Design of Induction Function Test System for Explosion-Proof Induction Lamps in Coal Mines

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Abstract. In order to improve the accuracy of induction function testing of explosion-proof induction lamps in coal mines, a PLC-based induction function testing system is proposed. Based on the analysis of the shortcomings of traditional coal mine explosion-proof lamps and the industry development trend, we design the induction function testing system of coal mine explosion-proof induction lamps and derive the induction distance and induction angle testing methods.

Keywords: Coal Mine; Induction Lamp; Testing System; Induction Distance.

1. Introduction

"Digital, intelligent and networked transformation to promote safe and green mining in coal mines" is a national strategic guideline for the coal industry, and an inevitable trend for the development of the coal industry. As the main electrical equipment of underground lighting, mine flameproof roadway lamp is suitable for underground mining roadway and corner, underground parking lot, cavern, underground coal bunker, substation and other places. The traditional coal mine explosion-proof induction lamp uses full power long-time operation mode, and the light emitted from the tunnel lamp when someone passes by is useful light, resulting in a large amount of wasted power resources. The coal mine explosion-proof induction light can intelligently detect moving people or objects, turn on the full-power operation mode when people or objects approach, and enter the standby or micro-power operation mode after people or objects leave. With the advantages of long service life, low power consumption, energy saving and environmental protection, coal mine explosion-proof induction lights have been widely used in underground coal mines.



Fig 1. Coal mine explosion-proof induction lamp physical diagram

The coal mine explosion-proof induction lamp is in line with the industrial policy of intelligent mining and energy-saving and environmental protection requirements, and belongs to the future development direction of coal mine explosion-proof induction lamp industry. Because of the complex production environment of underground coal mines in China (containing explosive gases such as gas and dust, darkness, humidity, sudden temperature changes, etc.), the quality and safety requirements of equipment for underground use are significantly higher than those for surface equipment. The induction function is the main indicator that distinguishes mining explosion-proof induction lamps from conventional coal mine explosion-proof induction lamps. The failure of induction function, induction angle too small, delay time too short, etc. will cause the failure of the induction function indicator to cause the failure of the tunnel lighting system. The current induction function is mainly

based on manual testing, with low precision of key indicators and poor reliability of results, resulting in uneven quality and low safety of explosion-proof induction lamps in coal mines, which brings accidental hazards to coal mine safety production.

2. Induction Function Test System

Coal mine explosion-proof induction lamp induction function test system consists of PLC, control panel, power supply module, illuminance sensor, display and parameter setting module, movement module, laser distance meter, adjustment mechanism, equivalence module, timer, test warning module. PLC is the core of coal mine explosion-proof induction lamp induction function test system, used to control the power supply of coal mine explosion-proof induction lamp, movement module, adjustment mechanism, timer, test warning module, while receiving and calculating the illuminance sensor, laser distance meter timer feedback illuminance, distance, time data, and send the system operation status and test results to the display and parameter setting module. The control panel consists of a start button, a stop button and an emergency stop button to control the power output and stop of the PLC and test warning modules in the power supply module, and an emergency stop button to stop the power output of the whole system in case of emergency. The power supply module has multiple different voltage outputs to provide working power for PLC, illuminance sensor, display and parameter setting module, and coal mine explosion-proof induction lamp, and the PLC, illuminance sensor, display and parameter setting module power output is controlled by the control panel, and the coal mine explosion-proof induction lamp power output is controlled by the PLC. The illuminance sensor is used to collect the illuminance information of coal mine explosion-proof induction lamp, and the illuminance data is fed back to the PLC.

