Case Analysis of GIS Partial Discharge Based on Cooperative Detection Method

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Abstract. Partial discharge diagnosis methods, such as ultrasonic method, ultra high frequency method and decomposition product method, have their respective advantages and disadvantages in the application. Therefore, in order to combine the characteristics of various detection methods, it is recommended to carry out joint detection of various methods in the field. In the end, a case of GIS PD is introduced.

1. Introduction
As an important equipment in power system, the reliability of GIS affects the security of the whole power system. When insulation occurs in equipment, partial discharge is usually generated and transmitted by acoustic, electrical, optical and other signals. Therefore, the live detection and on-line monitoring of GIS partial discharge are widely used in power system. At present, the detection methods of PD mainly include gas decomposition product method, UHF method and ultrasonic method[1-2].

However, in practical application, each method has its own advantages and disadvantages. The gas decomposition product method is not affected by electromagnetic interference, but because the number of gas chambers in GIS is very large, the workload is very large, the detection efficiency is low, and the gas in the gas chamber needs to be released in the detection process. UHF method has high detection sensitivity and wide detection range, but it is easy to be affected by external electromagnetic interference signals in the detection process. The installation position of the sensor is limited by the field equipment, and there is a detection blind area for some insulation defects. Ultrasonic method has strong ability of anti-electromagnetic interference, sensitive to free metal particles and unlimited detection position, but it has a large workload of detection and insensitive to some defects (such as suspension) [3-4].

Combined with the advantages and disadvantages of the above detection methods, this paper proposes a cooperative detection and diagnosis scheme combining the three methods. In the live detection, UHF method is used firstly. When the suspected partial discharge phenomenon is found, ultrasonic method is used for retest, and UHF and ultrasonic cooperative positioning method are used. In other words, the UHF method is used to realize the rough location of the fault point and determine the discharge area, and then the ultrasonic method is used to carry out the fine location in the discharge area. This method can not only improve the positioning efficiency, but also improve the positioning accuracy. In the case that the UHF method and ultrasonic method are used to detect the suspected serious partial discharge and the location of partial discharge is preliminarily determined,
and a very clear conclusion is needed, the decomposition gas can also be detected. Based on the information obtained by UHF, ultrasonic and decomposition gas methods, combined with the historical test records of the equipment, the conclusion of partial discharge diagnosis for GIS equipment is drawn.

2. A case of cooperative detection and diagnosis of internal discharge of GIS

2.1. Case history
In September 2008, the partial discharge of the phase C of the GIS whose number is 251 in a substation of a power company was too large (more than 3 times of the detection values of phase A and phase B). On January 7, 2009, SF6 gas component analysis technology was used to detect the decomposition products of the three-phase interval of the GIS 251 (gas chamber connected), and the test data showed that 1ppm HF gas was found in the interval; after that, the gas path of the GIS 251 three-phase gas chamber was cut off, and the ultrasonic partial discharge detection and SF6 gas component analysis were conducted once every two weeks, and if the discharge is stable or has a decreasing trend, it will be extended to once every three weeks. It is found that the CF4 content in the interval of phase C is much higher than the normal level (more than 3 times, about 100ppm in the normal gas chamber). After nearly two months of monitoring, it is concluded that there are unstable suspended discharge defects in gas chamber of phase C. On May 27, 2009, the air chamber was disassembled and inspected. It was found that two insulated screws used to fix the shielding aluminium plate were broken, and the broken screws (including metal nuts) fell to the equipment in the air chamber.

2.2. Detection and analysis method

2.2.1. UHF PD detection technique and analysis method. The UHF method is used 4 times per hour to online monitor three-phase of the GIS 251, and the test data is shown in Fig.1, and Fig.2.

According to the test data, in most of the monitoring time, the amplitude of partial discharge in phase C is higher than that of phase A and phase B, and the partial discharge of phase C is unstable.
some certain times, the value of partial discharges suddenly increases to several times of phase A and phase B, and the maximum value of the discharge amplitude can reach 14mV, and it will disappear after continuous discharge for about 20 minutes. According to the analysis of discharge waveform, there is unstable suspended shield or metal particle discharge in phase C. according to the trend of discharge amplitude, the defect of phase C does not break through the growth trend. It can be determined that the defect of phase C does not develop in the monitoring period.

2.2.2. Ultrasonic PD detection technique and analysis method. The results of ultrasonic PD detection are shown in Fig.3, and Fig.4.

![Fig.3 measurement results of phase C](image)

![Fig.4 Test results of phase A and B in May 8th](image)

According to the analysis of the situation of on-line measurement and multiple monitoring in the past three months, the measurement results of phase C have a strong correlation with 50Hz and 100Hz, the signal change is stable, the phase diagram is continuous, the discharge amplitude is increasing, and the measurement results of phase A and phase B are stable, and then it is judged that there is a suspended potential discharge in the gas chamber of the phase C in GIS 251, and the discharge energy is small, relatively stable, with a gradual increase trend.

2.2.3. Gas component detection technique and analysis method. In order to accurately analyse the possible internal defects of the abnormal partial discharge gas chambers in GIS, the SF6 gas components in these chambers were analysed[5-6]. The results are shown in Table 1.

| Date       | Object       | CF₄(µL/L) | CO₂(µL/L) | CO(µL/L) | HF(µL/L) | Hydrolyzable fluoride(µL/L) |
|------------|--------------|-----------|-----------|----------|----------|-----------------------------|
| 2009.1.7   | PT of GIS 251| 454       | 247       | 4        | 1        | 0.06                         |
| 2009.2.23  | PT of GIS 251| 433       | 263       | 9        | 0        | 0.05                         |
According to Table 1, the test results of HF in January 2009 is 1ppm (no HF in normal equipment). In addition, the continuous monitoring results show that the content of CF$_4$ (> 400ppm) in phase C is higher than that in normal operation equipment (test data of other equipment are within the normal range); however, HF is not found in the test after January, so it is believed that HF may be the original. Because the discharge is not large, HF content is not high and the chemical property of HF gas is not stable, HF adsorption or reaction with other components in the gas chamber disappears after the discharge, and the content of CF$_4$ gas in phase C Pt does not increase, and no such gases as SO$_2$F$_2$, SOF$_2$ and SF$_4$ are found. The gas measured several times does not increase.

2.2.4. Comprehensive analysis and equipment disassembly inspection. According to the test results of the three detection methods, it can be concluded that there is a suspended potential discharge in the gas chamber. Due to the small discharge energy, the degree of discharge is not serious, and there is no surge, but the discharge is gradually increasing. Therefore, it is recommended to immediately cut off the power supply for inspection and treatment to avoid accidents. On May 27, 2009, the air chamber was disassembled and inspected. It was found that two insulated screws used to fix the shielding aluminium plate were broken, and the broken nuts fell into the air chamber, which was a major hidden danger of the equipment. As shown in Fig.5.

![Fig.5 Scene break-up photos](image)

3. Conclusion

1) For the internal discharge defects in GIS, ultrasonic partial discharge, UHF partial discharge and SF$_6$ gas component analysis technology can be used for more effective detection. Three methods can be used to judge the nature, severity and location of internal discharge defects.

2) In the practical application, UHF can be used for large-area general survey. For the gas chambers that may be abnormal, the comprehensive judgment of partial discharge and SF$_6$ gas component analysis technology can effectively provide the efficiency of state evaluation.
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