STUDY OF THE POLLUTION RESISTANCE IN FRONT OF THE FLASHOVER DISCHARGE ON A DISK MODEL

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ABSTRACT

In this paper the pollution resistance before the foot of the discharge, and the geometrical form of the leakage current lines, during the evolution of the discharge until flashover, is very important for the modelling of this phenomenon on a real insulator, and for the determination of its critical conditions. To study this problems, we have achieves a new model of laboratory. This model looks like a real insulator of electric lines in his shape and also in his pollution. The suggested model is valid to act well as go-between the real insulator and simple laboratory models which have carefully studied. In this paper we present our model with its characteristics and the experimental results of its use for measuring the critical voltage and the pollution resistances between the ground electrode and a static discharge for many discharge positions.

Keywords: *discharge, flashover, high voltage, insulator, pollution.*

1. INTRODUCTION

In the literature of flashover, several models of a simple geometry were studied to determine the criterion, the critical conditions as well as the physical mechanism of this phenomenon. The assumptions which were extracted from the results obtained by using these models cannot be applied to the real insulators. The principal cause of this failure is due to the qualitative geometrical difference between these models and the real insulators.

After the explanation of the geometrical problem of the simple models we present, in this article, the study which led us to propose a new model of laboratory which represents better the geometry of the real insulator and the distribution of the various electric quantities having a role in the phenomenon of flashover.

The deposit of a solid layer of pollution on the upper and lower surface of the insulator, follow-up of a humidification of this deposit, generates an electrolytic layer of a complex geometrical form, which takes the shape of the insulator and occupies the entire surface between the cap and the pin.

The voltage applied between the two electrodes (the cap and the pin) causes the circulation of a current in the electrolytic layer. The Joule effect due to the passage of this current generates a partial draining of the pollution layer on the surface of the insulator from where the appearance of a dry band having the form of a loop which surrounds the cap and or the pin

Because of the very high resistance of the dry band compared to that of the wet part, the voltage difference between the cap and the pin is in its majority deferred between the end interior and external of the band, thus generating a discharge between these ends. If the critical conditions of the discharge elongation are realized, the discharge propagates on the surface of pollution to the total short circuit between the cap and the pin.

To be able to study the phenomenon of the elongation of the discharge as well as the influence of the various sizes on it; and considering the complexity of the form of pollution and that of the space distribution of the electric quantities; the researchers considered that the phenomenon which is a discharge in series with the pollution of the insulator is equivalent to a discharge in series with a resistance (figure 1).

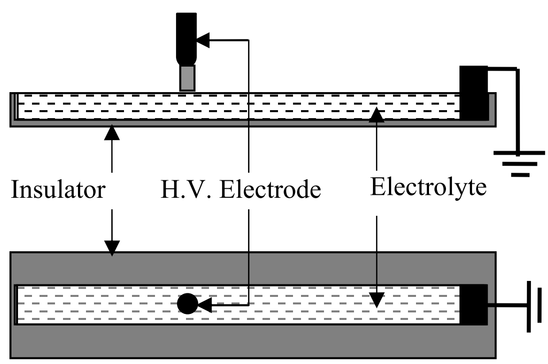

Fig. 1 One directional model of flashover

While being based on this idea, they proposed several experimental models having a simple geometry which present a discharge in series with the resistance of an electrolyte having a rectangular form [1-5] or the shape of a water jet or a narrow cylinder

From the experimental results obtained on these simple models and or those of the theoretical studies carried out on their equivalent electrical circuits, the researchers proposed several criteria of flashover and thus several methods for the determination of its critical conditions. Unfortunately the application of these criteria or these methods on more complex models or real insulators did not give good results.

To determine the reasons for which models suggested did not give good results, and in order to seek more general method for the determination of the critical conditions of flashover, we resumed the study of the phenomenon on another models.

Actually, the studies which were made led to a general result giving the critical conditions of flashover according to resistance per unit of length of the electrolyte, and more precisely: for each value of resistance per unit of length of the electrolyte exists a value of the leakage current from which flashover is established [6-10].

The significant role of the current in the determination of the critical conditions of flashover pushed us to seek if this result is due to the flow of the current in the discharge or in the electrolyte?

To answer this question, we proposed a study based on the use of a bidirectional flashover model [8-10] (figure 2).

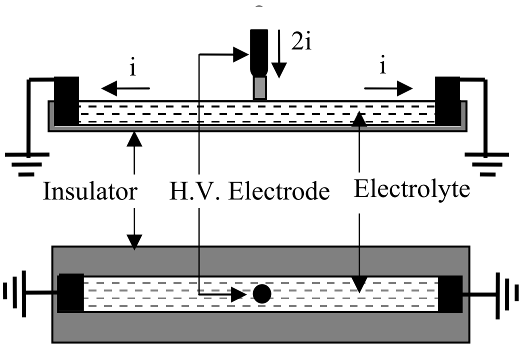

Fig. 2 Two directional model of flashover

The current in the discharge, in this model, is divided into two currents of opposed directions, each one of them crosses a resistance of electrolyte before reaching the ground electrode. If the two resistances are equal, the current in each one will be equal to the half of the discharge current.

