Study on Surface Charge Distribution Characteristics of Dielectric under Negative Corona in Sphere-plane Gaps

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This paper investigates the surface charge distribution characteristics of dielectric under negative corona in the sphere-plane gap by experiment. The experimental platform based on vibration electrostatic probe is set up for measuring the surface potential of dielectric under DC corona. Through this experimental platform, three round slices with different materials and two umbrella-type discs with different surface curvature are selected to measure the surface potential under negative corona in the sphere-gap. Then the surface potential is converted to the density of surface charges using a kind of inversion algorithm. The surface charge distribution characteristics of dielectric under the negative sphere-plane corona discharge are obtained preliminary, which provides references for the study on charge distribution characteristics of high voltage DC equipment insulation surface under the corona. Furthe rmore, it can be extended to surface composited electric field numerical calculation and optimization of insulation design of high voltage DC electrical equipment, which has a certain application value for projects.

***Index Terms*—Negative corona, surface charge, distribution characteristics, vibration electrostatic probe**

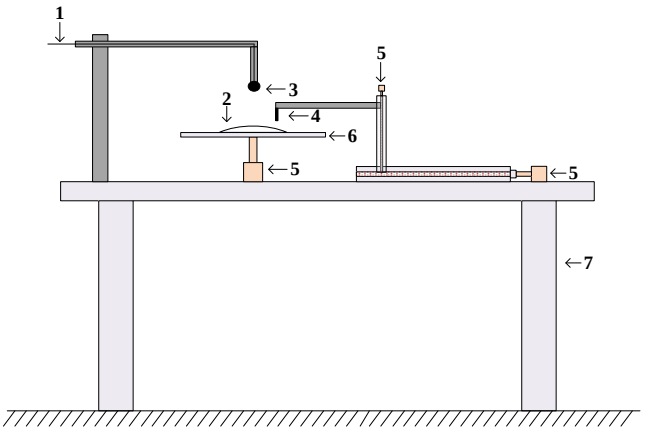
I. INTRODUCTION

CORONA discharge is the key issue in the design and operation process of High Voltage DC Transportation and Transfer Facilities [1]-[2]. Space charge resulted from DC corona would accumulate on the insulation surface of electrical equipment under the action of DC steady electric field. Miller's research shows that surface charge accumulation and surface electric field distortion caused by surface charge is an important reason of surface flashover [3]. Therefore, it is necessary to study the surface charge accumulation and distribution characteristics of dielectric under DC corona.

At present, the number of researches on the surface charge accumulation and distribution characteristics of insulation materials is small, and these researches mainly focus on the surface of dielectric in GIS. So an experimental platform based on vibration electrostatic probe is established to measure the surface potential of dielectric in this paper. Then the surface potential is converted to the density of the surface charge through an inversion algorithm [4]-[5]. The surface charge distribution characteristics of dielectric under the negative sphere-plane corona discharge are obtained preliminary, which provides references for the study on charge distribution characteristics of high voltage DC equipment insulation surface under the corona.

II. MEASUREMENT OF SURFACE POTENTIAL

The schematic diagram of experimental platform is show in Fig. 1. The experimental platformal includes two parts: generating system of DC corona and measurement system of surface potential. Generating system of DC corona is made of sphere-plane gap, dielectric and DC high voltage generator, which can generate stable DC corona and make the corona charge accumulate on the dieletric. Measurement system of surface potential mainly includes electrostatic probe called vibrating Kelvin probe, motion control system of the tested dieletric and electrostatic probe, electrostatic voltmeter, data acquisition card and PC.



1. high-voltage power line 2. tested sample 3. sphere electrode
4. electrostatic probe 5. motion control system 6. round plate electrode
7. insulation experiment table

Fig.1. Schematic diagram of experimental platform

In the experiment, three round slices with different materials and two umbrella-type discs with different surface curvature are selected to measure the surface potential. Round slices are made from epoxy resin, inorganic toughened glass and silicone rubber, whose diameter is 20cm and thickness is 3mm. Umbrella-type discs are made from resin by 3D printing. Their diameter is 20cm and thicknesses are 10mm and 20mm. The same diameter and different thicknesses make the umbrella –type discs' surface curvature different.

The whole measuring process is roughly as follows: Firstly, the sphere electrode is applied a high DC voltage which is more than the corona onset voltage of the sphere-plane air gap. After some time of the corona discharge, the applied voltage is stopped and the sphere electrode is taken away. Then the motion control system is turn on to make the electrostatic probe measure the surface potential from the edge to the center of the dielectric. At the same time, the potential signals that obtained by electrostatic probe are processed by electrostatic voltmeter and are delivered to the data acquisition card and PC to be saved. Finally, the surface potential measured by

experiment is converted to the density of surface charges using a kind of inversion algorithm.

III. Analysis of Experimental and Calculated Results

Due to the limit of the length of the article, only the results of three round slices are listed here.

The surface potential of three round slices obtained by experiment is shown in Fig. 2.

