Determination Method of Contact Ablation Degree of Power System Circuit Breaker Based on Power Load Property

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Abstract. In the field of electrical engineering, the stable operation of circuit breaker is one of the important indexes to ensure the safety and stability of power system. Because the influence of load property on electromagnetic wave waveform is not considered, the method to determine the ablation degree of circuit breaker by using the characteristics of radiated electromagnetic wave is not completely accurate. Therefore, this paper proposes a method to determine the ablation degree of circuit breaker considering the load properties. By adding load factor, the ablation degree of circuit breaker contact can be determined more accurately. When the load is resistive load, the load factor is 1, when the load is inductive load, the load factor is 2.5, when the load is capacitive load, the load factor is 3. When the duration of the radiated electromagnetic wave exceeds the corresponding time, it can be judged that the contact is seriously ablated. The method proposed in this paper mainly uses electrical detection means to realize the rapid determination of the ablation degree of the circuit breaker contact and avoid the misjudgment caused by not considering the nature of the load.

1. Introduction

Power system is a system of power production, transmission and consumption, which is composed of power generation, transformation, transmission, distribution and consumption. With the transmission and distribution of various energy situations, the structure of China's power system is becoming more and more complex. The power system is mainly composed of a variety of electrical equipment connected with each other, such as generators, transformers, circuit breakers, buses, transformers and grounding wires.[1-3] The safety and reliability of these electrical equipment directly affects the safety of the power system. In order to ensure the stable operation of power system, circuit breaker plays a very important role.[4-5]

Circuit breaker is used in power system, which can automatically cut off the circuit in case of serious overload, short circuit and undervoltage, so as to control the voltage stability of power system. Under long-term working conditions, the contact of circuit breaker will be ablated due to the high temperature and high pressure environment in the process of opening, and the ablated contact will affect the opening performance of circuit breaker, resulting in inflexible operation, opening failure and other faults, which seriously threaten the safety and stable operation of power grid. [6-8] Therefore, the characteristic value which can reflect the ablation degree of circuit breaker contact is very important for the performance evaluation of circuit breaker, and it is one of the key parameters to reflect its performance.

The method of radiated electromagnetic wave can be used to detect and judge the ablation degree of circuit breaker contacts. However, the current judgment is based on the duration of the radiated
electromagnetic wave, without considering the impact of the nature of the load. It is found in the test that the duration of electromagnetic wave radiated by circuit breaker is significantly different with different load properties. The duration of capacitive load is the longest, and that of resistive load is the shortest. The duration of inductive load is shorter than that of capacitive load, but significantly longer than that of resistive load.[9-11]

Based on the above situation, this paper proposes a method to determine the ablation degree of circuit breaker considering the load property. When the ablation degree of circuit breaker contact is detected by the radiated electromagnetic wave method, the load coefficient is added to determine the ablation degree of circuit breaker contact more accurately.

2. The relationship between load property and radiated electromagnetic wave

In order to study the corresponding relationship between the radiated electromagnetic wave and arc combustion under different kinds of loads. In this paper, the old contact is selected to break the 1kV voltage test circuit at the same speed in the air. Firstly, the 23K Ω pure resistance load was cut off, and the radiated electromagnetic wave signal and voltage current signal were measured. Then, the 0.2 μ f capacitor and 3.6h inductor loads are cut off respectively. Through comparative analysis, the influence of different kinds of loads on arc combustion and electromagnetic radiation can be found.

When the circuit breaker breaks the 23K Ω resistance load, the typical breaking process electrical signal is measured as shown in Figure 1.

When the circuit breaker breaks 3.6h inductive load, the typical breaking process electrical signal is measured as shown in Figure 2.

When the circuit breaker breaks 0.2 μ f capacitive load, the typical breaking process electrical signal is measured as shown in Figure 3.

Figure 1. Resistive load
Through the comparative analysis in the figure, it can be seen that there is a phase difference between the voltage and current signals of capacitive load and inductive load. It can be analyzed that the arc is extinguished at the current zero crossing point. It is more difficult to break the capacitive load with high voltage level, and the number of signals is more.

3. Simulation result
For the contact defect of power circuit breaker, electrical measurement and waveform observation can be used to realize rapid diagnosis. The antenna is used to receive the radiated electromagnetic wave generated in the opening process of the circuit breaker, and the common oscilloscope is used to monitor the waveform. The number of electromagnetic wave pulses per unit time is analyzed to determine the ablation degree of the circuit breaker contact. If more pulses are found, it can be judged that the contact is seriously ablated.[12-13]

In this paper, a method to determine the ablation degree of circuit breaker considering the nature of load is proposed. Its feature is that when the ablation degree of circuit breaker contact is detected by radiated electromagnetic wave method, the load coefficient is added to determine the ablation degree of circuit breaker contact more accurately.
The load factor is determined by laboratory measurement. Under the condition of the same value of breaking voltage and current, the duration of radiated electromagnetic wave in the breaking process of pure resistive load, pure capacitive load and pure inductive load is measured respectively. Taking the duration of electromagnetic wave radiated by resistive load as the reference, the duration of electromagnetic wave radiated by pure capacitive load and pure inductive load during breaking process is divided by the reference as the corresponding load factor. The load factors corresponding to the measured results are 3 and 2.5, respectively.

For a circuit breaker A and B of the same type, the contact ablation degree of the circuit breaker is determined by the duration of the radiated electromagnetic wave. The breaking of circuit breaker A is resistive load, and the radiated electromagnetic wave is shown in Figure 4. The breaking of circuit breaker B is capacitive load, and the radiated electromagnetic wave is shown in Figure 5. The influence of load property is not considered in the current method of contact ablation degree. The duration of electromagnetic wave radiated by circuit breaker B is twice that of circuit breaker A. It should be judged that the contact is seriously ablated, which leads to misjudgment.

By adopting the judgment method of the invention, for circuit breaker B, the load factor is added during judgment, and for capacitive load, the load factor is 3. For circuit breaker B, the duration of radiated electromagnetic wave is twice that of resistive load, which is less than 3 times of the value after adding the load factor. It should be judged that the contact ablation is normal, which effectively avoids misjudgment.

4. Conclusion
In this paper, the radiated electromagnetic wave method is used to detect the contact ablation of circuit breaker, and on this basis, the influence of load properties on the contact ablation of circuit breaker is proposed. Based on the analysis of the characteristics of the load and the electrical signal of the circuit breaker, the different effects of resistive load, inductive load and capacitive load on the contact of the circuit breaker under the same conditions are judged. Finally, the simulation experiment is carried out to monitor the electromagnetic wave radiated by the circuit breaker, so as to determine the ablation degree of the circuit breaker contact under different load conditions.

The detection method of collecting radiated electromagnetic wave has been widely used in the detection of all kinds of power equipment. Due to the change of external conditions, power equipment will be affected by different factors and radiate different types of electromagnetic signals. However, there are many factors that affect the electromagnetic signal. Therefore, when monitoring the electromagnetic wave, we should also consider the type of measuring equipment, and compare a variety of influencing factors.

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