Live Detection of Cable Insulation Aging Defects in 35kV Switchgear

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Abstract: Through the live detection of partial discharge, it is found that there is an insulation discharge phenomenon at the end of the B phase cable of a 35kV Switchgear. After power failure inspection, it was found that there was obvious discharge traces in the contact position between B phase cable and ground whip. After the disintegration of the cable head, it is found that the production process of the cable head is bad and the shielding layer is missing, which leads to the uneven local electric field. Meantime, it is also found that there is an aging phenomenon in the main insulation of B phase cable, and its colour has been changed from white to dark yellow. The insulation defect is effectively discovered by the live inspection work, which makes the occurrence of power accidents be avoided with the equipment long-term operation.

1. Introduction

As an important type of equipment, the switchgear is one of the indispensable components of the power grid. Its operation stability is an important guarantee for the safe operation of the power grid. For switchgear, how to detect the equipment defects and manage them in advance will be an important means to ensure its operating safely and stablye. It is well known that partial discharges are often present in switchgear insulation systems. Although partial discharge will not affect the safety of the equipment temporarily, partial discharge is a hidden danger in electrical equipment. The damage process reflects chronic and long-term damage, which will eventually cause equipment damage. Therefore, it is of great significance to carry out on-line detection technology research and on-site measurement of partial discharge in switchgear.

In order to carry out this work faster and better, Zhang Canhua of Shandong University studied the detection technology of UHF, TEV and ultrasonic for partial discharge of switchgear [1]. Li Haide and Cao Feixiang of North China Electric Power University have studied the joint detection technology of TEV and ultrasonic for partial discharge of switchgear [2,3]. Wang Liuhuo, Lu Hong, et al used the TEV and ultrasonic detection technology to detect and analyze the typical partial discharge pattern in switchgear [4]. Huang Shilong, Wang Xiaohui, et al studied the principle of partial discharge transient voltage generation in switchgear, developed TEV sensor, and successfully realized three typical partial discharge defect of switchgear [5].

Similarly, Inner Mongolia Power Company has also set up a live detection technology team for electrical equipment. On July 13, 2017, when the ultrasonic (AE), ultra-high frequency (UHF) and transient ground voltage partial discharge tests were carried out on a 35kV switchgear in a 220kV power station, the insulation partial discharge was found, which located at the lower B-phase cable terminal of 35kV Longxin I line 377 switchgear. Through ultrasonic positioning analysis, the final location of partial discharge signal is determined, which located at the B phase cable terminal position of the lower part of 377 Switchgear. On July 25, 2017, the equipment was disintegrated. It was found that the insulation strength of phase B cable terminal decreased, and partial discharge was produced on the near ground braid, which verified the accuracy of the test conclusion.

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2. Introduction of partial discharge detection method for switchgear

Partial discharge is one of the main reasons for the deterioration of electrical equipment in switchgear. The main types of partial discharge in switchgear include insulation internal discharge, surface discharge and corona discharge. The main testing methods of partial discharge is the ultra-high frequency and ultrasonic partial discharge live detection.

2.1 Ultra high frequency detection of partial discharge in switchgear

Because of its anti-interference ability, the Ultra high frequency mothod (UHF) is usually used to detect the UHF signal produced by partial discharge of power equipment so as to judge the partial discharge status of equipment and realize the judgment of insulation status. With its high sensitivity and interference ability, it is used to realize the live detection, location and fault type judgment of partial discharge. The principle of UHF is shown in Fig. 1.

2.2 Ultrasonic detection of partial discharge in switchgear

Partial Discharge Ultrasonic live detection includes contact type and air type ultrasonic testing. For the contact ultrasonic testing, the AE sensor attached to the surface of power equipment to detect the vibration induced by ultrasonic signals generated. For the air ultrasonic testing, the air-type ultrasonic sensor is usually used to detect the vibration of the ultrasonic signal generated by the discharge in the air. The principle of detection is shown in Fig. 2 and Fig. 3.

