Electrical Life Test of Small Shell Type Special Contactor and Analysis of Change Trend of Key Characteristics

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Abstract. In dealing with electrical fire cases, it is necessary to trace the quality of various electrical products running on the line. It is a very effective and direct way to test the electrical life of the samples of the same specifications and models. The research of electrical life test characteristics can reflect the structural problems, movement performance and other characteristics of the product, which provides a basis for understanding the working state of the product and analyzing the failure reasons. In this paper, a kind of small shell type special contactor commonly used in low-voltage distribution system is taken as the research object, and the variation trend of characteristic parameters such as arcing time, arcing energy and opening phase angle with the operation times of electrical life test is analyzed. Through the establishment of key characteristic quantity database of electrical life, we can better analyze the product performance and grasp the operation status, and provide strong data support for the traceability work caused by its quality problems in electrical fire cases.

Keywords: Electric life, electrical fire, arc time, arc energy, opening phase angle.

1. Introduction

When there are "overload, poor contact, short circuit, electric leakage and other fault phenomena or heating traces in the electrical circuit and electrical equipment", "other non electrical fire causes can be eliminated", "there are combustibles in the electrical fault point" and other accidents, the fire accident should be recognized as an electrical fire accident. In the actual investigation and judicial practice, whether the fire is caused by the quality defects of the electrical circuit and electrical equipment itself is an extremely important technical work [1-2]. It is well known that when the AC control circuit in the low-voltage power supply and distribution system is on and off, the phenomena of liquid metal bridge, arc and spark discharge appear between the contacts due to the effect of heat and electricity. The accumulation of arc will cause the wear of contact materials. With the increase of the operation times of electrical life test, the amount of wear will increase with a certain law. When the contact reaches a certain failure threshold, the contact will fail, which may cause serious damage such as electrical fire. In order to master the actual quality of various AC control electrical appliances running on low-voltage distribution lines, it is a very effective and direct means to trace the source of electrical life test for the samples of the same specification and model. The research on the characteristics of electrical life test can reflect the structural problems, movement performance and other characteristics of
products, and provide reference for understanding the working state of products and analyzing the failure reasons\textsuperscript{[3-7]}. In this paper, a kind of small shell type special contactor commonly used in low-voltage distribution system is taken as the research object, and the variation trend of characteristic parameters such as arcing time, arcing energy and opening phase angle with the operation times of electrical life test is analyzed. Through the establishment of key characteristic quantity database of electrical life, we can better analyze the product performance and grasp the operation status, and provide strong data support for the traceability work caused by its quality problems in electrical fire cases.

2. Electrical life test and its key characteristics

2.1. Electrical life test

The test sample in this paper is a small shell type special contactor, which is an ideal control electrical appliance for HVAC, welding, washing, food processing and other equipment. Its rated working voltage is 380V, rated working current is 12A, which is a common electrical appliance in the product quality traceability of electrical fire cases.

Under the condition of rated voltage, set the test current 15A (1.25Ie), power factor 0.75, 1s on and 9s off, operate the prototype 360 times per hour, conduct the electrical life test under the worst phase angle 80°, and stop the electrical life test when the contact is welded. The test waveforms are collected by the electrical life test and analysis software, which also includes the statistical analysis of the key characteristics of electrical life. By using the function of electrical life test and statistics, a group of test data is recorded for every 100 electrical life tests, including operation times, three-phase contact arcing time, three-phase contact arcing energy, three-phase contact opening phase angle, etc.

2.2. Key characteristics

The arcing time, arcing energy and contact opening phase angle are selected as the key characteristics.

Arcing time refers to the time from arc generation to extinction, which determines the erosion and structural composition of contact surface. The longer the arcing time is, the greater the arcing energy is, and the more serious the burning loss of the contact is, thus reducing the electrical life of the contact. Therefore, the arcing time is an important parameter to check whether the switchgear works reliably\textsuperscript{[8]}.

Arcing energy refers to the energy contained in the arc generated when the contact is disconnected. The higher the arcing energy is, the more heat will be released between the contacts, which will accelerate the rising speed of the surface temperature of the contact, accelerate the melting and gasification of the contact, and accelerate the transfer or splashing of the contact components, so as to accelerate the change of the surface structure and composition of the contact, and seriously affect the electrical life of the contact. Therefore, the arcing energy is also one of the important parameters to evaluate the reliability of the switching device \textsuperscript{[9]}.

If the change of contact breaking time is reflected indirectly by the change of contact breaking angle. The more intense the change of contact opening phase angle is, the more serious the contact wear is, and the greater the impact on the remaining electrical life of the contact is. Therefore, the contact opening phase angle is also one of the important parameters to evaluate the reliability of the switchgear.

