THE EFFECT OF AN ELECTROELECTRET STATE ON SURFACE DISCHARGE OF SOLID DIELECTRICS

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In this work studied the effect of an electroelectret state on surface discharge of solid dielectrics in a non-uniform electric field with predominant components tangential to the dielectric's surface. The amount and nature of the charge distribution accumulated in the layers and on the surface of the dielectric depend on the type of applied voltage. The article examines the formation of charges in a dielectric when an alternating (sinusoidal) voltage is applied to it. The analysis showed that the reason for the decrease in discharge voltage on the surface of polymer dielectrics used in insulating structures is the formation of a surface and space between charges in them, i.e. the presence of an electret state. In the literature, these charges are also called hereto- and homo-charges, respectively. We should note that in series production of gas-filled, sealed switchgears the use of polymer dielectric materials possessing an electroelectret state, epoxy resins in particular, needs to be reexamined.

Keywords: gas-filled, electric charges, dielectrics materials, electrographic method ,electroelectret, discharge, if insulation structures.

INTRODUCTION

In recent years, there have been more and more reports in the scientific literature about the occurrence of so-called "electrodeless surface discharge" (ESD) on the surface of the insulated part of gas-filled, sealed, high-voltage switchgears with strengths of the electric field significantly less than the critical strength [1-4]. In [1], a hypothesis was expressed about an effect of free charges accumulated on the surface of a dielectric in the zone near the electrode on the initial voltage of an electrodeless surface discharge. The authors of [2-4], who studied the characteristics of these charges in greater detail by the electrographic method, explain this phenomenon by the fact that the field due to charges accumulated in the zone near the electrode, being superimposed on the sinusoidally varying field of the electrodes, distorts it, thereby reducing the flashover voltage.

In electric-insulation designs of open switchgears, porcelain and glass are used as solid insulation. In the scientific literature there is no information in relation to the appearance of anomalous discharges of the electrodeless surface discharge type in insulation structures of these materials.

In gas-filled, sealed switchgears insulation designs are still being perfected. Individual assemblies of these designs are made in pilot conditions from epoxy resins with various fillers [5].

Epoxy composite materials, as polymer dielectrics, are strong electrets [6,]. The electret state (accumulation and prolonged preservation of electric charges) in polymers is explained by various factors. Electrets obtained under the action of a high-strength electric field without heat treatment are called electroelectrets. Formation of flashovers on the surface of high-voltage bushings of gas-filled, sealed switchgears with field strengths below critical should be explained by the presence of an electroelectret state of dielectric materials used in these structures, epoxy in particular.

We studied the effect of an electroelectret state on surface discharge of solid dielectrics in a non-uniform electric field with predominant components tangential to the dielectric's surface.

Cylindrical specimens 8 mm in diameter and 2-12 mm long were placed between electrodes of stainless steel with the same diameters equal to the diameter of the specimens used. Specimens of fluoroplastic-4, ebonite, epoxy compounds in various modifications, insulation porcelain, and glass were tested.

It is known that if certain conditions are met (the absence of a gap between a solid dielectric and electrodes of moisture and irregularities on the surface of the dielectric, and other factors) the presence of a solid dielectric between electrodes has practically no effect on the discharge voltage in comparison with its absence. This is confirmed by our experiments and the works of other authors [5].

As experiments have shown, if insulation structures are under voltage for a long time, in the case of polymer dielectrics, other factors being equal, the discharge voltage is less than when non-polymer materials serve as the dielectric, for example, porcelain and glass.

The amount and nature of distribution of charges accumulated in the volume and on the surface of a dielectric depend on the kind of voltage applied. Formation of charges in dielectric when ac (sinusoidal) voltage is applied to it was investigated in. With ac voltage, charges accumulate over a long time. To accelerate accumulation of charges in a dielectric, we conducted experiments with application of dc voltage to the dielectric.

After careful surface preparation, cylindrical specimens of the materials under investigation were mounted between electrodes and subjected to the action of dc voltage with $U = (0.6 - 0.7)U_{dis}$ for one hour. Then the dc voltage was turned off, and ac voltage was fed to the system, with a smooth rise in it from zero until formation of a flashover. For specimens of

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different types of polymers, the discharge voltage averaged 20% lower than the discharge voltage of specimens that had not been subjected to the preliminary action of dc voltage (see Fig. 1). It was established that the preliminary action of high dc voltage does not affect the surface discharge (flashover) voltage for specimens of porcelain or glass.

