Current Status of Testing and Research on Circuit Breaker Mechanical Performance and Arc Extinction

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Abstract. The performance of the circuit breaker mainly includes mechanical performance and arc extinguishing performance. This paper reviews the current status of its detection methods. Research indicates that the dynamic characteristic instrument method can meet the needs of offline detection for the detection of mechanical properties, but it cannot be implemented with electricity. The traditional method for detecting the degree of contact ablation is the electrical life method, which determines the change in the degree of contact ablation of the high-voltage reactive switching switch by the weighted calculation of the number of breaking and the breaking current. This method can only reflect the deterioration of the contact ablation degree of the high-voltage reactive switching switch, but it cannot reflect the abrupt or abnormal contact ablation degree deterioration. It is necessary to carry out research on new technology for live detection of circuit breaker performance.

1. Introduction
The safe operation of high-voltage transmission and transformation equipment has become an important factor affecting the safe, stable, and economic operation of the power system [1-4]. The number of high-voltage switches in the power grid is huge, which plays a role of control and protection. When a fault occurs, it will directly cause a power grid accident or further expand the accident, causing considerable economic and social losses. How to effectively detect the working state of the high-voltage switch, find the early defects of the switch in time, deal with the defective parts in advance, and prevent the occurrence of vicious accidents such as switch explosion, are very important for ensuring the safe and reliable operation of the power grid. The performance of the circuit breaker mainly includes mechanical performance and arc extinguishing performance [5-7]. This paper reviews the current status of its detection methods. Current circuit breaker performance testing mainly focuses on mechanical performance testing. The main methods include electrical stopwatch method, oscilloscope method and dynamic characteristic instrument method. The detection of arc extinction contact ablation degree mainly uses electrical life method and contact resistance method.

2. Testing Method of Circuit Breaker Mechanical Performance

2.1. Electric Stopwatch Method
You can use an electric stopwatch to measure time intervals greater than 10ms. The basic circuit for measurement is shown in figure 1. Figure 1a) is electric stopwatch and arc contact connected in series to measure the inherent opening time. Figure 1b) is electric stopwatch and arc contact connected in parallel to measure the inherent closing time. In the figure, A is switch arc contact, B is electric stopwatch. 35kV and below high-voltage load switches and high-voltage reactive switching switches...
can measure their inherent opening and closing times with an electric stopwatch. Different periods can be displayed with a light bulb (a low-voltage light bulb connected in series with each break) or with a multimeter, and the measuring instrument measures the difference in distance. The measurement results of the electric stopwatch method are intuitive, but the accuracy is poor, and it is rarely used now.

![Figure 1](image_url)

**Figure 1.** Principle of wiring for measuring time interval of electric stopwatch.

2.2. Oscilloscope Method

For the measurement that needs to be accurate to the ‘ms’ time interval, an electric stopwatch cannot be used. Generally, an oscilloscope is used to measure the switch opening, closing time and three-phase synchronization time difference. The 16-channel oscilloscope is generally used to measure the time parameters of 110kV and above voltage level high-voltage reactive switch. From the one-time opening and closing oscillogram of the high-voltage reactive switching switch, the closing time, opening time, different period of closing and the time difference of different periods of opening can be measured. When measuring, it is necessary to connect wires to each break and apply voltage, and judge the opening and closing of the switch through the change of the current signal on the break. The following is an example of the closing-opening process to illustrate the measurement principle of the oscilloscope method. When the high-voltage reactive switching switch receives the closing command, the current on the closing coil jumps from zero to the rated value, and the closing time starts to count; when the first break in the three-phase is closed, the current flowing through the break Jumping from zero to a certain value, the closing time timing ends, and the timing of the closing time of different periods starts; when the last break in the three phases is closed, the timing of the closing time of different periods ends. The opening process can be deduced by analogy. The principle diagram of the measurement process is shown in figure 2.
Figure 2. Schematic diagram of opening and closing of high-voltage reactive switch.

2.3. Action Characteristic Tester Method

The switch action characteristic tester is actually a single-chip microcomputer based on the oscilloscope method, which measures the time difference from the opening/closing signal to the opening/closing of the three-phase contacts through the single-chip microcomputer, so as to realize the opening/closing time and the opening/closing time in different periods. The measurement, measurement principle and time parameter definition are the same as the oscilloscope method. The switch action characteristic tester programs all the measurement steps and is simple and convenient to use. It is currently the most widely used time parameter measurement method. The main disadvantage is that it requires complex wiring, large-scale high-voltage reactive switching switches also need to ascend the operation, the test time is longer, and can only be measured during power outages.

3. Testing Method of Circuit Breaker Arc Extinguishing Performance

3.1. Electrical Life Method

This method installs a current sensor on the high-voltage reactive switching switch, detects the effective value of the breaking current, and calculates the electrical life of the high-voltage reactive switching switch after weighted accumulation with the number of switching times, thereby indirectly ablating its contacts. The degree of detection and evaluation. The electrical life method can only reflect the general change trend of the ablation degree of the contact of the high-voltage reactive switching switch, but cannot reflect the ablation degree of the contact of the abrupt high-voltage reactive switching switch.

3.2. Contact Resistance Method

Contact resistance method includes loop resistance method and dynamic resistance method. The difference between dynamic resistance testing and static loop resistance is that the test results can directly reflect the ablation of arc contacts in the arc extinguishing chamber. Measuring principle of dynamic contact resistance of SF₆ high voltage circuit breaker is shown in figure 3. In the picture, R₁, R₂, R₃, R₄ are the experimental lead resistance, R5 is adjust the lead resistance of the loop resistance current, R is the experimental circuit breaker. Since the current ablation directly acts on the arc contacts during the opening process of the high-voltage circuit breaker, the reliability of the dynamic resistance method for diagnosing the breaking capacity of the circuit breaker is higher. However, from the current technical point of view, dynamic resistance testing can only be carried out after a power outage, and the test operation is relatively cumbersome and cannot be carried out on site. In summary,
the current characteristic testing of high-voltage reactive switching switches is mainly for mechanical performance. The degree of contact ablation can only be qualitatively judged by the electrical life test, and cannot reflect the sudden change.

![Figure 3](image)

**Figure 3.** Measuring principle of dynamic contact resistance of SF₆ high voltage circuit breaker

4. Conclusion

For the detection of mechanical properties, the dynamic characteristic instrument method can meet the needs of offline detection, but it cannot be implemented with electricity. The traditional method for detecting the degree of contact ablation is the electrical life method, which determines the change in the degree of contact ablation of the high-voltage reactive switching switch by the weighted calculation of the number of breaking and the breaking current. This method can only reflect the deterioration of the contact ablation degree of the high-voltage reactive switching switch, but it cannot reflect the abrupt or abnormal contact ablation degree deterioration. It is necessary to carry out research on new technology for live detection of circuit breaker performance.

5. References

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