Search of the efficiency of the insulating barrier in a system point-barrier insulating-plan

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Abstract - The aim of our work is the study by numerical simulation of the efficiency of the insulating barrier according to its geometrical dimensions and position by considering two cases:
- Without Electrical discharge
- Reproduce the forms of electric discharges, in point insulating barrier- system plan.

1. INTRODUCTION

The mixed insulating structures solid/gas is present in many equipment in high and average voltage. In this study, we are interested more particularly in the efficiency of the solid insulator (represented in experiments by the rapport between the disruptive voltage with barrier and that one without barrier) which depends on the geometry of the barrier (length and thickness) and of its position between electrodes [1].

In general, the maximum of this efficiency is obtained when the barrier is close to the point electrode (10 to 20% of the distance between electrodes) [1-4].

In order to avoid the experimental tests, we try to find a theoretical efficiency relating to the electric field distribution in the system.
In this work, the studies of the dimensions and the position of the barrier on the efficiency are presented, for two cases:

1- Without electrical discharge.
2- With electrical discharge.

With this intention, a model to simulate the evolution of the discharge is developed which things to see a clear influence on the field in the system point-plan with insulating barrier. Indeed, a digital study to determine the values of the electric field as well as the efficiency by using the software FEMM [5] is making.

2. STUDIED MODEL

The system studied (Figure 1) consists of an arrangement of point and plane electrodes distant of **d**, between which an insulating barrier of length **L**, thickness **e** and permittivity **εrsol** is inserted, which is placed at distance **x** of the point. The point electrode of radius **rp**, is connected to the high voltage and the plane electrode of width **Lp**, is put at the ground. The studied system contains air with **(εrair)** permittivity.

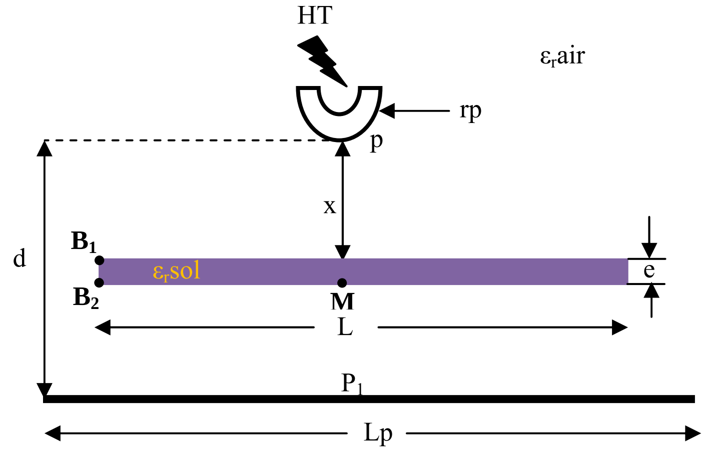

Figure 1: Presentation of the studied system.

In order to examine the possible paths that could borrow the discharge, the followings points are defined:

p: The point electrode.

M: Low medium of the barrier (in front of plane electrode).

B1: The high edge of the barrier with dimensions electrode points.

B2: The low edge of the barrier (in front of plane electrode).

p1: Medium of the plane electrode

The results reported in the literature [1, 2, 3, and 4], all indicated that the electrical discharge cans evaluate:

- Directly from the point towards the plan by perforating the barrier so to pass from the high medium to the low middle of the barrier to lead on the plan
- Or to circumvent the latter while passing by the high edge and the low edge of the barrier to reach the plan.

In order to obtain the efficiency by considering the avereage electric field, we search for the rapport which would take the same form of evolution according to the position of the barrier as that obtained by Boubakeur **[1].**

On the basis of the possible trajectories of the electrical discharge met in the literature [1-4], and in order to find an efficiency theoretical, two theoreticals efficiency are defined:

1- **efficiency 1:** The rapport of avereage electric field **Eb1** between the point **p** and the high edge of the insulating barrier at the **B1** point on average electric field **Esb** enters the point **p** and the plan at the point **p1** without barrier.
2- **efficiency 2:** The rapport of avereage electric field **Eb2** between the point **p** and the low edge of the insulating barrier at the **B2** point on the avereage electric field **Esb** beetween the point **p** and the plan at the point **p1** without barrier.

