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IMPULSE BREAKDOWN CHARACTERISTICS IN AIR IN THE PRESENCE OF A LOCAL SPARK

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ضواحي الانهيار النبضي للهواء في وجود شرارة موضعية

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ص . ب ١٥٠٥ وهران الجزائر

في هذا البحث تمت دراسة الإنبعاث الوميضي داخل فجوة تحتوي على معادن على السطح . درس تأثير الشرارة الموضعية على خواص الإنهيار وكذلك نموذج الفجوة ومحاكاه التأثير العزلي للغاز المختبر معملياً نظام الثلاث اقطاب عبارة عن سيقان مخروطية تواجه بعضها البعض . أحد السيقان الأفقيه ثيار والأخير يترك متدفق . شرحت عدة نماذج للشرارة الموضعية التي تؤثر على جهد الانهيار . ووجد أن ميكانيكيه الشرارة الموضعية المؤثرة على هذا الانهيار يكون مرتبط بالمجال الكهربي العالي وطول الشرارة الموضعية والذي يثير شرارة موضعية عبر السطح .

Key words: Breakdown, Dielectric strength, Discharge; Electrical field; Floating electrode; Local spark.

ABSTRACT

In this paper, we study the flashover phenomena in air gaps containing floating metallic objects. The effect of a local spark on the impulse breakdown characteristics of a model gap arrangement which simulating a gas insulated switch (GIS) has been experimentally investigated. The three electrode gap consists of two conical rods facing each other together with a ground plane (or conical rod with the angle of the tip being varied). One of the horizontal rods is energized and one is left floating. Possible mechanisms by which the local spark may influence the main breakdown voltage are discussed. The possible mechanism by which the local spark initiates the main breakdown would seem to be associated with the high electric field around the local spark channel enhanced by unnecessary streamers protruding from its surface.

INTRODUCTION

For the electrical insulation design of H.V. power apparatus, it is important to consider flashover characteristics in both uniform and non uniform field gaps. For example, the gas insulated switch (GIS) or frequency converters are designed to form a quasi uniform field inside the apparatus for the suppression of the corona discharge. In contrast, electric field between the transmission lines and ground is non uniform. Moreover, foreign objects such as animals, rain drops, insects and others which may intrude accidentally into such field are equivalent from a view point of electrical discharge to those of gaps containing floating objects. In order to develop compact power equipments with high reliability, it is necessary to know the flashover properties of simple gap geometries containing floating objects.

Although few papers have treated this problem recently, the results cover a very limited range of parameters involved. Considering this, we tried to treat the problem by making the conditions as simple as possible by stimulating the ignition spark by a local spark from an energized rod to a floating rod.

Gap arrangement and experimental procedure

The flashover characteristics were investigated experimentally. The three electrode gap consists of two horizontal conical rods (of diameter 0.8cm) facing each other together with an earthed plane plate electrode (the plane plate electrode could be replaced by a conical rod of diameter 1.5cm with cone angles 15°, 30°, 45°, 90°, and 120°) parallel to them. The dimensions of the earthed plate plane electrode are (55.5cm x 29cm). One of the two horizontal rods is energized and one is left floating. Various experiments have been performed by varying the rod – rod distance d (0.3cm, 1cm, 2cm and 3cm), and the horizontal rod-plate (or conical rod) at a distance L. We studied the effect of a local spark in configuration of Fig. 1, where one rod is electrically floating and is supported on the wall of the experimental tank by an insulator. The experimental

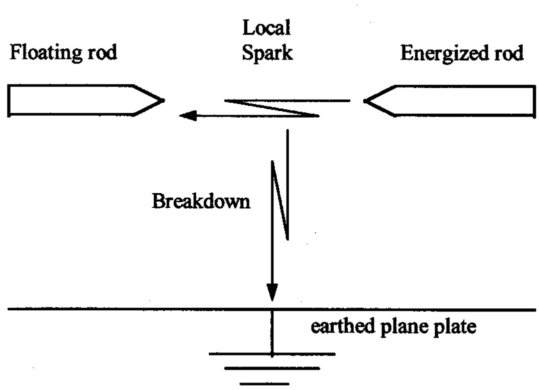

Fig. 1: Experimental cell

procedure as follows: We applied a high voltage pulse (1.2/50 μs up to 200KV) directly to one of the horizontal rods, which produced a local spark between the two rods. This resulted in the impulse voltage being applied to the gap consisting of two horizontal rods and the plane plate (or conical rod) in the presence of a local spark.