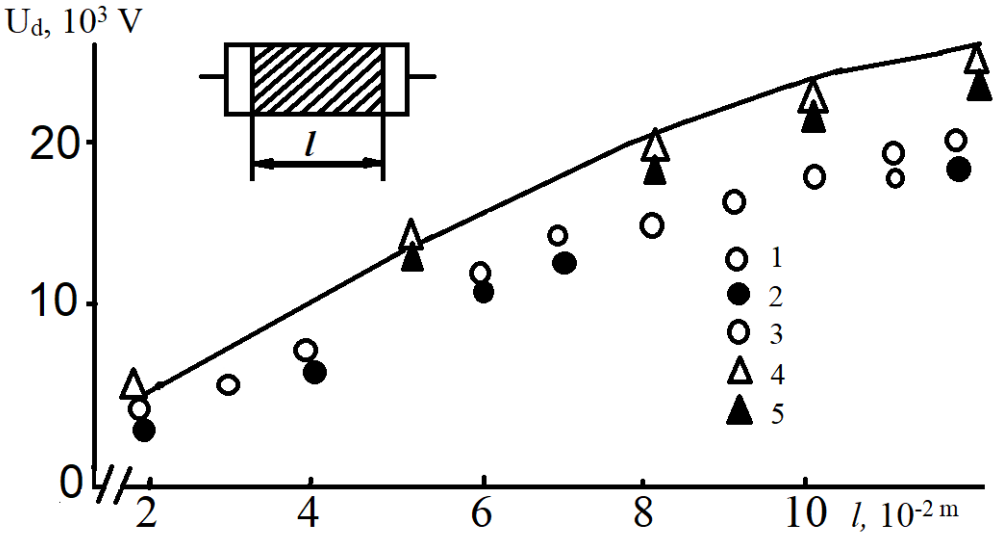

Fig. 1. Dependence of discharge voltage in air with ac voltage (50 Hz) along the surface of solid dielectrics on the inter-electrode distance after preliminary action of dc voltage. 1) fluoroplastic – 4; 2) epoxy (ED-5); 3) ebonite; 4) porcelain; 5) glass. The solid line shows the dependence without preliminary action of dc voltage.

In the case of dielectrics, above all else, the breakdown voltage is lower than when non-polymeric materials, such as porcelain and glass, serve as dielectrics if the enabling structures are under long-energy pressure [6].

Accumulated in the volume and on the surface of the dielectric, the quantity and nature of the charge distribution depend on the type of applied voltage. The article investigated the formation of charges in a dielectric when an alternating (sinusoidal) voltage is applied to it.

Analysis showed that the reason for the decrease in discharge voltage on the surface of polymer dielectrics used in insulation structures is formation of surface and space between charges in them, i.e. the presence of an electret state. In the literature, these charges also called hereto- and homo-charges, respectively.

Visual observation and photography established that in the case of polymer dielectrics the discharge channel is repelled by the field of accumulated charges away from the surface of the specimens into the space between the electrodes, which once again confirms the presence of space and surface charges in the dielectric.

With preliminary application of dc voltage to an insulation structure, the subsequent action of ac voltage does not lead to electrodeless discharge. The electrodeless surface discharge observed in practice should be explained by the fact that space and surface charges accumulated over a long time under the action of ac voltage in polymer dielectrics are distributed sharply unevenly: the charges are concentrated mostly in the zones near the electrodes [7]. The thickness of the layer occupied by space charges reaches ~30% of the total thickness of an electret between electrodes. For this reason, the discharge occurs not between electrodes, but between sections somewhat removed from the electrodes. In this case, the conditions for detachment of the discharge channel are complicated, due to the low concentration of charges in the section under the discharge channel and consequently the limited nature of Coulomb action.

CONCLUSION

Thus, the article investigated the influence of the electroelectret state on the surface discharge of solid dielectrics in a non-uniform electric field with predominant components tangential to the surface of the dielectric.

We should note that in series production of gas-filled, sealed switchgears the use of polymer dielectric materials possessing an electroelectret state, epoxy resins in particular, needs to be reexamined.

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