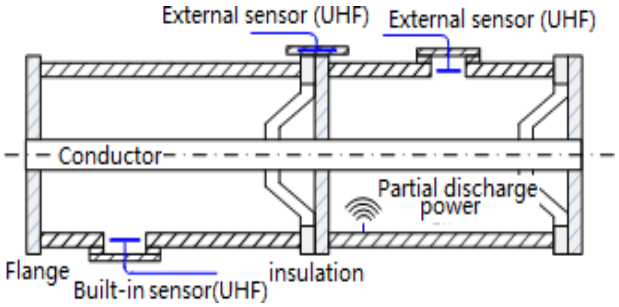

Fig. 1 the principle of UHF testing

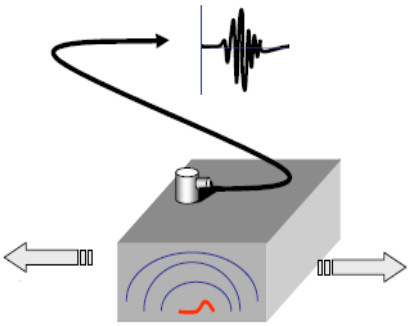

Fig. 2 the principle of contact ultrasonic testing

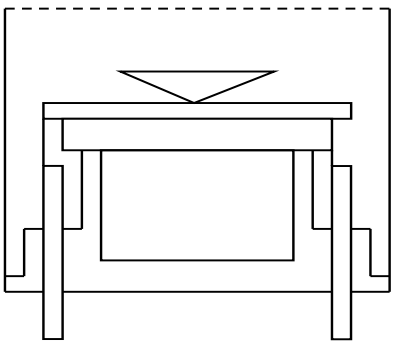

Fig. 3 the principle of air-type ultrasonic testing

3. Partial Discharge Electrification Detection

3.1 Ultrasonic testing

PDS-T90 partial discharge detector was used to detect the crack of 377 Switchgear of 35kV Longxin I line by ultrasonic detection. The ultrasonic detection atlas was abnormal at the back and bottom cracks. The ultrasonic detection data were shown in Fig. 4.

By analysis of ultrasonic testing data at the back slot of 377 Switchgear of 35kV Longxin I line, it shows that the amplitude of ultrasonic signal is 23dB, the amplitude of ultrasonic signal is stable, and the amplitude of frequency component is stable. The phase diagram shows that ultrasonic pulses are concentrated near the phase angles of 90 and 270 degrees. Two clusters of pulses appear in one cycle, and the signal waveform is stable and checked. There is a strong discharge sound in the headset.

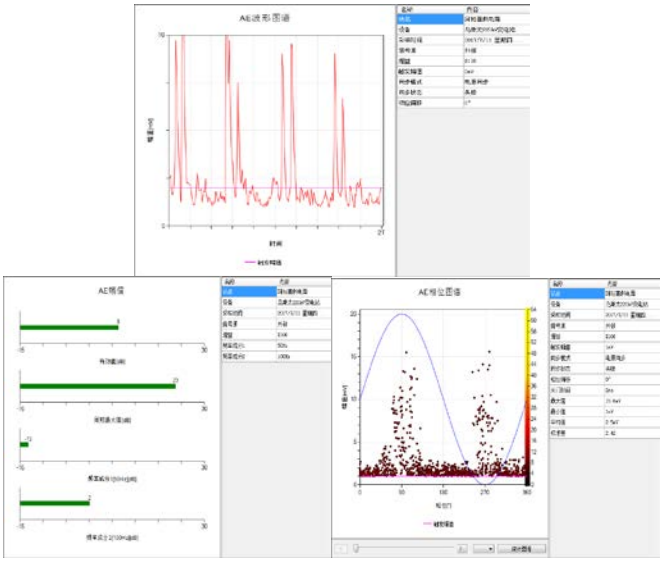

Fig. 4 Ultrasonic testing data of 35kV 377 Switchgear

3.2 UHF detection

Using the PDS-T90 PD tester to detect the 35kV Longxin I return line 377 Switchgear based on UHF partial discharge detection, UHF detection map is abnormal, and the UHF test data is shown in Fig. 5.