All measurements and observations were carried out using 1.2/50 μs impulse voltage in air at atmospheric pressure.

RESULTS AND DISCUSSION

The influence of a rod discharge on the dielectric strength of the gap rod-plate depends principally upon the rod – rod distance d, the geometry of the third electrode and upon the rod-plate distance L. We assume that the effect of the rod discharge in initiating a breakdown depends on the field distribution near the rod gap.

The experimental results Fig. 2, show that with positive polarity of the energized electrode the breakdown voltage is lower than with negative polarity. The breakdown voltage for this configuration is lower than that reported by Wintel [1, 2] for the configuration horizontal wire to plane. Which is similar to one of our geometries without the floating electrode. We have shown that the breakdown voltage is lower when using rod discharge than when the discharge is stimulated by a wire. The local spark from an energized rod to a floating rod lowers the breakdown voltage, then becomes equal to the case of one rod-plane plate gap (Fig. 3). The breakdown voltage V for the configuration rod to plate is for the positive impulse voltage (rod) given (in KV by the following equation [3].

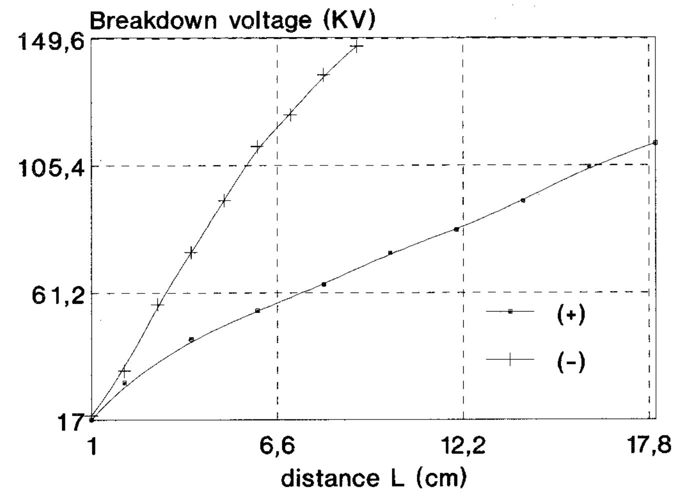

Fig. 2: Breakdown characteristics for positive and negative polarity of energized rod, the plane is the third electrode (d = 0.3cm)

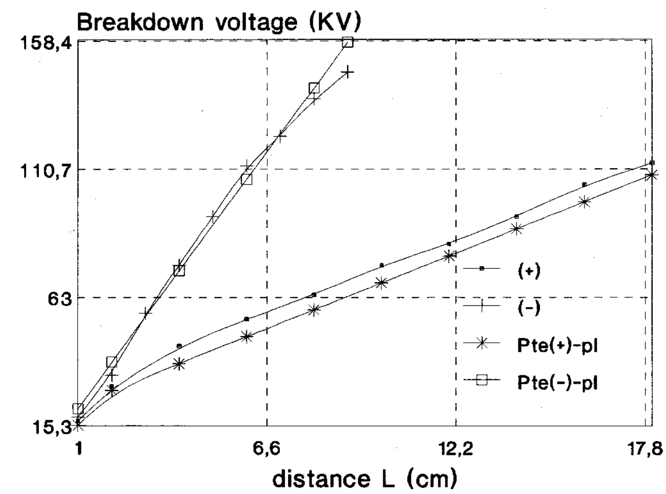

Fig. 3: Breakdown characteristics for positive and negative polarity of energized rod, the plane is the third electrode (d = 0.3cm), and rod to plane gap.

$V = 18.4 + 5.01d$ when $d \geq 1.8$ cm

$V = 0.5 + 15d$ when $0.4 \leq d \leq 1.8$ cm

and for the negative impulse voltage by the following equation, [4]

$V = 21.6d$ when $0.4 \leq d \leq 1.0$ cm

$V = 5 + 17d$ when $d \geq 1.0$ cm

We noticed that the length of a rod discharge or of a local spark influences the breakdown voltage (Fig. 4). We noticed a remarkable influence on the breakdown voltage, when the plate electrode is substituted by a conical rod with variable angle. When the length of the local spark is 0.3cm, we noticed that the breakdown voltage at negative polarity becomes lower than the one at positive polarity, when the angle of the third electrode, which is conical rod, decreases (Fig. 5.1, Fig. 5.2). This influence increases when one increases the horizontal rod – rod distance d, (Fig. 6.1, Fig. 6.2, Fig. 6.3).