This efficiency will be examined for two cases:

- Without an electrical discharge
- With an electrical discharge

A second program to evaluate the electrical discharge contribution on the efficiency is made. To reproduce the discharge, a square meshing between the point and the plan whose nodes represent the points probable to be started by the discharge during its evolution (Figure 2) is elaborated.

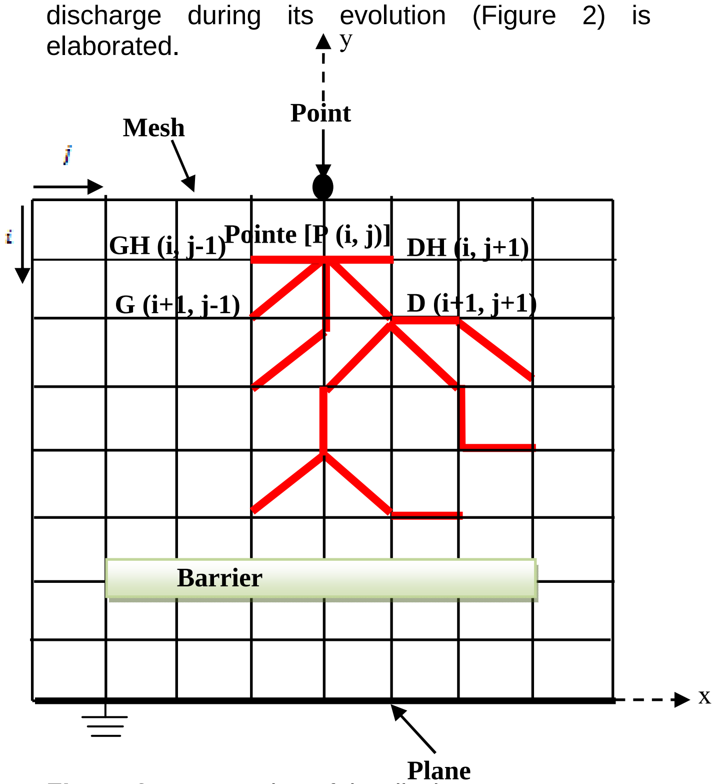

Figure 2: Progression of the discharge.

The discharge boots of the point electrode whose field is sufficient to make it evolve by step to the plane electrode. With each phase, the nodes possible to move present 5 possibilities of progression (Figure 2): D (straight line), C (Centrex) and G (left), DH (right horizontal) and GH (left horizontal).

It is considered that there is discharge if the following criterion is checked out:

$$Ecible>Emax*R \qquad (1)$$

Where:

Ecible indicates the field at the targeted point (D or C or G or DH or GH).

Emax: the maximum field computed with each phase of evolution.

R: Random variable generated by the uniform law (random).

During all the evolution of the discharge, the outfall channel is considered as a pure conductor (no voltage drop inside the outfall channel).

3. RESULTS

The variations, according to the position of the barrier for différents dimensions, of the two definite efficiency (Figure 4 and 5), in absence of discharges, reproduce speeds of curves similar to those met in the literature [2, 4]. They increase to reach a maximum ranging between 5 and 10% then decrease.

Efficiency 1 and 2 reach a higher maximum not exceeding 1,9. This value presents a good approach of the experimental value (~1, 2).

According to these results, the efficiency obtained without electrical discharge for the two points (High and low edges) of the barrier demonstrate well the influence of this last one on the behaviour of the system.

