Safety Detection of Mine Explosion-proof Electrical Products against Short Circuit Arc

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Abstract. The open-cover power off switch of mine flameproof low-voltage explosion-proof electrical appliances must be absolutely electrified to open the cover in the use process. When the workers need to repair the flameproof products, the pre-stage power supply can be cut off for construction. "Bolt fastening locking mechanism of main flameproof chamber" is a new power failure method tried by domestic mining enterprises. It is on the bolt fastening open cover mode, add a layer of thin steel plate, and tighten with bolts. This steel plate through the switch button to the flameproof chamber to play the role of power failure. The purpose of this paper is to protect the safety of explosion-proof product users by designing the safety performance test of mine explosion-proof electrical products to prevent short circuit arc. This paper analyzes the cause of flammable gas explosion in short circuit arc under the condition of the explosion-proof safety performance and the harm degree, the influence of initial short circuit arc causes and preventive measures are given, through the experiment was designed to prevent short-circuit arc safety inspection mechanism, and makes the product security pass rate is higher than 98%, in the end, made clear that to strengthen the quality control of flameproof switch products is of great significance to ensure the safety of coal mine.

Keywords: Mine Electrical Products, Explosion-proof Safety, Short Circuit Arc, Safety Detection

1. Introduction
In coal mine safety engineer, equipment and environment system, explosion-proof electrical equipment is very important to safety. Mine explosion-proof switch electrical appliances are universal equipment throughout the underground coal mine, generally divided into two types of distribution electrical appliances and control electrical appliances, the former is represented by low-voltage feed switch and high-voltage distribution device, the latter is represented by high-voltage starter. According to the current theory of safe production science, these two kinds of electrical appliances control the energy (electrical energy) and cut or lock the fault loop when the fault occurs, so as to realize the
safety of the whole system. This kind of electric appliance not only has the ability to control and cut off the unexpected energy release, but also requires it not to ignite the gas explosion outside the shell when the gas ignition explosion occurs inside the flameproof shell.

Aiming at the heat dissipation and internal condensation of explosion-proof frequency converter in underground coal mine, an explosion-proof double-throttle air conditioning system is proposed. Yufeng Zhang discusses the feasibility and superiority of explosion-proof dual throttle cooling dehumidification air conditioning system applied to explosion-proof frequency converter. The physical model of dual - throttle air conditioning system is established and its performance parameters are described mathematically. The system is designed and calculated. The experimental results show that after running for 45 minutes, the system reaches the steady state of refrigeration mode and the highest temperature in the flameproof chamber is 31.0 °C. After 37 minutes of operation, the system entered the dehumidification mode. The maximum relative humidity in the flameproof chamber was 33.4% and the temperature was 36.3 °C. Therefore, the system has a good heat dissipation ability to avoid internal condensation. Compared with water cooling system, it is energy-saving and economical [1]. Tank fire and explosion accidents occur from time to time, which will cause huge economic losses and serious casualties in the process of tank operation and maintenance. Yi Zhou set up a large tank experiment system to study the explosive characteristics of oil and gas mixture in the tank. The experimental results show that the concentration of the mixture, the initial temperature of the mixture and the initial O2 and N2 in the tank have important effects on the explosion of the mixture and its products. The upper and lower explosion limits of gas-gas mixture are 0.86% and 4.3% HC, respectively, and the critical explosion concentration is about 2.5% HC. Through the explosion test of gasoline-air mixture at 2.5% concentration at different initial temperatures, it was found that the maximum explosion overpressure was at the initial temperature of 308k [2]. The effect of loop current (LC) on motor magnetic field is always neglected in ITSC fault analysis. Hongbo Qiu made a comparative study on the electromagnetic field of permanent magnet synchronous motor (PMSM). The purpose of Hongbo Qiu is to discuss the necessity of LC in fault analysis and the electromagnetic characteristics of ITSC fault permanent magnet synchronous motor with LC in mind. Based on the finite element method, the fault model is established and the magnetic density under the fault condition is analyzed. The induced electromotive force and LC of short circuit ring are studied. The unbalance of three-phase induced electromotive force and three-phase current is studied. Finally, Hongbo Qiu built a prototype test platform to obtain fault data. Results - the effect of fault on magnetic density is obtained. The current phase lag during ITSC failure leads to the magnetic enhancement of the armature reaction [3].

For the purpose of better maintenance of mining safety, this paper studies the mine explosion-proof electrical short-circuit arc safety inspection mechanism, for the mining flame-proof electric common fault at the same time, combining the reality of coal mine site production, try to use FTA analysis and processing, the fault tree is established, and failure reason of mining flame-proof electric appliance has carried on the qualitative and quantitative analysis, the minimum cut sets of the fault occurred, improve the efficiency of the coal mine electrical equipment fault diagnosis.