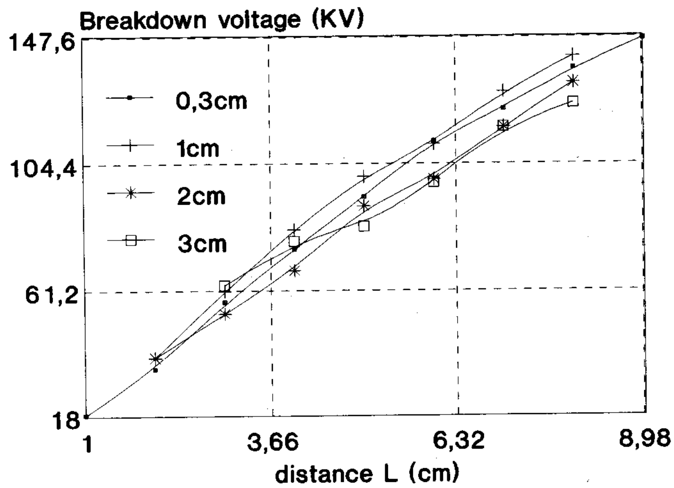

Fig. 4: Breakdown characteristics for negative polarity of energized rod, the plane is the third electrode (d = 0.3cm; 1cm; 2cm and 3cm).

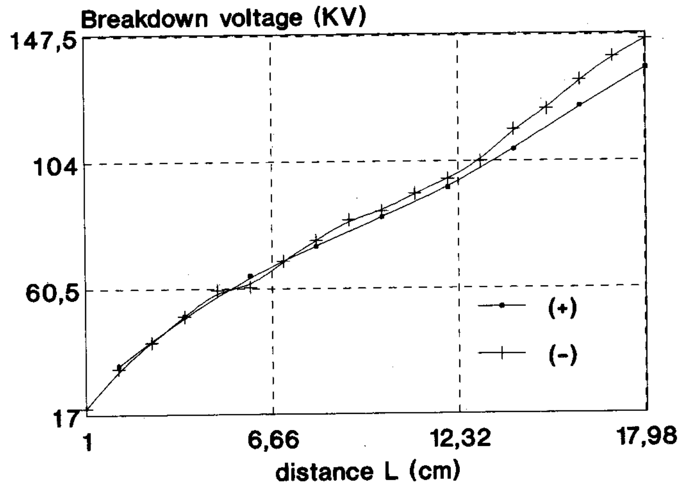

Fig. 5.1: Breakdown characteristics for positive and negative polarity of energized rod, the third electrode is a conical rod with the angle of the tip being 120° (d = 0.3cm).

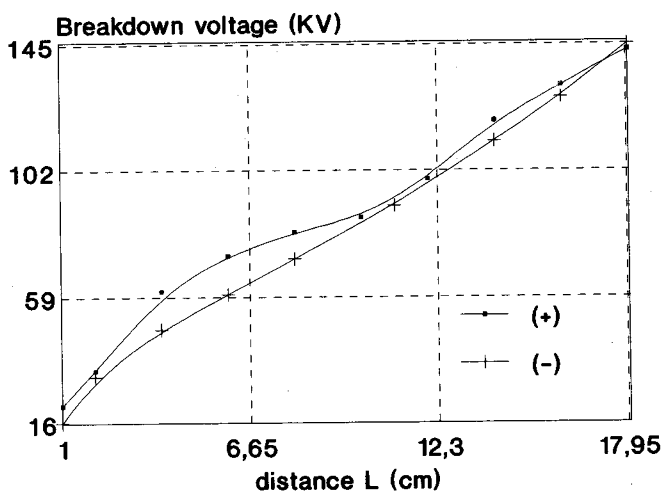

Fig. 5.2: Breakdown characteristics for positive and negative polarity of energized rod, the third electrode is a conical rod with the angle of the tip being 30° (d = 0.3cm).