3. Change trend of key characteristics

3.1. Variation trend of arcing time

The variation of arcing time of three-phase contacts of test samples with electric life and operation times is shown in Figure 1, in which phase B is the first open phase. It can be seen from Figure 1 that the arc time curve will increase with the increase of the operation times of the electric life test. The arcing time of phase A is the longest, followed by phase C and phase B. After about 60000 times of electric life test, the arc time difference between A and C phases is more and more large, with the
maximum difference of about 0.5 ms, which is the most serious wear of phase A contact and accelerated contact aging.

![Graph showing arcing time variation](image1)

(a) Arcing time of A and C phase contacts

![Graph showing arcing time variation](image2)

(b) Arcing time of B phase contacts

**Figure 1.** Variation of arcing time with operation times of electrical life test.

3.2. Variation trend of arcing energy

The variation law of arc energy of three-phase contact of test sample with the operation times of electrical life test is counted, as shown in Figure 2. Phase B is the first open phase. It can be seen from Figure 2 that with the increase of operation times of electric life test, the arc energy curve has a trend of increasing, which is similar to the variation law of arc time. The arcing energy of phase A is the largest, followed by phase C and phase B. After about 30000 times of electrical life test, the difference of arcing energy between A and C phases tends to increase, which is the performance of A-phase contact wearing more seriously than C-phase contact and accelerating contact aging.
3.3. Change trend of contact opening phase angle

The change rule of the three-phase contact opening angle of the test sample with the operation times of electric life test is counted, as shown in Figure 3. Among them, Fig. 3 (b) enlarges the change rule of phase A contact opening angle with the operation times of electrical life test.
It can be seen from Figure 3 that the opening phase angle of the three-phase contact decreases with the increase of the operation times of the electrical life test, and the three-phase variation trend is basically the same, with the difference 120° between each phase. The decrease of the contact opening phase angle is due to the shorter overtravel and the shorter breaking action time of the contact in the electrical life test, which makes the contact break ahead of time.

3.4. Analysis of key characteristic quantity before and after test

Table 1 shows the change of arcing time, arcing energy and opening phase angle of three-phase contact of test sample after 100000 times of electric life test.

| Characteristic       | Phase A | Phase B | Phase C |
|----------------------|---------|---------|---------|
| Arcing time/ms       | Before  | After   | Before  | After  | Before  | After  |
|                      | 4.72    | 5.93    | 0.31    | 1.36   | 4.51    | 5.53   |
| Arcing energy/J      | 63.11   | 91.04   | 0.13    | 4.80   | 53.23   | 70.84  |
| Arcing energy/°      | 289.55  | 263.92  | 173.14  | 152.02 | 51.81   | 30.36  |

It can be seen from table 1 that after the electrical life test of three-phase contact, the increase of arcing time is more than 1ms, and the decrease of opening phase angle is more than 20 degrees. At the same time, the arcing energy increases a lot, and the arcing energy of A-phase contact is the largest.

To sum up, the changes of arcing time, arcing energy and contact opening phase angle can indirectly reflect the residual electrical life of the contact, and the phase A contact is most seriously worn during the electrical life test. In the actual operation process, it is possible that phase A will fail first, resulting in quality problems such as contact welding, and then lead to electrical fire. Therefore, through the analysis of the electrical life test of the test samples and the change trend of the key characteristic quantity, it can provide data support for the traceability of product quality in the case of electrical fire, and provide the basis for solving the case faster.

4. Conclusion

In this paper, a kind of special contactor with small shell frame, which is commonly used in electrical fire cases, is taken as the research object, and the variation trend of characteristic parameters such as arcing time, arcing energy and opening phase angle with the operation times of electrical life test is analyzed.

(1) With the increase of operation times of electrical life test, the arcing time curve tends to increase. The arcing time of phase A is the longest, followed by phase C, and phase B is the shortest.
(2) The opening phase angle of three-phase contact decreases with the increase of operation times of electrical life test, and the change trend of three-phase contact is basically the same, and the difference between each phase is 120 degrees.

(3) After the electrical life test, the increase of arcing time is more than 1 ms, and the decrease of opening phase angle is more than 20 degrees. At the same time, the arcing energy increases a lot, and the arcing energy of A-phase contact is the largest.

Through the electrical life test of test samples and the analysis of the change trend of key characteristic quantity, it can provide data support for the traceability of product quality problems in electrical fire cases, and provide the basis for solving cases faster.

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