2. Proposed Method

2.1 Reaction Analysis of Mine Explosion-proof Electrical Products

(1) Explosion-proof mechanism

When methane and hydrogen react with oxygen (explosion), a large amount of heat is generated. If the reaction is completed in a very short time, it can be considered that this reaction is in an adiabatic condition, and the water produced after the reaction is still in a gaseous state, and the heat generated during the reaction is also rarely absorbed by the shell. Then, the heat value generated by it, the specific heat of the gas produced and the ideal gas equation [4-5]:

\[ \frac{dE}{dT} = \frac{\partial Q}{\partial T} \]

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Under the special condition that the volume does not change, the change of gas pressure in the explosion-proof shell can be calculated approximately and directly after the explosion intensity of combustible gas. Due to the high pressure gas and combustion gas flame generally along the shell and flame-proof level from gas explosion proof shell cavity to leak into the cavity in the body, flame after the gas gas explosion in a shell and flame-proof shell gap when the gas cooling, eventually flame reaches outside the cavity due to lower the temperature of shell is not enough to fully lit outside the charges of compounds in the environment of flameproof shell cavity and gas, which has a limit to achieve the explosion-proof security [6].

Flame-proof joint surface, therefore, is not a very small gap, we can ensure security and isolation performance is the necessary premise of appropriately increasing the explosive shell and the joint surface, explosion-proof clearance, so that can have to speed up the explosion-proof casing moisture when the explosion inside the shell of the discharge of the heat and pressure, thus have to reduce the gas flame-proof shell strength and the influence of impact. Explosion-proof casing of moisture in the event of a flammable gas explosion because casing produced a lot of water, when the gas is cooled water vapour condensation completely in the explosion-proof casing may instead of water to form larger negative pressure, so it has been many times in the explosion-proof casing after gas explosion by the phenomenon of moisture absorption of the gas explosion flat instead [7].

In the actual explosion-proof casing products quality inspection and production process, generally two explosion-proof are mainly used for assessment of methane and hydrogen gas mixture for explosion pressure test, assessment of methane because the energy of the big explosion shell can be used to direct the inspection of all kinds of explosion-proof products shell all kinds of mechanical strength of explosion pressure, hydrogen for small molecules can be used to direct the inspection of various explosion-proof explosion-proof shell casing mechanical explosion and fire prevention performance. In general, different volumes and contents in different explosion-proof shells vary greatly in their internal temperature and the movement path of flame propagation due to different contents, so the duration of the explosion and the internal impact intensity (explosion pressure) of the explosion are also different [8].

In the actual situation, we use the test method of hydraulic tri-element distribution to determine and control the mechanical strength ratio of various explosion-proof gases, which can be used to evaluate the mechanical strength of various explosion-proof product shells under the most severe explosion pressure. It is clearly stipulated in the relevant standards of our country that the peak explosion pressure intensity of the static pressure test of explosion-proof products (hereinafter referred to as hydrostatic test), which is used to assess the mechanical explosion pressure intensity, should generally not be less than 1.5 times of the explosion-proof gas pressure. Specific peak can also be engaged in explosion-proof product research and development production of the enterprise to formulate relevant regulations. According to the test data measured by static pressure test, 1.5 times of the peak intensity of explosion gas pressure generally does not exceed or exceed 1Mpa, so the peak value of 1Mpa is usually taken as the standard value of mechanical strength in the static pressure test of explosion-proof products [9-10].

3. Experiments

3.1 Experimental Background
There are a lot of flammable gases such as gas and CO in underground working environment of coal mine. Resulting in poor working conditions. Even seriously affects the staff's life safety. Therefore, in order to ensure the safety of construction, most of the flameproof electrical equipment to carry out construction operations. Due to the complicated factors of technology and environment, the coal mine in China is constructed safely. Avoid unnecessary safety accidents. Although mine flameproof
explosion-proof appliances are widely used in low-voltage electrical equipment, mine electrical failure accidents still occur from time to time. Therefore, it is imperative to analyze the reliability of low voltage electrical products. It is found that the accident in mining area can be avoided by optimizing the design and safety inspection of the open-cover power off switch. There are several fretting switches in the open-cover power off switch of mine flameproof low-voltage electrical appliances. Open cover power off switch to the internal micro switch for normally open access, implementation of open contact out. Generally, the control stroke of the open-cover power off switch is small, and it adopts the design structure of double spring. The external spring mainly plays a role of a buffer, when the switch button of the open cover power off switch, due to the action of the external force, the bearing capacity of the lower spring is weak, so the first action, so that the internal trip switch closed, connected to the electric line.

