ELECTRIC FIELD AND POTENTIAL DISTRIBUTIONS ALONG A CHANNEL FILLED WITH AN ELECTROLYTE MODELLING POLLUTED HIGH VOLTAGE INSULATOR

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ABSTRACT

The electric field and potential distributions in the vicinity of polluted insulators using laboratory model in order to determine their behavior to the flashover phenomenon are presented in this paper.

A two and three-dimensional electric field analysis programs have been used for the calculations.

Considering the real geometry of the laboratory model numerical method are preferred for solving electric field and potential distributions to find a physical explanation to the extension of the leader of the discharge along channel filled with electrolyte that materialized the layer of pollution. Moreover the results of EFPD have been discussed.

I. INTRODUCTION

It is very important to control the elcetric field strenght arround high voltage insulators because it may cause corona arround insulators , which may result in degradation of the housing materials.

Serval studies related to the electric field and potential distributions arround high voltage and power lines insulators have been published [1,3] in which the models developed for calculations are based on photographs of insulators undergoing aging tests in a fog chamber.

Because the high voltage insulators have a complex geometry ,numerical method are preferred for solving EFPD. Numerical methods can be divided into two groups. The first group is to discretize the under lying integral equations. These are charge simulation method and the boundary element method which are preferred for open boundary problems . The second group is to solve the gouverning differential equations. These are the finite element method and the finite difference method which are commonly used in field analysis of problems with limited boundary conditions.

For this present work , the commercially available programs adapted to our data QUICKFIELD, software based on finite elements method and COULOMB , based on the boundary method suitable for two and three dimensional geometries and polluted layers have been employed.

Considering the real geometry of the laboratory model the finite element method and the boundary element method are used in this studies for solving the electric field and potential distributions.

Our objective is to present the potential distributions and to determine the domain at strong electric fields favorable to the ignition of the discharges or to the propagation of the streamers. In link with the different phenomena susceptible to develop during the discharge extension and flashovers can occur.

II. LABORATORY MODEL TO BE MODELED

In our case, to simulate the flashover phenomenon, we took for model the experimental device of the figure 1.



Figure 1. Laboratory model

The high voltage electrode represents the voltage of the line (Va), the plug potential represents the potential in the pollution (Vp), the height of this electrode above the layer of the electrolyte represents the dry zone (3 mm). The layer of electrolyte represents the pollution on the insulator surface, the plate of Plexiglas of L length, of width 4 cm and of depth 3 mm represents the insulator the grounded electrode represents the pylon of the line high tension [4].

The materials that we used in our model are: The salty water that materializes the layer of pollution and the Plexiglas.

In this work, to represent the geometry of the experimental model, we chose the axi - symmetrical representation where the axis of symmetry is simulair to the axis of the high voltage electrode. This arrangements assimilates the high voltage electrode to a cylinder finished by a half sphere and the column of the discharge to a cylinder [5]. The grounded electrode having in this arrangements the form of a ring, it is very far from the reality, but it is necessary to take account because more it moves away of the leader of the discharge, less the results of the simulation in this model correspond to the physical reality. This simulation permitted us to estimate the amplitude of the electric field and potential distributions around the leader of the discharge that facilitates the formulation of the hypothesis on the nature of the phenomena occurring when this discharge extended.



III. MODELLING RESULTS USING QUICKFIELD SOFTWARE

Figure 2. Potential distributions between the high voltage electrode and the electrolyte surface

The figure 2 represents the results of the calculation of the potential distributions for this configuration when the applied voltage is of 13.2kV and a resistance of pollution per unit length $rp=5k \Omega$ /cm

The constriction of the equal-potentials between the high voltage electrode and the polluted surface are h, because the electrolyte in absence of current that browses it prolongs the grounded electrode. Thanks to the potential distribution , we can predict the domain of the dischage ingnition for all points situated at the aplomb of the electrodebetween the axis of the high voltage electrode and the electrolyte surface.

The figure 3 represents the potential distributions on the surface of the electrolyte channel.



Figure 3. potential distributions on the surface of the electrolyte channel between the leader of the discharge and the grounded electrode.

We raised the values of potential on the line that joins the leader of the discharge to the grounded electrode on the surface of the channel for a axisymetrical geometry of our device when HV applied voltage is 13.2kV. The results of the computation of the potential on the surface of the channel represented on the figure 4 show that the potential reduces progressively close to the discharge and this reduction becomes linear. The potential decreases quickly to the neighborhood of the leader of the discharge, because the constriction of the current lines increases the electric field in this region. From about ten millimeter of the column of the discharge the distribution of the potential becomes quasi - linear because the lines of current become parallel with the sides of the channel.

We have compared on the figure 4 the applied values of the potential on the line that joins the leader of the discharge to the grounded electrode on the surface of the channel according to x with the results calculated in axisymetric geometry .We note a good agreement with experimental values.



Figure 4. Computed and measured values of the potential distributions on the electrolyte surface channel

IV. MODELLING RESULTS USING COULOMB SOFTWARE

We have also employed three-dimensional COULOMB software analysis program for the computation of the electric field and potential distributions.

In this case, we have represented on the figure 6 and 7 the results of this distributions, we have gotten the same evolutions of EFPD neighborhood of the leader of the discharge and along the channel found with QUICKFIELD software in the first modelling.



Figure 5. Three-dimensional geometry of the experimental model.



Figure 6. Potential distributions along the channel.



Figure 7. The evolution of the electric field

The important part of the voltage is situated to the neighborhood of the leader of the discharge because this region is characterized by space charge.

Our results show that the domain in which the value of the electric field comparable to the value found by Rizk [6] that corresponds to the re-ignition field of positive streamers. The electric field profile from the hint of the HV electrode to the the salty water (Z -vertical direction) was presented on the figure 8.



Distance from the hint of the HV electrode to the electrolytic surface [mm]

Figure 8.Electric field profile from the hint of the HV electrode to the the salty water (Z- vertical direction)

The potential values for different length of the leakage line on the channel computed using 2D solving EFPD are tabulated against the 3D solving EFPD obtained results in table 1. The results given in table 1 shows that the mean absolute errors (MAE) of this modeling is found to be < 5%.

Table1: Comparison of modeled potential distributions along the channel

Length of the leakage line (cm)	2D modeled Potential values (V)	3D modeled Potential values (V)
1	11407	11579
2	9806	9900
3	8511	8612
4	7276	7372
5	6058	6136
6	4845	5000
7	3633	3640
8	2422	2503

CONCLUSION

The electric field strenght and potential distributions along channel filled with salty water modelling HV insulator have been studies using QUICK FIELD 2D and COULOMB 3D softwares .

The results show that the solving method 2D and 3D with open boundary or limited boundary conditions give the same observations of the EFPD neighborhood of the leader of the discharge and along the surface of the electrolyte channel between the leader of the discharge and the grounded electrode.

The electrical field values computed in a backing region of the discharge are compatible with the development of streamers.

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