Influence of the electric field to the neighbourhood of the discharge on its propagation to flashover

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ABSTRACT:

In order to investigate the effect of electric field to the neighbourhood of the discharge of the flashover on its propagation, we modified this field by an outside element of the electric circuit (discharge in series with a pollution resistance) without modifying the electric quantities of the circuits. We found that the critical voltage of flashover becomes smaller, that mean, the electric field to the neighbourhood of the discharge is a direct influence factor on the discharge propagation to flashover.

KEYS WORDS:
Discharge, Flashover, electric field.

1 - INTRODUCTION:

In the literature dedicated to the flashover, several authors put criteria in order to determine the critical conditions of flashover, among them HAMPTON and REMILI [1], [2] showed that the critical conditions are reached (or flashover is possible) if the gradient of potential in the pollution layer could always be kept greater than the gradient of potential in the positive column of the discharge. WILKINS, HESKETH and Al [3], [4] affirmed that the discharge propagation is possible if it's followed by an increase in the current (that mean, if the length of the discharge and the current simultaneously increase until flashover). The two criteria depend on internal quantities of the electric circuit, gradients or current.

On the other hand FLAZI [5] found that the electric field in the air to the neighbourhood of the discharge is a direct influence quantity on its propagation. This field is an external quantity of the electric circuit; it is determined by the internal, electrical and geometrical quantities, which has a non-direct influence on the discharge propagation. FLAZI expressed his criterion as follows: the discharge growth to flashover if critical condition of the electric field to the neighbourhood of the discharge is satisfied; this condition is the breakdown condition in the air-gap between discharge and pollution surface.

We can modify the electric field to the neighbourhood of the discharge by an independent outside element of the electric circuit, without modifying the internal quantities, like current and gradients. We can also measure the critical voltage of flashover with and without field modification; that mean in the presence and in the absence of outside element. If the external modification of the field has some influence on the critical voltage value, then we can say effectively that the field is a quantity of direct influence on the discharge propagation.

2 - EXPERIMENTAL SET-UP AND MEASUREMENTS

EXPERIENCE (1): MODEL, IN ABSENCE OF OUTSIDE ELEMENT.

We used a bi-directional or two-channel model [5] described in Fig (1). A channel of 2 cm width was dug in an insulating plate, full of an elecrolytic solution (water + NaCl) representing the pollution layer. Tow electrodes-mass in copper was placed to extremities of the channel. H.T pointed electrode was placed perpendicularly to an h height to the over of the electrolyte and to same distance of extremities.

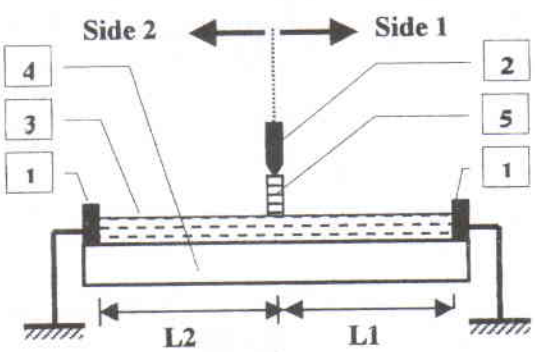

Fig. 1: Model bi-directional or two-channel
Without outside element [5]

1: Electrode of mass.
2: Electrode high voltage.
3: Electrolyte ($H2O$+NaCl).
4: Insulating support.
5: Discharge.
L1, L2: length of the channel

When we applied the high voltage coming of the discharge of 10 capacitor of 1,67 µF each, and if the voltage was sufficient, the flashover took place arbitrarily on the left side or on the right side of the channel.

The critical voltage of flashover was measured and given in Tab (1) for fife values of electrolyte resistance by unit of length r, and for lengths equal L1=L2=10 cm.

r KΩ/cm	3	5	10	15	20
U kV	12	14	17	18.5	18.8

Tab (1): critical tensions according to r
L1 = L2 = 10 cm

If we decreased the length of the channel on one side, the flashover took place on the reduced side.

