Research on Fixed Separated Low Voltage Switchgear Based on Electronic Sensing Technology

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Abstract: In order to solve the problem of poor accuracy of traditional partial discharge identification methods for switchgear, this study introduces the control principle of single chip microcomputer and designs a new partial discharge identification method for switchgear. Firstly, the partial discharge characteristic data of the switch cabinet are collected to detect the operation state of the switch cabinet and the abnormal values therein. Then, according to the acquisition results, the characteristic types of partial discharge in the switch cabinet are judged, thus realizing the identification of partial discharge in the switch cabinet. The simulation results show that the recognition method has high recognition accuracy and the recognition process takes less time, which proves that the method is practical and reliable.

1. Introduction
As the internal main device of power distribution system, the internal organization structure and working situation of switch cabinet affect the feasibility of the whole system at all times. Once the switch cabinet fails or deviates, it will bring irreversible consequences. The most direct impact is that the lines and devices protected by the electrical system will be damaged, resulting in the loss of large-scale electricity, while the indirect impact will lead to power failure in local areas, resulting in the failure of basic power supply.

In document [3], an on-line identification method for partial discharge of switchgear based on acousto-electrical combination is proposed, and in document [4], an identification method for partial discharge of switchgear based on ultra-high frequency method is proposed. However, these two methods have the problem of poor identification accuracy. For this reason, this study designs a partial discharge identification method for switchgear based on single chip microcomputer control, in order to efficiently and accurately check the local leakage area inside the switchgear, eliminate the potential safety hazards in the device in time, and improve the safety and feasibility of power transmission.

2 Switch Cabinet Partial Discharge Identification

2.1 Partial Discharge Characteristic Acquisition of Switch Cabinet
Based on the acquisition and judgment of the discharge information of the switch cabinet, the gap of the insulation medium inside the switch cabinet in the substation is obtained to obtain the characteristic sample data of local leakage. The sum $C_1$ and $R_1$ are respectively the capacitance and resistance of bubbles in the internal insulation medium, and the sum $C_2$ and $R_2$ are respectively the capacitance and resistance of series insulation medium around the local leakage. As for the parts other
than the insulation material medium that are connected in parallel, the sum $C_i$ and $R_i$ are used to express the time parameter of gap power supply during the duration of gap leakage:

$$\sigma = \frac{C_2 - C_1}{2(R_1 + R_2)} (R_1 - C_i)$$

(1)

On this basis, further analysis is made on the internal pressure change of the insulating material medium in the switch cabinet structure. The voltage of the fault position of the equipment and the change parameters of the adjacent insulating materials are collected and recorded as $a$, $b$ respectively, and the information is distributed according to the standard capacitance equipment of the equipment, and the change of the ratio of the electric field strength of the abnormal area position to the electric field strength of the adjacent insulating material medium is recorded to judge its own solid dielectric constant. Record as $f$, when the voltage of the local on/off equipment is detected to be high, record its fastest discharge rate, and record as $v$. If the leakage charge of the equipment on and off is $q$, assuming the charge quantity of the local leakage pulse is $z$, the maximum leakage charge characteristic value of the on and off is calculated, and the process is as follows:

$$\sigma = \frac{\sigma \times (q - 1)}{2f(a + b)(v - z)}$$

(2)

Among them, $v > z$, $q > 1$. So far, it can effectively realize the accurate identification of partial discharge information characteristics of the switch cabinet, obtain important characteristic samples, accurately locate the anti-dropping area, detect leakage charge, monitor current and voltage, etc. to determine the leakage status.

2.2 Judgment of Partial Discharge Characteristic Types of Switchgear.

According to the detection results of fault areas, high-speed aging operation and other technologies are used to simulate the influence of insulation medium aging and other factors. On this basis, the classical artificial fault system is simulated to detect the local leakage value of the oil-paper insulation system inside the transformer equipment, and the internal gap leakage system and the on-off surface leakage system of the insulation are respectively established, and they are marked as $G$ and $S$ leakage values respectively. The switch-on and shutdown structure is simulated according to the $G$-type leakage characteristics. In the process of $G$-type leakage characteristics, if the local abnormal voltage of the switch cabinet reaches a certain limit, the local leakage phenomenon will occur at the dividing line of the switch cabinet equipment. The rising duration of Gaussian current with local leakage is nanosecond, and the steeper its rising path, the greater the frequency of electromagnetic wave radiated outward, so the frequency of electromagnetic wave with local leakage can reach above GHz level.

When leakage occurs inside the high voltage switchgear, the local leakage position can be regarded as an electromagnetic wave radiation port. At this time, the electromagnetic wave signal of the equipment can be transmitted to the surrounding area for dielectric propagation. Combined with the classical Maxwell electromagnetic field equations, the distances from the dividing line to the upper electrode and from the dividing line to the lower electrode of the electromagnetic wave magnetic field can be set to $h_1$ and $h_2$ respectively, and $h$ are control sample data. Further, the $G$ type characteristic discharge category is calculated, and the specific algorithm is as follows:

$$\Delta G = \frac{\sigma - 1}{2\sigma(h_1 + h_2)}$$

(3)

If the above algorithm is further switched in rotation angle, the $S$-type leakage numerical electromagnetic wave frequency equation can be obtained. The specific algorithm is:

$$\Delta S = \frac{\Delta G - 1}{2(\sigma - \sigma)(h_1 - h_2)}$$

(4)
If the dynamic mark measurement and dynamic phase measurement of the discharge data of the switch cabinet $e$ and $A$ are substituted into the above equation, assuming that the dielectric value is $t$, the power supply is $P$, the current density $L$ and the internal electromagnetic conductance frequency are $d$ expressed. The discharge value of the switch cabinet is simplified according to the Lorentz principle, specifically as follows:

$$K = A \times \frac{pe + lv}{2\Delta S + \Delta G} - dL$$

Assuming that the charges are evenly distributed, considering the influence of all charges, the calculation of some electromagnetic fields is essentially running in a four-dimensional space. In the partial finite mean difference computation, it is generally necessary to create a grid module to differentiate networks. At the same time, the internal electromagnetic field solved by the grid module is dispersed, and the key flow of the grid module division is to estimate the real-time electric field value and electric charge value by using the electromagnetic field quantity and the electric charge number according to the similar frog step jump flow, and to judge the discharge characteristic category of the switch cabinet.