We found in experiments that the current in the electrolyte (i) determines the critical conditions of flashover and not the current in the discharge (2i), and that the critical current in the liquid, in the case of bi directional model (i) is the same one as that in the case of the mono directional model. This result shows that:

a - The critical conditions of flashover are determined by the effect of the leakage current during its circulation in the electrolyte and not by that of the discharge current.

b - The total current does not determine the critical conditions of flashover but the current in the direction of the propagation of the discharge which determines them.

The results obtained by these models proved that the critical current in one branch is the same, whether the other branches are connected or not. These results enabled us to say that the distribution or the geometrical shape of lines current is very important in the problem of flashover. This reality is not taken into account in the simple models of laboratory by taking account of these observations we proposed a new laboratory model which represents better, geometrically and electrically than the real insulators

2. EXPERIMENTAL SETUP

This model looks like a real insulator of electric lines in his shape and also in his pollution [10]. It's a circular insulating disk (ϕ=210mm) which carries on his upper surface a metallic cylinder that represents the cap or the pin of the insulator and the high voltage electrode too (figure 3). The low voltage electrode is shown as a second metallic cylinder placed on the lower surface of the disk. We put this disk in a cylindrical insulating container filled with (H_2O+NaCl) so that we can change the liquid thickness on its top, bottom and on the edge of the disk.

From the geometrical resemblance between the disk model and the real insulator results a geometrical resemblance of several electrical quantities:

a- A geometrical resemblance in the distribution of the current in the electrolyte between the foot of the discharge and the electrode on the opposite side which represents the target of the discharge as it is shown on the (figure 1). The one directional model do not take into account the existence of the current lines in all directions around the foot of the discharge.

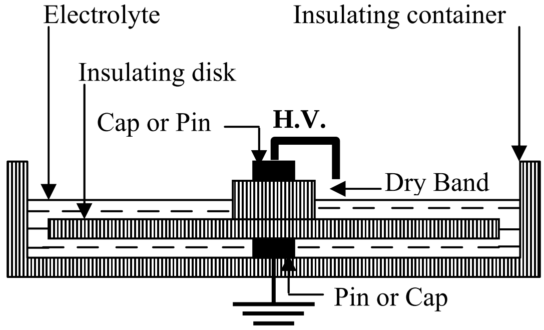

Fig. 3 The disk model of flashover.

The current lines around the foot of the discharge are discontinuous.

b - The resemblance in the distribution of the current lines led to a similarity between the voltage distribution in the electrolyte of our model and that in the pollution of the real insulators, and another similarity between the distribution of the electric field in the air in the neighborhood of the electrolyte surface of our model and that of the neighborhood of the real insulator pollution.

c - A geometrical resemblance in the form and the value of the resistance, between the foot of the discharge and the electrode on the opposed side, during the evolution of the discharge. This resistance is essential for the modeling of flashover in dynamic state, i.e. during the evolution of the discharge

The problem in the determination of this resistance is that the circuit current penetrates the electrolyte by the foot of the discharge, this foot is variable in position and in surface during the evolution of the discharge, and it leaves the electrolyte by the electrode on the opposite side.

The current lines are diverged while entering the electrolyte by the foot from the discharge and is converged to leave the electrolyte by the electrode of opposite side, there for the value of the resistance depends on the geometry of the electrode on the opposed side, of the discharge foot geometry and the way of the current lines between the point of entered and that of the exit of the current. Our model enables us to measure this resistance for several forms and position of the discharge foot on the surface of the electrolyte [11-12].

3. MEASUREMENT OF RESISTANCE

We measured the value of the electrolyte resistance between a given point A of distance x of the dry band external edge and the ground electrode in the bottom of the disk (figure 4) by using an electrolytic resistance measurer which contains two electrodes of measurement: the first has a diameter of ϕ= 3 mm placed at the measurement point A, the second is connected with the ground electrode in the bottom of the disk.