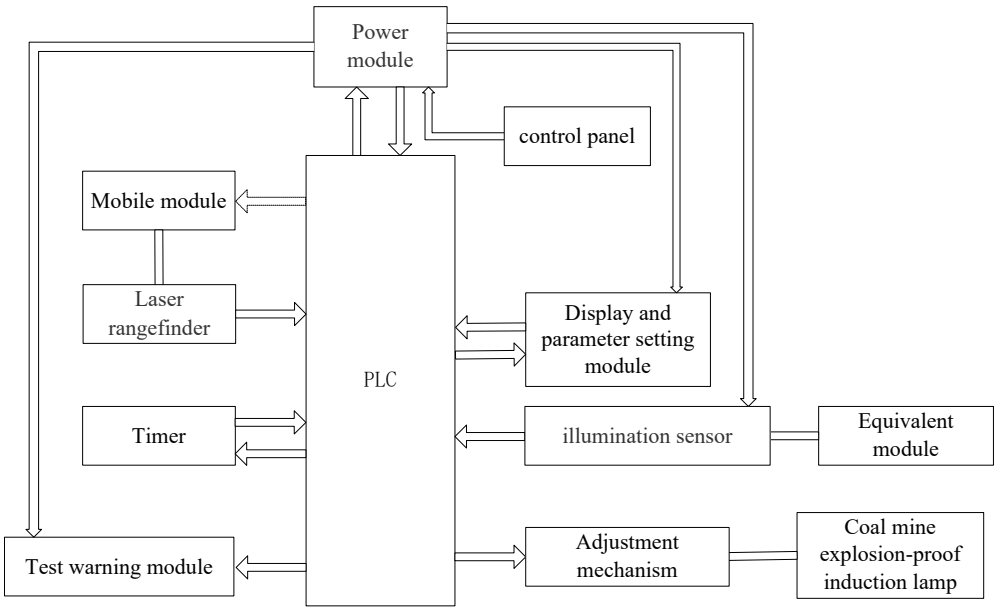


Fig 2. Structure diagram of induction function test system for explosion-proof induction lamp in coal mine

Coal mine explosion-proof induction lamp induction function test system can make the data of induction distance and delay time obtained from the test, and at the same time obtain the induction angle data after PLC operation processing. Description of the working process of the induction function test system for explosion-proof induction lamps in coal mines.

(1) Press the control panel control start button, PLC, test warning module, display and parameter setting module are powered on, PLC self-tests, the system performs step (2) normally, otherwise it stops.

(2) According to the height of coal mine explosion-proof induction lamp using place, PLC control the height of adjusting mechanism, so that coal mine explosion-proof induction lamp hanging with the use of the site, the equivalent module fixed in coal mine explosion-proof induction lamp and the ground vertical foot point position.

(3) PLC control power module output (test warning module from yellow to red flashing state), coal mine explosion-proof induction lamp on power to start operation.

(4) Make a straight line through the equivalent module, and when the coal mine explosion-proof induction lamp is running with low power consumption, the PLC controls the moving module to move slowly along the straight line from a distance to the equivalent module.

(5) PLC collects illuminance sensor data in real time and records respectively low and high-power consumption illuminance data E1 and E2 of coal mine explosion-proof induction lamps.

(6) PLC control of the power module to stop output (test warning module from the red flashing state to yellow), coal mine explosion-proof induction lamp extinguished.

(7) PLC control the movement module to return to the initial movement position, PLC control the power module output (test warning module from yellow to red flashing state), coal mine explosion-proof induction lamp on power to start operation.

(8) PLC controls the slow movement of the mobile module along a straight line from the distance to the equivalent module, PLC collects illumination sensor data in real time, and PLC sends a stop command to the mobile module at the moment when the illumination data changes from low power to high power consumption.

(9) The mobile module stops running, while the PLC sends a timing command to the timer, the timer starts timing, and the counter stops counting when the illumination data changes from high power consumption to low power consumption, while the recorded time data is fed back to the PLC, which gets the delay time data.

(10) Laser distance meter tests the distance from the mobile module position to the coal mine explosion-proof induction lamp and equivalent module, and feeds the distance data back to the PLC.

(11) The PLC calculates the laser rangefinder to obtain the sensing distance and sensing angle data.

(12) PLC controls the power supply module to stop outputting (the test warning module changes from red flashing state to yellow), and the coal mine explosion-proof induction lamp goes out;

(13) Press the stop button on the control panel, and the system stops running.

3. Calculation of Induction Distance and Induction Angle

The schematic diagram of the calculation of induction distance and induction angle during the induction function test of coal mine explosion-proof induction lamp is shown in Figure 3. Point O is the lowest hanging point of coal mine explosion-proof induction lamp. Point A is the position of laser rangefinder. Point B is the foremost position of the mobile module. Point P is the intersection of the explosion-proof induction lamp of coal mine with the vertical line on the ground and the horizontal line at the same height at the position of laser rangefinder.