2.3 Implementation of Partial Discharge Identification in Switch Cabinet.

When there is a local leakage phenomenon inside the switch cabinet, the abnormal phenomenon of the electric pulse height of the N-S electrode usually occurs, causing electromagnetic waves with a large width. The abnormal value of the pulse height can generally reach more than 1GHz, resulting in the reflection phenomenon of the electromagnetic wave propagating inside the switch cabinet due to the complicated composition structure. When the electromagnetic wave is affected by discharge inside the switch cabinet, there will even be diffraction reaction, which greatly reduces the energy of the electromagnetic wave and leads to poor identification results of local leakage electromagnetic waves in the switch cabinet. When local leakage occurs in the switch gear, Influenced by the uneven distribution of electric field intensity, causing discharge leakage, In order to more accurately identify the classical leakage characteristics and electric field strength layout characteristics under high voltage, the instantaneous electric field strength simulation is carried out for the classical types of local leakage. At the same time, the dielectric constant of the switch cabinet is given to ensure that it is less than the constant of common insulating substances. The potential difference formula of any internal node is adopted as follows:

$$\bar{\psi} = \nabla K + R \frac{Q}{\tau_i}$$

Wherein the discharge characteristic value $Q$ is represented, the dielectric data $\tau_i$ is represented, and the distance between the charge and the node is represented as $R$. If the power supply charge at the port of the switch cabinet is $U$, when the operating voltage of the equipment increases to the maximum value $x$, local leakage will occur in the gap of the insulation internal medium, and local leakage will also occur in the contact part between the insulation medium and the high voltage conductor along with the metal top. The high voltage application in the simulation system uses 35KV Gaussian pulse, which is expressed as follows:

$$\psi = 350e^{-100t} \times \frac{x}{2\bar{\psi}}U$$
On this basis, the discharge information of the switch cabinet is identified. Dividing the grid structure of the switch cabinet, the module size is 10*10*10mm, and the electric actuator and the control unit of the discharge model are installed on the base of the electric control structure. The base of the equipment, the switch cabinet and the pressure relief top plate of the bus room are fastened through bolts. Install a dust cover at the outer end of the switch cabinet. When not running, the discharge model is recovered into the shielding space under the base of the electronic control structure. The copper bar electrode is tightly connected with the bus bar through bolts, and the flexible buffer is tightly connected with the copper bar electrode through threads. Finally, the switch is used to collect and identify the internal insulation faults of the switch cabinet. Judge whether there is any abnormality in the device, and locate the local leakage source of the switch cabinet.

3. Experiment and Result Analysis

In order to verify the effectiveness of the partial discharge identification method for switchgear based on single chip microcomputer control, the following comparative experiments are designed.

3.1 Experimental Environment

The XFDTD system is used to simulate the discharge identification process. The voltage value of the switchgear is 35kV, and the size of the switchgear is 80X50X180mm. The switchgear is divided into two spaces at a height of 120mm inside. A 2mm space is set at the switch of the switchgear to imitate the specific state of the real switchgear. The switchgear conductance is 5.8 x1 and the relative electrolyte constant is 1.

3.2 Experimental Result

The validity of discharge identification is detected under the above experimental environment. In order to ensure the effectiveness of the experiment, the on-line identification method of switch cabinet partial discharge based on acousto-electrical combination in reference [3] and the identification method of switch cabinet partial discharge based on ultra-high frequency method in reference [4] are taken as comparison methods, and the application performance of different methods is verified from the perspectives of identification accuracy and identification process time consumption.

Firstly, the recognition accuracy of different methods is tested, and the experimental results are shown in Figure 1.

![Figure 1. Identify accuracy comparison results](image)

On this basis, testing the recognition process of different methods takes time, and the experimental results are shown in Figure 2.
3.3 Result Analysis

Analysis of FIG. 1 shows that with the increase of experimental time, the recognition accuracy of different methods is also constantly changing. The recognition accuracy of the method in reference [3] is between 92-95%, the recognition accuracy of the method in reference [4] is maintained at about 90%, while the recognition accuracy of the method in this paper is always maintained at above 95%. Through comparison, it can be seen that the partial discharge identification method of switch cabinet based on single chip microcomputer control designed in this paper has the highest identification accuracy, which shows that the method has the strongest accurate identification ability.

Analysis of Figure 2 shows that with the increase of experimental time, the recognition process time of different methods is also constantly changing. The recognition process time of the method in reference [3] is between 6-10s, showing a downward trend. The recognition process time of the method in reference [4] is between 10-12cm, while the recognition process time of the method in this paper is below 7s. Through comparison, it can be seen that the identification process of switch cabinet partial discharge identification method based on single chip microcomputer control designed in this paper takes the shortest time, which shows that the identification efficiency of this method is the highest.

4 Concluding Remarks

In this study, a partial discharge recognition method for switchgear based on single chip microcomputer control is designed, which optimizes the recognition process from two angles of recognition accuracy and recognition process time consumption, and the experimental results prove the effectiveness of the method.

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