EXPERIENCE (2): MODEL WITH EARTHED METALLIC SPHERE

On the same set-up of the first experience, we placed an earthed metallic sphere (Fig 2) covered by an insulating thin layer. The sphere was to 10 mm over the electrolyte and 20 mm beside of H.T. electrode. While keeping constant all dimensions of the two sides, the flashover took place on the sphere side only.

The critical voltage of flashover was measured and given in Tab (2) for the same fife values of r, and for lengths equal L1=L2=10 cm.

r KΩ/cm	3	5	10	15	20
U kV	11.2	13	15.7	17	17.1

Tab (2): critical tensions according to r.
L1 = L2 = 10 cm
With earthed metallic sphere

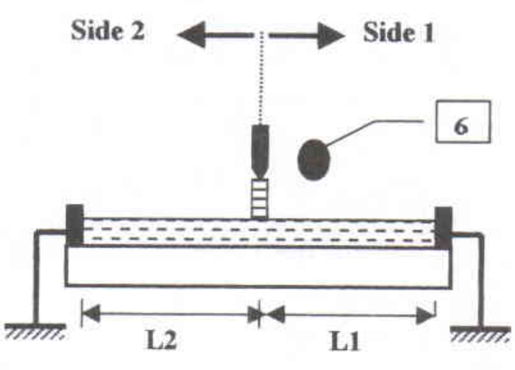

Fig. 2: Model bi-directional or two-channel
With metallic sphere [6]

6: Metallic sphere.

While decreasing the distance of the side (2) of the channel until (L2 = 8,5 cm), the flashover take place always on the side of the sphere, side (1).

EXPERIENCE (3): MODEL WITH FLOATING METALLIC SPHERE

We replaced the earthed sphere by floating one, on 10 mm above the electrolyte and 10 mm beside H.T. electrode

Measures were made as previously, and values were reported on the Tab. (3). The flashover took place always on the sphere side.

r KΩ/cm	3	5	10	15	20
U kV	11.1	12.7	15.7	16.8	16.7

Tab (3): critical tensions according r to
L1 =L2 = 10 cm
With floating metallic sphere

Even while decreasing the length L2 of 20% and keeping the length L1 constant, the flashover took place on the side of the sphere.

3 - INTERPRETATION:

We calculated the electric field strength to the neighbourhood of the discharge in presence and in the absence of outside element. We found that the presence of outside element increases the strength of the field, and for this reason the discharge propagated on side (1). That means the discharge preferred the side of most elevated field.

The reducing of length L2 to 8.5 cm or 20% make the current and the potential gradient in side (2) bigger than in side (1). There for the discharge preferred the side of most elevated field and smallest current and gradient.

We can note that the field in the air to neighbourhood of the discharge is a direct influence quantity on the discharge propagation. We can note also that the internal quantities (electric and geometric) create the electric field. That means, the internal quantities have a non-direct influence on the discharge propagation.

4 - CONCLUSIONS:

The critical voltage of flashover on a rectangular bi-directional channel full of electrolytic solution under d.c voltage (discharge of big capacitors) was measured, in absence and presence of outside element (metallic sphere) which modified the electric field in air to the neighbourhood of the discharge without modifying the internals quantities of the electric circuit.

It has shown that:

a- The presence of an outside sphere decreases the critical flashover voltage.

b- If the tow side of the channel is symmetric, the propagation take place on the side of the sphere, even if the opposite side was until 20% smaller, that mean, with total resistance until 20% smaller, current and gradient until 20% bigger.

We can note that the influence of the internal quantities (like I and E) and the geometrical form on the discharge propagation is not direct, but across the creating of electric field which has a direct influence. The critical condition is finely determined by electric field in air to the neighbourhood of the discharge and electrolyte surface.

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