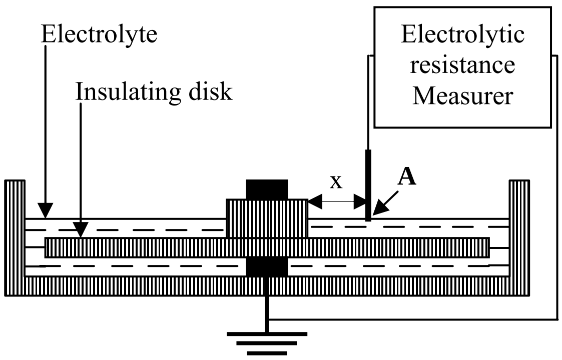

Fig. 4 Experimental setup for measuring the electrolyte resistance by a measurer

Figure 5 presents the influence of the position of the measurement point on the electrolyte resistance value. The distance x varies from 1 to 7 cm, the depth of the electrolyte e = 0.3 cm maintained constant and the resistivities used are 2, 4, 6 and 8 kΩcm. It is noticed that the reduction in the resistance value during the displacement of the measurement point is very slow, we can say, for the four resistivities, that the resistance decreases , when the distance decreases .

Figure 6 shows the depth effect of the electrolyte on the value of the electrolyte resistance. Two depths were used e=0.3 cm and e=0.4 cm for two values of resistivities ρ=2 and ρ=8kΩcm. We notice that the curve for e= 0.4 cm has the same appearance as that for e= 0.3 cm.

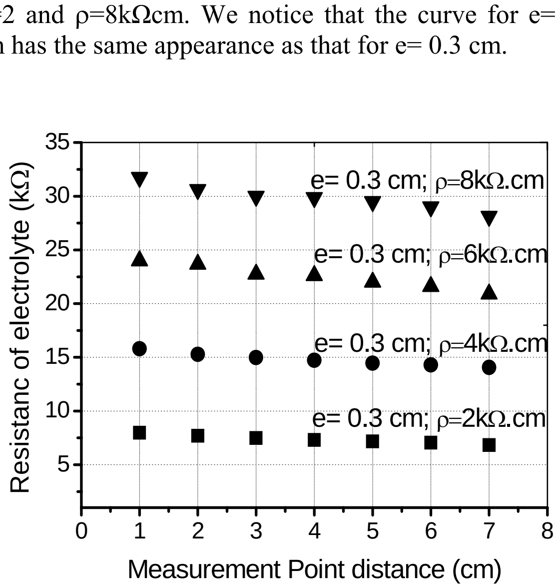

Fig. 5 The electrolytic resistance according to distance

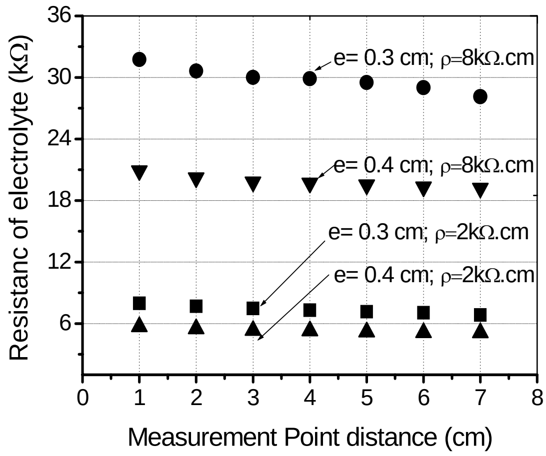

Fig. 6 The influence of the electrolyte depth on its resistance

Figure 7 presents the comparison between the two methods of measurement for a depth of 0.3 cm and two values of resistivity 2 and 8 kΩ.cm. We can notice that the value of the resistance measured with the Up/I ratio is lower than that measured directly with the electrolytic resistance measurer. We can explain this difference by the difference of the diameters between the foot of the discharge and that of the measurer electrode. Indeed, the diameter of the foot of the discharge is larger than that of the measurer electrode because the used currents are relatively large.

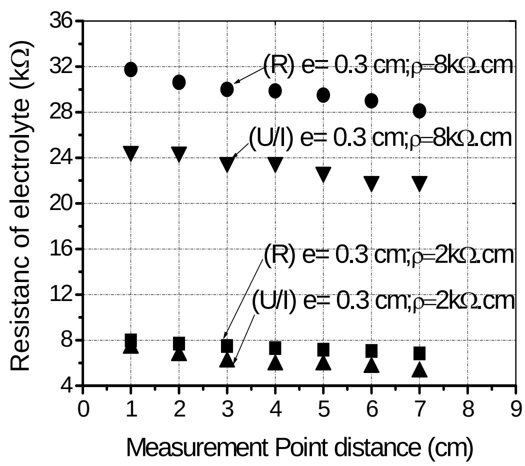

Fig. 7 Comparison between the two methods of measurement of resistance

4. CONCLUSION

Our new laboratory model represents better the geometrical form of the electrical quantities, pollution resistance, and the electric field in the neighborhood of the pollution surface

The functionality of this model was tested by the measurement of the electrolyte resistance according to starting point of the discharge evolution[13-14].The results obtained were meaning and encouraging to continue the research by using this model.

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