DISTRIBUTION VOLTAGE OF INSULATORS MEASURING USING TUNGSTEN NEEDLE ELECTRODES

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ABSTRACT

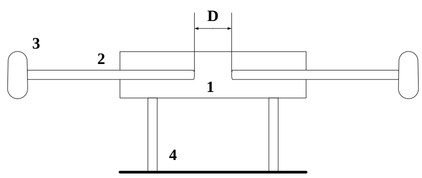
Sphere gap was widely used in measuring high voltage. However, in some cases, such as distribution voltage measuring of insulators, sphere gap did not work well for its too-large self-capacitance.
A new method of measuring the distribution voltage of insulators has been established.
In this paper, the distribution voltage of a section of insulators has been induced by a drainage ring to a pair of needle electrodes, which was made of tungsten and had a 20μm tip radius [1]The gap between the two needle electrodes were 1mm, 2mm and 3mm.The relationship between the sustained voltage, including the distribution of insulators and the discharge phenomenon the distribution of insulators and the discharge phenomenon, has been found on two aspects: discharge frequency and discharge intensity [2].
. The discharge frequency was obtained by recording the current flowed the needle electrodes and analyzing the recorded data. The discharge intensity was defined by the grey scale of the discharge photograph obtained by a high resolution camera. With this novel method , the distribution voltage along the insulators, including ceramic insulators, glass insulators and composite insulators can be easily and precisely measured ,which contributes to the study of the electric properties of insulator. Therefore, failures of insulators caused by unevenly distributed voltage can be avoided by innovating design of insulators.

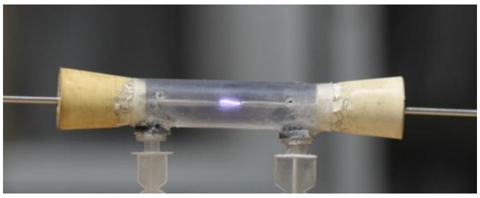
1 INTRODUCTION

Composite insulators have been widely used in power systems in China since 1980s. Advantages of composite insulators are their lower weights, ease of handling, reduced installation and maintenance cost, increased resistance to vandalism, and superior contamination performance. The voltage and electric field are unevenly distributed along the composite insulator, which means particular positions of the insulator sustained extremely electric filed stress and may cause deterioration of the insulation material. To measure the voltage distribution along the composite insulator, there is no satisfactory and mature method: this paper presents a new method: using a pair of needle electrodes and recording the discharge phenomenon to measure the distribution of composite insulators.

2 TEST SYSTEMS

The structure of these needle electrodes is shown in figure 1, consisting mainly of a pair of tungsten electrodes and a discharge chamber,



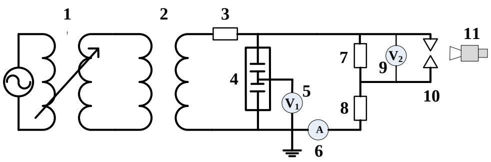


1. Discharge gap 2.pin electrodes 3.corona ring 4.holder

D refers to width of the gap

Figure 1 . structure of the pin electrodes gap

The needle electrodes were parallel connected at the half position of composite insulator. Detailed configuration of the test system is shown in figure 2.



1. Regulator 2.transformer 3.protection resistor R_0 4.voltage-divider 5.voltagemeter V1 6.Current measuring system 7.Resistor Z_2 8.Resistor Z_1 9.voltagemeter V2 10. Needle electrodes gap 11. Camera

Figure 2 Configuration of the test system

In Figure 2, Z_1 and Z_2 stands for the impedance of the halves of the composite insulator. U_1 stands for the applied voltage from the voltage divider. U_2 stands for the sustained voltage on the needle electrodes gap. I stands for the current flowed through the gap. The discharge frequency was obtained by analyzing the recorded data of I, the discharge intensity was obtained by the photographs taken by the camera.

3 RELATIONSHIPS BETWEEN APPLIED VOLTAGE AND DISCHARGE FREQUENCY

A series value of voltage U_1(from 2kV to 10kV) has been applied on the Test circuit, thus a series value of U_2 has been applied on the needle electrodes.