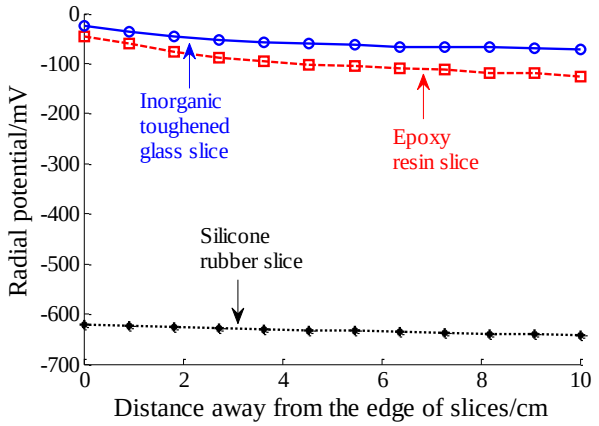
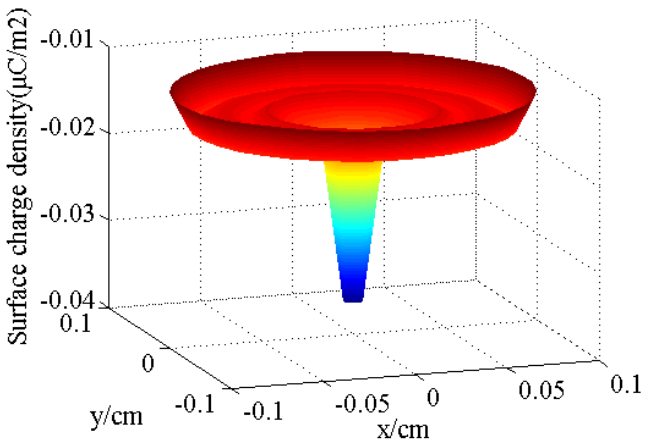
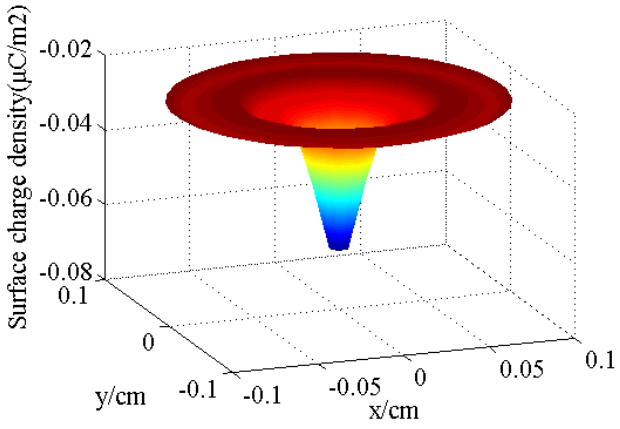


Fig.2. The radial potential distribution of three slices with different materials

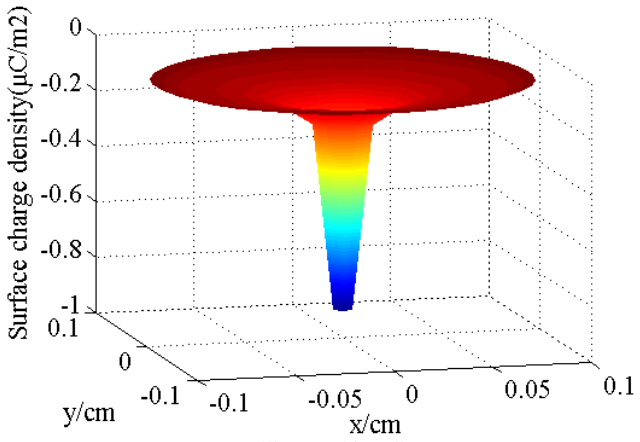
The distribution of surface charge calculated by inversion algorithm is shown in Fig. 3.



(a) Inorganic toughened glass slice



(b) Epoxy resin slice



(c) Silicone rubber slice

Fig.3. Surface charge density distribution of three slices with different materials

IV. Conclusion

In this paper, the surface charge distribution characteristics of the dielectric under negative corona in the sphere-plane gap are studied. An experimental platform based on vibration electrostatic probe is established to measure the surface potential of the dielectric. Then the surface potential is converted to the density of surface charges by charge inversion algorithm. Three round slices with different materials and two umbrella-type discs with different surface curvature are selected to be as tested samples. From the results obtained by experiment and calculation, three conclusions can be infered.

a) The distribution trend of the surface charge and the surface potential of the dielectric under negative corona in the sphere-plane gap is consistent. And the trend is that both surface charge and surface potential are decreasing from the center to the edge of the dielectric. It proves that there is a positive correlation between the surface charge and surface potential.

b) The surface charge density accumulated on three different insulation materials is different in the same condition. The surface charge density on the silicone rubber is biggest and that of the inorganic toughened glass is smallest.

c) In the same condition, the surface charge density accumulated on the dielectric with bigger surface curvature is bigger.

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