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The Characteristics of Partial Discharge on Corona Defect in GIS based on Multi-Detection method

Abstract. *Gas insulated switchgear (GIS) is the most important equipment in the power grid. The partial discharge (PD) is the premonitory detection method for the insulation failure. The UHF detection method and acoustic detection method is the most used in filed. UHF method has excellent anti-interference performance and acoustic method has excellent defect location ability. Metal tip defect will appear on GIS for manufacturing and other reasons. The metal tip will lead to corona discharge under operating voltage. It is necessary to study the characteristics of corona discharge for fault detection and diagnosis. The experimental system is set up and the corona discharge characteristics on conductor and ground in actual GIS model are studied using above two methods. The comparing of the two methods is studied in this paper.*

Streszczenie. *Wyładowanie niezupełne może być metodą detekcji złej izolacji w przełącznikach gazowych GIS. Doi wykrywania wyładowania najczęściej używa się metody UHV lub akustycznej. Pierwsza z nich jest odporna na zakłócenia druga bardzo dobrze pozwala na lokalizację wyładowania. W artykule przedstawiono porównanie obu metod. (**Badanie różnymi metodami wyładowania niezupełnego w przełącznikach gazowych**)*

Keywords: GIS; corona; UHF; acoustic.
Słowa kluczowe: przełącznika gazowy GIS, wyładowanie niezupełne.

1. Introduction

Gas Insulated Switchgear (GIS) is the key equipment in modern power system for the advantages of small floor space and high reliability. In order to ensure its safe and stable operation, detection of internal insulation defects for GIS has become an increasingly important research topic. Among the detection methods of defects in GIS, commonly used methods in field are acoustic detection method and UHF detection method [1].

When partial discharge (PD) happens inside the GIS, it is usually accompanied by many electrical phenomena, such as electric current pulse and ultra high frequency (UHF) EM signal, as well as non-electrical phenomena, such as lights, heat and acoustic. Hence, PD detection methods consist of two types, namely the electrical type and non-electrical type. For the GIS PD detection, the electrical method frequently used in field is UHF detection and the non-electrical detection method is acoustic detection.

For the UHF method, excellent anti-interference performance make it widely used in on-line monitoring. MD Judd study the excitation of UHF signals by partial discharges in GIS[2]. Yoshikazu computed the relationship of current waveform and UHF bandwidth[3]. With the development of online detection, the UHF on-line monitoring system has been became the important component element of smart equipment. The acoustic detection method is very suitable for defects detection in GIS, for it has the advantages of on-line detection and easy realization of locating the defects. Lundgaard take a lot of study to acoustic detection method, especially for the detection of free metal particles [4~6].

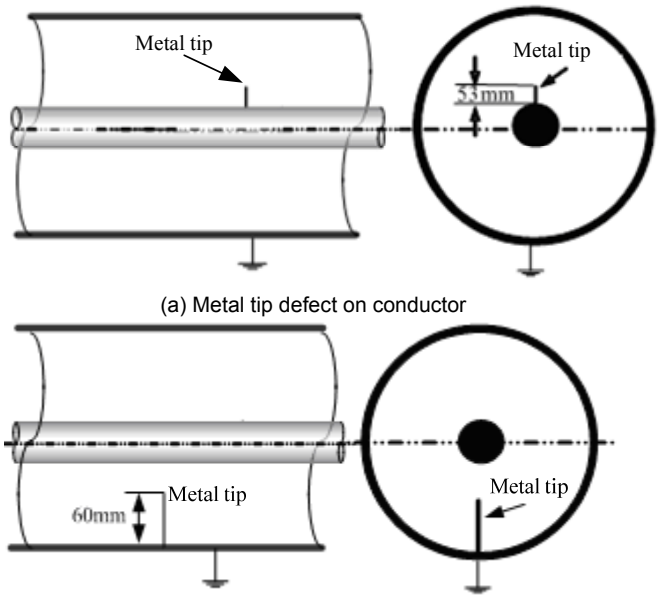
UHF and acoustic methods have their advantages and disadvantages in practice. Previous studies are one of the methods and the joint detection of two methods are rarely taken. The joint detection of these two methods are studied In this paper,

In the process of manufacture and transportation for the GIS, tip defect such as metal tip may appear. The metal tip will lead to corona discharge under operating voltage and it can be detected by UHF and acoustic detection. The places that may appear metal tip are high voltage conducting rod and grounding shell. The UHF and acoustic detection method are used in this paper to study the characteristics of corona defect in an actual GIS model.