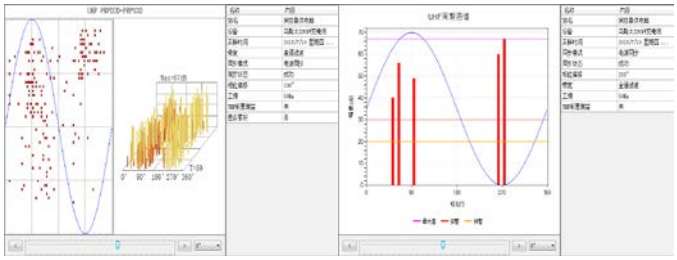

Fig. 5 UHF test data of 35kV 377 Switchgear

By analysis of the UHF detection data of 35kV Longxin I line 377 Switchgear, the following results are found.

a) The amplitude of partial discharge is 67dB.

b) There has two stable clusters of pulse signals, which appear near the 90 and 270 phase angles in PRPS spectrum.

c) The positive half-cycle discharge pulse has wide phase distribution, dispersed amplitude distribution and high pulse density.

d) The negative half-cycle discharge pulse has narrow phase distribution and high amplitude.

Based on the above analysis results, preliminary judgment of the grounding terminal corona

discharge probability in the Switchgear is larger. It not only has the discharge characteristics between metal to insulating dielectric, but also does not rule out the possibility of insulation strength reduction.

3.3 Transient Voltage Detection

The average metal background of the 35kV Switchgear room is 13dB, while the transient ground voltage detection value of the 35kV 377 Switchgear is 11--32dB. Thus, the transient ground voltage detection value is overall high.

4. Accurate Location and Diagnosis of PD Signals

According to the characteristics of fast ultrasonic attenuation and strong directivity, ultrasonic amplitude positioning method was used to analyze the ultrasonic signal. Through ultrasonic positioning detection, it is judged that the discharge source is located near the B-phase position of the lower part of 377 Switchgear of 35kV Longxin I line. The on-site detection diagram is shown in Fig. 6.

Fig. 6 PD location of 35kV 377 Switchgear

5. Outage Inspection and Treatment of Switch Cabinet with Abnormal Partial Discharge

5.1 Power Cut Check

On July 25, 2017, the electrified inspection technicians conducted a power outage check on the“35kV Longxin I line 377 Switchgear”. It is found that there were obvious discharge marks at the contact position between B phase cable and grounding whip at the lower part of 377 Switchgear. The grounding whip produced corona discharge on B phase cable. There were obvious discharge marks on the outer surface of the cable. The discharge marks were shown in Fig. 7.

Fig. 7 B phase cable surface discharge traces of 35kV 377 Switchgear

5.2 Anatomy analysis of B phase cable

Anatomical analysis of this B phase cable shows that the main insulation of the cable is aging, and the main insulation layer changes from white to dark yellow. In the course of dissection, it was also found that the fabrication technology of cable was not good, and the shielding layer was absent, which resulted in the local electric field non-uniformity. The B phase cable is dissected as shown in Fig. 8 .

Fig. 8 B phase cable anatomy of 35kV 377 Switchgear

6. Conclusion

a) The insulation defect of B-phase cable was found effectively in 377 Switchgear by partial discharge live detection.

b) By PD detector, the defective equipment can be detected quickly and conveniently. By PD positioning system, the location of abnormal partial discharge signal can be found accurately.

c) Insulation aging is a common problem in power cables running for a long time. The latent defects can be detected conveniently and quickly by live detection.

d) The insulation level of power equipment can be predicted in advance and the insulation breakdown accident can be prevented by partial discharge live detection.

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