltage

power distribution device travel detection system consists of high-precision linear displacement sensor, signal processing circuit, PIC microcontroller, communication interface and industrial computer, the system structure is shown in Figure 3.

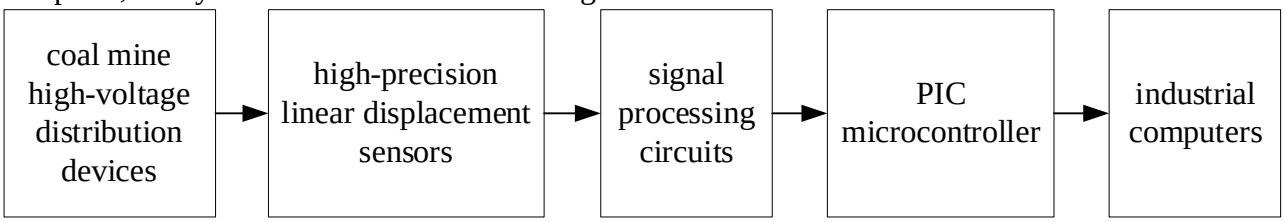

Figure 3. Structure of trip detection system of coal mine high voltage distribution unit

Coal mine high-voltage power distribution device movable contact travel detection refers to the use of high-precision linear displacement sensors to detect the travel of the movable contact in the process of opening/closing, to achieve the effective measurement of the movable contact full travel parameters. Based on the relationship curve between stroke and time, this detection system can calculate parameters such as time taken during the entire motion process of dynamic contacts, average speed, and maximum speed, thus obtaining their mechanical characteristics. Additionally, it can derive motion characteristics of the mechanism based on calculations between operating mechanisms and contact strokes. The stroke detection system for dynamic contacts in coal mine high-voltage distribution devices selects high-precision linear displacement sensors (as shown in Figure 4) with an accuracy of ±0.04%, a resolution greater than 0.01 mm, and an output signal that is analog in nature.

Figure 4. Sensors

4. Conclusion

High-voltage distribution devices in coal mines is an important equipment of underground power supply system, and its safety is directly related to whether the coal mine safety production work can be carried out smoothly. The high-precision linear position sensor is used as the terminal to collect the dynamic contact travelling signal of the circuit breaker in the high-voltage power distribution device of the coal mine, which is fed back to the PIC microcontroller after the signal processing unit, and the PIC microcontroller calculates to get the travelling information of the circuit breaker in the high-voltage power distribution device of the coal mine, which can provide a reference for the safe operation of the coal mine power grid.

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