2. Detection model and measurement system

According to the typical metal tip defect types in GIS, this paper establishes the corona defect in an actual GIS model. The GIS model used in this study is shown in figure 1. Typical defects are shown in figure 2.

Fig. 1 GIS model



(a) Metal tip defect on conductor

(b) Metal tip defect on ground

Fig. 2 Typical corona defects in GIS

According to the experience in designing typical GIS defect models, a needle plate model is designed to simulate such metal tip defect. In figure 2(a), the silver needle is 53mm long for conductor and 60mm for ground. In order to make the metal tip discharges more easily and ensure it a single point of discharge, the tip needle is carefully chosen. The pinpoint's equivalent radius of curvature is 80μm and the pinpoint is relatively smooth without bifurcation and burr.

In the course of the study, a set of integrated measurement system based on UHF and acoustic method are adopted in this paper. The experimental circuit is shown in figure 3, which includes AC high voltage system and detection circuit. AC voltage was generated using a test transformer rated at 50Hz, 10kVA, 0-100kV, Z is protective impedance. C_K is a coupling capacitor. This paper mainly studies the UHF and acoustic characteristics of PD of corona defects. The UHF detection use self-developed UHF detection system, which has 400MHz ~ 800MHz detection bandwidth[7]. The acoustic detection use AIA detection system.

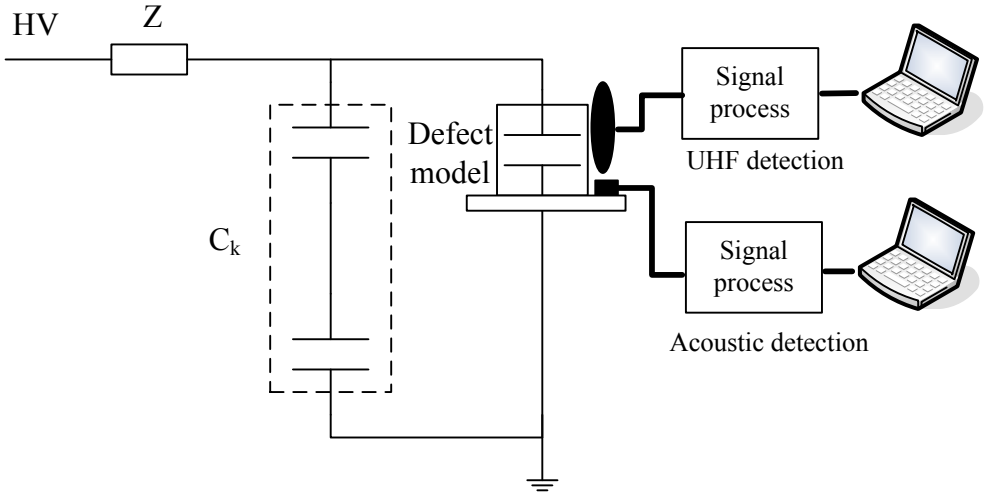
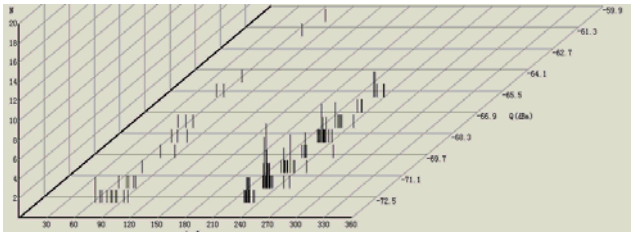


Fig. 3 Measuring system

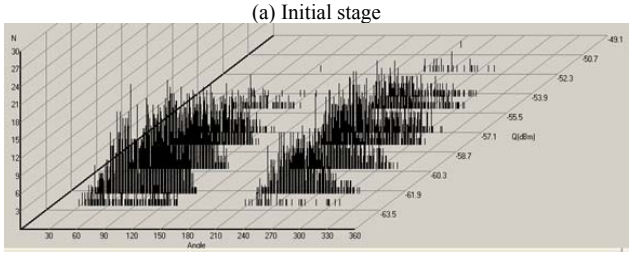
3. Results and analysis

3.1 Corona discharge on conductor

The typical discharging pattern of corona discharge on conductor for UHF method is shown in figure 4.



(a) Initial stage



(b) Severe stage

Fig. 4. The typical discharging pattern of corona discharge on conductor for UHF method

It can be seen from Figure 4, discharge at positive and negative cycle was significantly asymmetry. The discharge appeared in negative at initial stage. The situation will change at severe stage. Negative peak discharge was smaller and the higher repetition rate. Positive discharge is large but the repetition rate is low at severe stage. The UHF signal frequency distribution about the corona discharge on conductor is shown in figure 5.