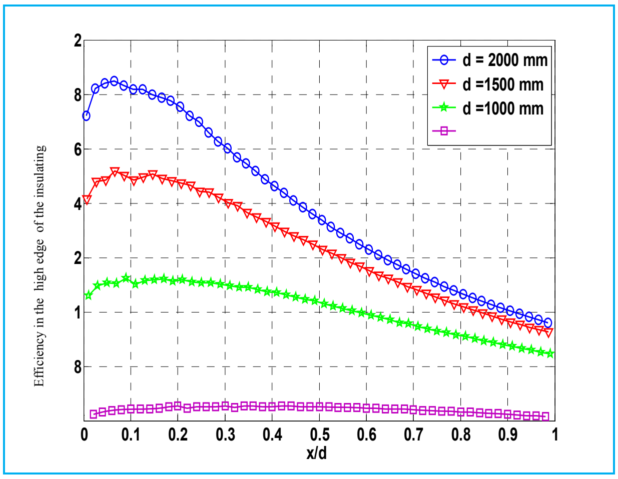

Figure 3: Variation of efficiency 1 according to the position of the barrier without discharge for various distances betwen electrodes.

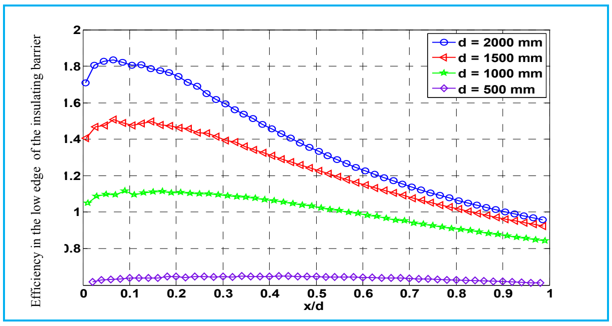

Figure 4: Variation of efficiency 2 according to the position of the barrier without discharge for various distances betwen electrodes.

The difference between this two efficiency and the experimental result would come owing to the fact that the evolution of the electrical discharge was neglected.

On the figures 5, 6 and 7, we present the 3 forms of discharges observed during the execution of the program:

- Discharge perforating the barrier (fig .5)
- Discharge advancing by the middle of the barrier then sliding towards the edge (fig. 6)
- Discharge advancing on the barrier then sliding on the surface and drilling in the same time the barrier (Figure 7)

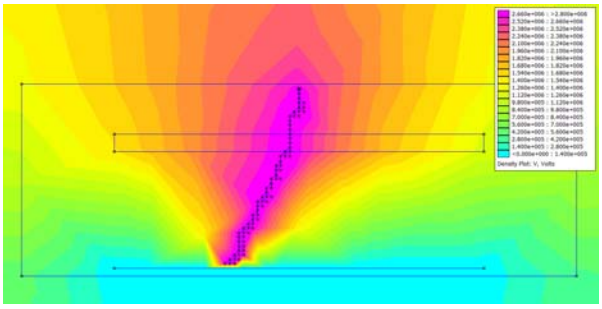

Figure 5: direct discharge perforating the insulating barrier.

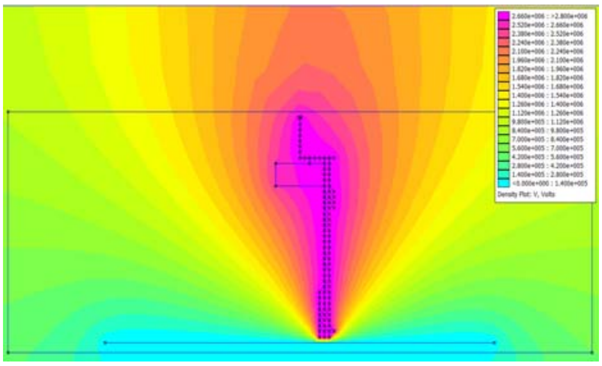

Figure 6: discharge evolving to the barrier then dragging towards the edge.