3.2 Experimental Design
The test was carried out in three sealed enclosures with volumes of 30, 250 and 500 cubic decimeters respectively. Short-circuit power is 100MVA; The voltage is 6kV; The duration of short circuit is 0.25s. As the short-circuit arc burns inside the flameproof enclosure, the air rapidly heats up and the internal pressure rises sharply. The pressure depends on the volume of the enclosure, the size of the flange joint gap, the short-circuit power and the duration of the arc. The relationship between them is complex. However, how to assume that the energy released by the arc is absorbed by the gas inside the shell completely, the pressure generated by the arc inside the shell can be deduced by calculation, and then the relevant parameters of safety detection measures can be set. The increase of pressure in the shell is directly proportional to the product of arc voltage drop V and short circuit current I, and inversely proportional to the square of volume V inside the shell. Therefore, limiting the short-circuit current and increasing the volume in the shell can both reduce the increase of pressure in the shell. The experimental results are shown in Table 1.

| Short circuit power(MVA) | The cavity volume(V) | Initial period of short circuit current(kA) | Internal pressure (Mpa) |
|--------------------------|----------------------|-------------------------------------------|------------------------|
| 100                      | 60                   | 10                                        | 1.3                    |
| 100                      | 250                  | 10                                        | 1.2                    |
| 100                      | 500                  | 10                                        | 1.0                    |
| 100                      | 550                  | 10                                        | 1.1                    |

4. Discussion

4.1 Detection and Analysis of Safety Performance of Mine Explosion-proof Electrical Products to Prevent Short Circuit Arc
As shown in Figure 1, the above test results show that the explosion-proof shell is filled with 8.5% methane. Air mixture, in short circuit test, the internal pressure is higher than the former. At the same time, the water content in the shell and the volatilization of the insulation material under the action of electric arc have effects on the explosion pressure. But in general, in the case of an electric arc short circuit in the explosion-proof shell, especially in the case of flammable gas, the pressure generated by the explosion is much greater than that caused by methane alone. The pressure caused by the explosion of the air mixture. As a result, the damage caused by short circuit and arc to the explosion-proof shell is more dangerous to safety production. The damage to the explosion-proof performance of the switch electrical appliances and the safety of the whole mine caused by the unexpected and uncontrollable short circuit arc is often more serious than that caused by the explosion of methane - air mixture gas in the simple explosion-proof shell. Therefore, while paying attention to
the explosion-proof safety performance of explosion-proof switch electrical products, more attention should be paid to the impact of the electrical performance of explosion-proof electrical products on the explosion-proof safety performance.

![Figure 1. Internal pressure comparison](image)

4.2 Suggestions on Safety Detection of Mine Explosion-proof Electrical Products against Short Circuit Arc

The pouring sealing type is adopted to lay out the leads. Before pouring the leads, the sealing process of silica gel shall be carried out around the junction surface of the outer box and all parts of the installation frame to ensure that the pouring sealing fluid does not leak. The potting adhesive that needs to be used along the potting seal for the potting operation is used as the epoxy potting material that can be cured quickly at room temperature. In the process of filling and sealing. Ensure the uniformity of filling and sealing speed. Ensure that no porosity and associated defects are produced. When the construction personnel presses the outer button cap, because the spring force inside the outer button is small, it is preferred to carry out the action. When the lower part of the inner button cap is in contact with the lower shell, if this time continue to press. The outer spring ACTS. This not only solves the defect of OMRON control line stroke, but also protects the internal switch from being crushed.

In the design process of the shell, the value is 1 MPa. Make sure you have enough margin. The flameproof enclosure shall be cast in one pass. Different materials are selected according to different use environments. Currently, most of the shell is Q235A. Meanwhile, no obvious deformation, scratches or cracks are allowed on the surface of the shell, so as to avoid stress concentration and reduce the bearing capacity of the shell.

5. Conclusions

In view of the research status of the open-cap power off switch of coal enterprises in China, and combined with the relevant advanced technical means at home and abroad, to improve the relevant supporting capacity of the open-cap power off switch. Achieve quality, level, quality improvement. It is urgent to develop the flameproof open-cap switch which is suitable for the underground work of coal mine in China. Based on this, this paper studies the safety performance detection mechanism of mine explosion-proof electrical products to prevent short circuit arc, provides the method of pre-determination detection for the possibility of switch short circuit, and proves its feasibility through experiments.
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