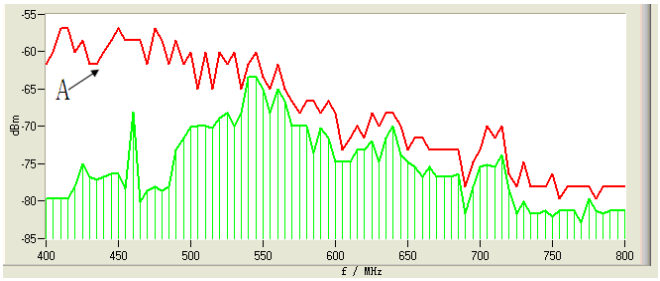
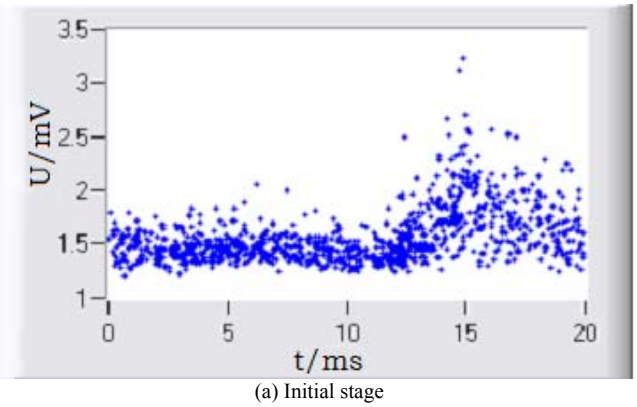


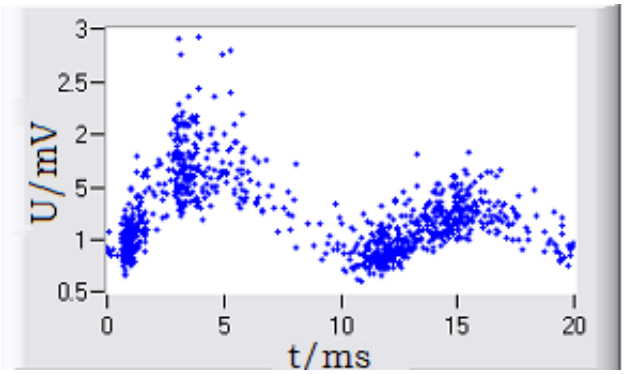
Fig. 5 UHF signal frequency distribution

It can be seen from figure 4, the energy of corona discharge on conductor mainly concentrated in 400MHz-550MHz range. Higher the frequency and the lower energy.

The typical discharging pattern of corona for acoustic method is shown as figure 6.



(a) Initial stage



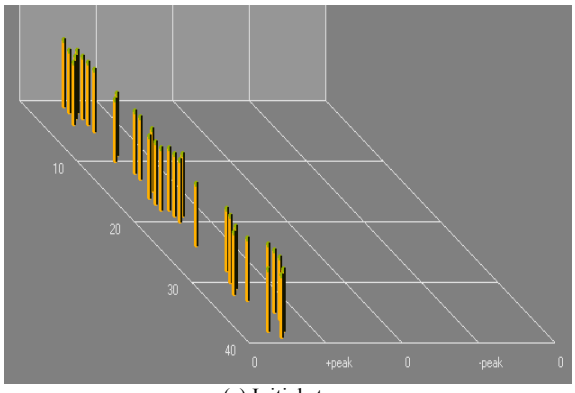
(b) Severe stage

Fig. 6. The typical discharging pattern of corona discharge on conductor for acoustic method

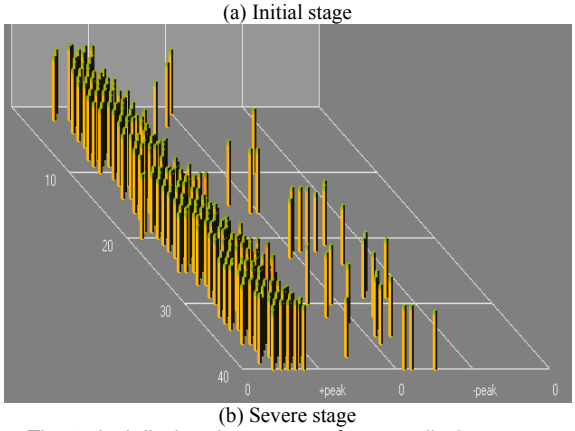
It can be seen from figure 6 that the initial stage of the discharge is also concentrated in the negative half-cycle. With the increase of test voltage, positive discharge signal amplitude than the negative to be significantly higher, but the negative discharge density is higher than the positive. With the increase of test voltage, the positive and negative discharge phase becomes wider, increasing the amplitude of the discharge, which is UHF detection method measured the same result.