From the view of equivalent circuit, when U_2 is relatively low, no discharge phenomenon happened on the gap G. Under this situation, we have:

$$I=\frac{U_1}{Z_1+Z_2}$$
$$U_2=\frac{Z_2}{Z_1+Z_2}\bullet U_1 \qquad (1)$$

With the increasing of the applied voltage U_1, the sustained voltage between the gap U_2 reached the breakdown condition, air breakdown happened between the gap, at this time, we have:

$$I=\frac{U_1}{Z_1+Z_2 \parallel Z_G}$$
$$U_2=\frac{Z_2 \parallel Z_G}{Z_1+Z_2 \parallel Z_G}\bullet U_1 \qquad (2)$$

ZG stands for the equivalent resistance of the arc when breakdown happens. The value of the *ZG* is too little compared with *Z1*, *Z2*, thus we can simplify equation (2) to:

$$I \approx U_1/Z_1$$
$$U_2 \approx 0 \qquad (3)$$

After the breakdown process, the sustained voltage on the gap G decreases rapidly, then the arc extinct. From (3) we can learn that the current flowed through the gap doesn't influenced by the configuration of the needle electrodes. However the discharge phenomenon of needle electrodes can help measuring the applied voltage. Typical waveform of I is shown in figure 3.

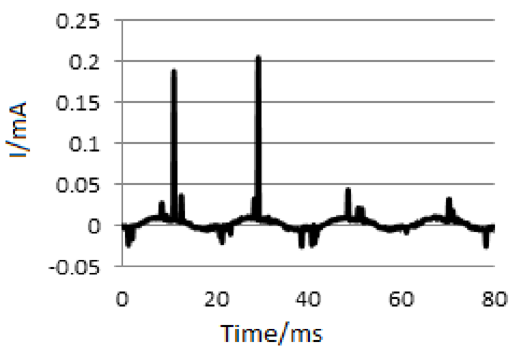
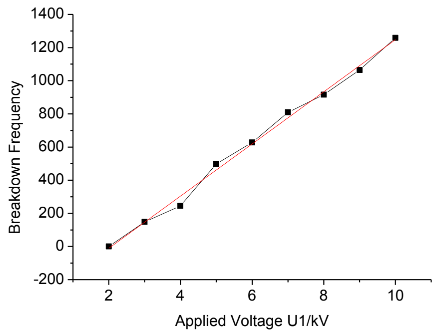


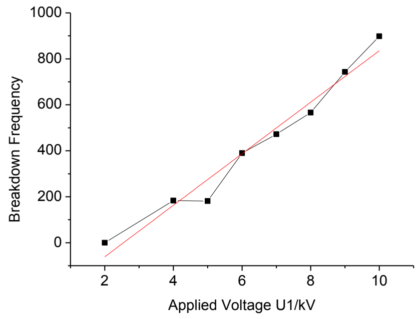
Figure 3 waveform of I

From figure 3 we can conclude that when discharge happens, a pulse current occurs, which means one breakdown process finished. The frequency of breakdown process was influenced by both the applied voltage U_1 and the gap length D.

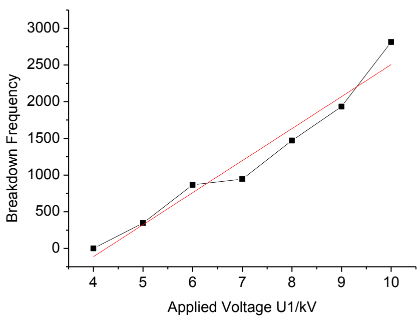
The Preliminary test result of this relationship is shown in figure 4



D=1mm



D=2mm



D=3mm

Figure 4 Breakdown frequency changed with applied voltage

From the above result we have two conclusions:

1) There is a linear relationship between the applied voltage and the breakdown frequency
2) Under different gap length, such rules have similar appearance, but have different parameters.

With the test result we have connected the relationship between the applied voltage and the breakdown frequency, which means under fixed gap length condition, we can obtain the applied voltage on the insulator by knowing the breakdown frequency of the needle electrodes. Based on the above analysis, we have obtained a new method to measure the voltage distribution along the insulator.

4 RELATIONSHIPS BETWEEN APPLIED VOLTAGE AND DISCHARGE INTENSITY

The discharge gap in sphere electrodes can be treated as uniform electric field so the discharge voltage has a linear relation with the gap length. Whereas in needle electrodes condition, where generates extreme non-uniform electric field, the relation between discharge voltage and gap length appeared randomness. To obtain a quantitative analysis method, the following measures has been taken.

(1) Install the pin electrode gap at a fixed position. Finish the optical focusing procedure.
(2) Extract the voltage of specific section of composite insulator by using copper wire and connect the wire to the pin electrodes.
(3) Apply high voltage on the composite insulator, increase the voltage gradually.
(4) Photograph the pin electrode gap with high precision camera when the voltage is at a set value.
(5) Finish photographing at every measuring point then removes the applied voltage.
(6) Process the obtained photos and calculate the evaluation index of the discharge intensity.