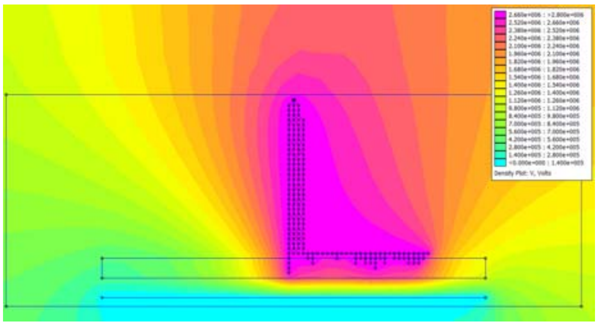

Figure 7: discharge dragging and perforating the barrier.

After integration of the electrical discharge, the obtained results improve the value of the efficiency (1 and 2), and the difference between the experimental and theoretical values strongly decreases (Figure 8 to 10).

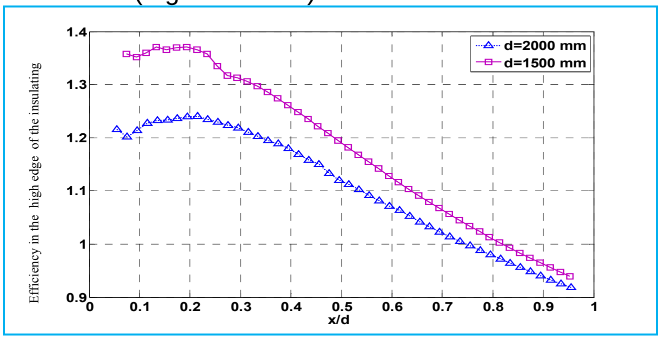

Figure 8: Variation of efficiency 1 according to the position of the barrier in the presence of discharge for various distances betwen electrodes.

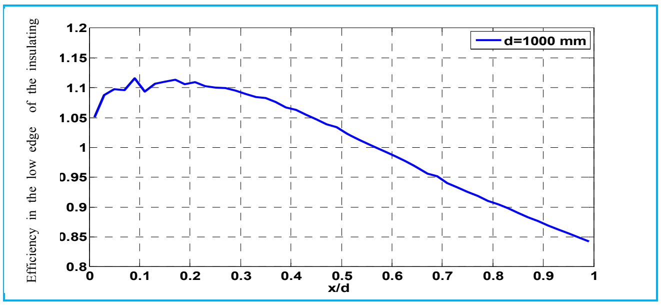

Figure 9: Variation of efficiency 2 according to the position of the barrier in the presence of discharge.

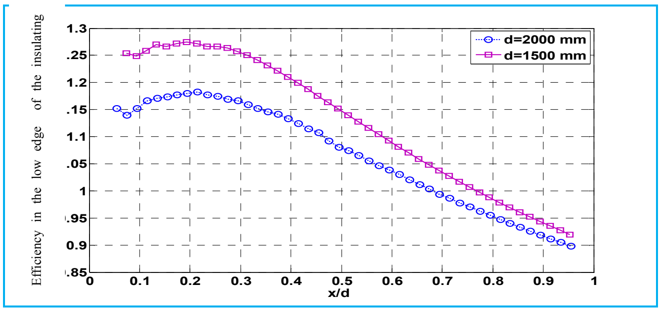

Figure 10: Variation of efficiency 2 according to the position of the barrier in the presence of discharge for various distances betwen electrodes.

4. Conclusion

The efficiency defined by the rapport of the avereage electric field **E** between the point and the low edge of the insulating barrier on the average electric field **Esb** without barrier is a very interesting means to predict the rigidity of the system point-barrier insulating-plan.

The model worked out with efficiency such as definite accurately reproduces the same experimental observations.

1- When one moves the barrier of the point towards the plan, its effectiveness increases to reach a maximum in the neighborhoods from the 20% then decreases [1].
2- The assumption of responsibility of the evolution of the discharge evaluates with precision the maximum efficiency. Nevertheless, to neglect the discharge remains a good estimate.

5. REFERENCE BIBLIOGRAPHY

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