3.2 Corona discharge on ground

The typical discharging pattern of corona discharge on ground for UHF method is shown in figure 7.



(a) Initial stage



(b) Severe stage

Fig. 7 The typical discharging pattern of corona discharge on ground for UHF method

It can be seen from figure 7 that the discharge appears in positive cycle at initial stage. The discharge amplitude and repetition rate at positive cycle is higher than negative cycle. The discharge characteristics of ground corona are different than conductor corona especially at initial stage as figure 7 and figure 4 shown.

The UHF signal frequency distribution about the corona discharge on ground is shown in figure 8.

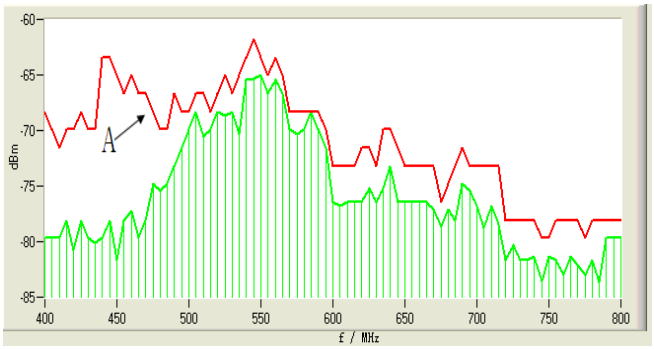
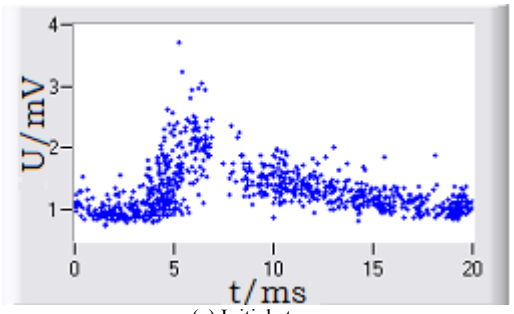


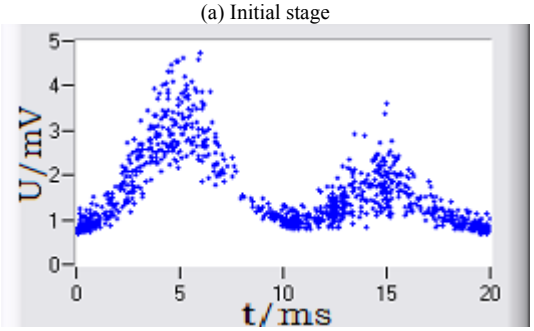
Fig. 8 UHF signal frequency distribution

It can be seen from figure 4, similar with the conductor corona, the energy of corona discharge on ground mainly concentrated in 400MHz-550MHz range.

The typical discharging pattern of corona for acoustic method is shown as figure 6.



(a) Initial stage



(b) Severe stage

Fig. 9 The typical discharging pattern of corona on ground for acoustic method

Similar with the UHF detection results, the discharge appears in positive cycle at initial stage and both in negative and positive cycle at severe stage. Acoustic detection result and UHF detection result has better consistency.

It can be seen from figure 4 to figure 9, for the corona discharge, UHF and acoustic methods are able to effectively detect the discharge signal.

Corona discharge often occurs at the surface of the high voltage conductor and ground shell. In the vicinity of the metal tip, a serious distortion of the electric field, gas ionization is very strong during the positive frequency half-cycle. A large number of positive ions get close to the plate, which equals reducing the space between the tip and the plate. Continuous ionization forms electron collapse, thus forms streamer discharge, therefore breakdown may happens and produces large amplitude discharge pulse in the positive half-cycle. With the increasing degree of partial discharge, a large number of discharge pulses will appear in the positive half-cycle and discharge pulses in positive

and negative half-cycle both happen near the frequency phase of positive and negative peak[8].

4. Conclusions

The typical corona GIS discharge types are designed in this paper . The PD is detected by the UHF detection method and UHF method. The characteristics of Partial Discharge on corona Defect in GIS based on Multi-Detection method is studied in this paper. The studied results show that the corona discharge for UHF and acoustic methods has good sensitivity, the characteristics performance has similar.

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