With the using of long exposure photography, the discharge intensity can be measured by the overlapped discharge image among certain period of time. The voltage applied on the pin electrodes can also be measured through this method.

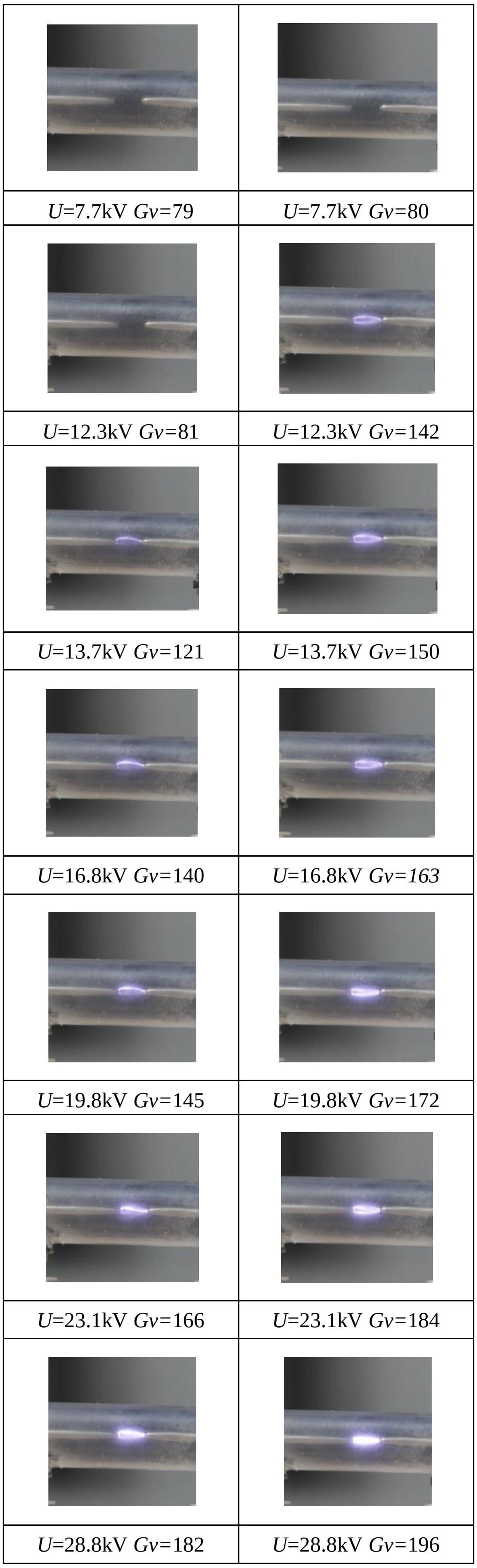


Figure 5 discharge intensity of the needle electrodes under different voltage

The procedure of getting discharge intensity evaluation index *Gv* is shown below: Firstly pixelate the obtained image. Secondly, acquire the grey value of each pixel, 0 for absolute black and 255 for absolute white. Lastly, calculate the average grey value of the whole image. When the image is absolutely black, which means no discharge occurred, the grey value is zero .if discharge happened in the gap, there will be light spot on the image and the *Gv* will increase. With the increasing of the applied voltage, the discharge in the gap will be stronger and the discharge area will be larger, then *Gv* will increase accordingly. The max *Gv* value can reach 255 if the discharge is strong enough. Take into consideration that the test environment is not absolute dark; the acquired *Gv* has a starter value. Test results indicate that the start *Gv* is generally below 80. With the obtained *Gv* result, we can reverse deduct the applied voltage on the composite insulator.

5 CONCLUSIONS

A new method of measuring the distribution of composite insulators has been proposed. Two criterions have been founded: discharge frequency and discharge intensity.

1) The breakdown frequency of the needle electrodes proved to be in linear relationship with the under given voltage.
2) The breakdown intensity obtained by discharge image is also a way to reflect the sustained voltage of composite insulator.

REFRENCE

[1]Pattanadech, N.; Pratomosiwi, F.; Muhr, M.; Baur, M., Condition Monitoring and Diagnosis (CMD), 2012 International Conference on, vol., no., pp.597,600, 23-27 Sept. 2012

[2]Gerling, T., et al.Journal of Physics D: Applied Physics46.14 (2013): 145205.