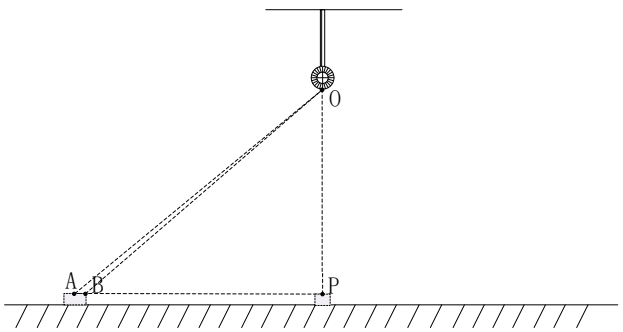


Fig 3. Schematic diagram of calculation of induction distance and induction angle

Data L_{AB} can be obtained by laser rangefinder test, and data L_{OA} and L_{AP} can be obtained by the above test. The calculation method of induction distance L_{BO} is as follows:

$$L_{BO} = \sqrt{L^2_{BP} + L^2_{OP}} \tag{1}$$

Where L_{BO} is the sensing distance in meters (m), L_{BP} is the distance from the front end of the mobile module to the intersection of the vertical line of the ground and the laser rangefinder position at the same height and level, in meters (m), L_{OP} is the distance from the intersection of the vertical line of the ground and the laser rangefinder position at the same height and level to the lowest point of the hanging position of the coal mine explosion-proof induction lamp, in meters (m).

$$L_{OP} = \sqrt{L^2_{AO} - L^2_{AP}} \tag{2}$$

Where L_{AO} is the distance from the position of the laser rangefinder to the position of the lowest point of the coal mine explosion-proof induction lamp hanging, the unit is meter (m), L_{AP} is the distance from the position of the laser rangefinder to the intersection of the vertical line of the coal mine explosion-proof induction lamp and the ground and the horizontal line of the same height of the position of the laser rangefinder, the unit is meter (m).

$$L_{BP} = L_{AP} - L_{AB} \tag{3}$$

Where L_{AB} is the distance from the laser rangefinder position to the foremost position of the mobile module, in meters (m).

According to equations (2) and (3), the formula for calculating the sensing distance can be obtained as follows.

$$L_{BO} = \sqrt{(L_{AP} - L_{AB})^2 + L^2_{AO} - L^2_{AP}} \tag{4}$$

Induction angle is the angle between the induction points on both sides of the same plane and the location of the lowest point of the coal mine explosion-proof induction lamp suspension, as shown in Figure 2 shows the induction angle of $\theta = 2\angle BOP$, and then the $\angle BOP$ sine value is

$$Sin\angle BOP = \frac{L_{BP}}{L_{BO}} \tag{5}$$

According to the calculation, the value of $Sin\angle BOP$ can be obtained, and the value of induced angle θ can be obtained by querying the sine value table.

4. Test

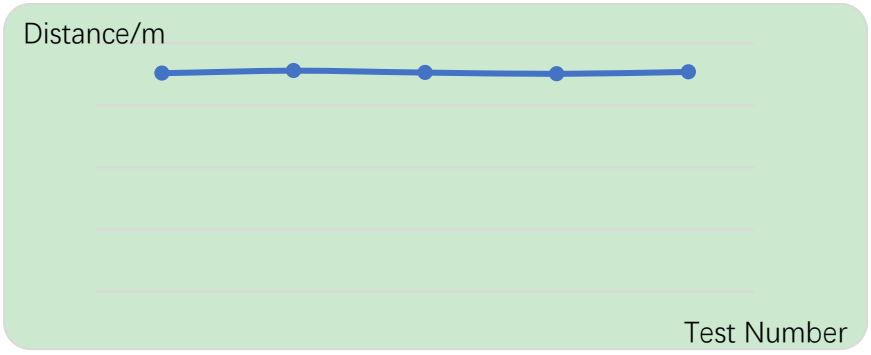


Fig 4. Test of coal mine explosion-proof induction lamp

DJS 48/127LW explosion-proof induction lamp in coal mine is selected as an example for testing and the test results are shown in Figure 4. It can be seen from the figure that the induction distance of explosion-proof induction lamp in coal mine is about 3.5 meters.

5. Conclusion

Energy conservation is the development trend of coal industry and the development direction of intelligent underground explosion-proof equipment. Based on the analysis of the advantages of coal mine explosion-proof induction lamps compared with traditional explosion-proof lamps, the induction function testing system of coal mine explosion-proof induction lamps is designed which realizes the reliable testing of parameters such as induction angle and induction distance of coal mine explosion-proof induction lamps and provides technical support for the development of intelligent testing technology of coal mine explosion-proof equipment.

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