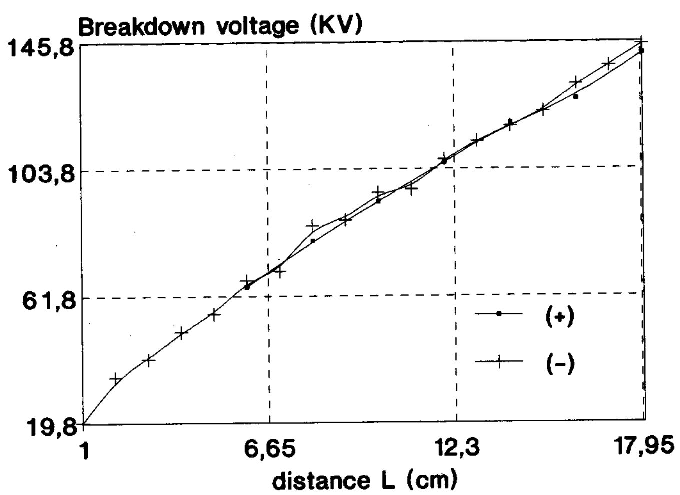

Fig. 6.1: Breakdown characteristics for positive and negative polarity of energized rod, the third electrode is a conical rod with the angle of the tip being 120° (d = 1cm).

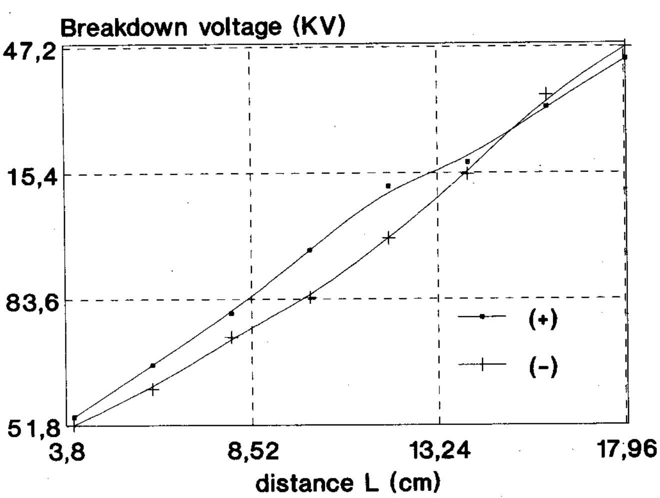

Fig. 6.2: Breakdown characteristics for positive and negative polarity of energized rod, the third electrode is a conical rod with the angle of the tip being 30° (d = 1cm).

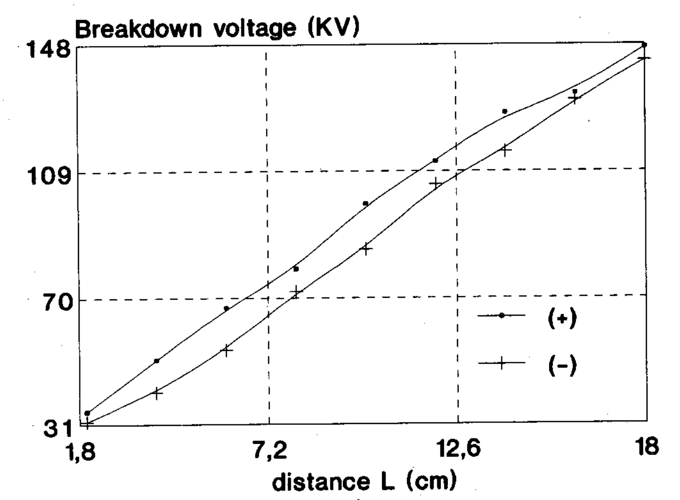

Fig. 6.3: Breakdown characteristics for positive and negative polarity of energized rod, the third electrode is a conical rod with the angle of the tip being 15° (d - 1cm).

Such a result is surprising. Indeed, in the phenomena using the discharges, the negative polarity is usually considered less severe, hence a high breakdown voltage corresponds to it. It is in part this observation which explains that most of the studies are made under positive polarity which is decisive for the dimensions of high voltage systems.

The following mechanisms have been suggested concerning the lowering of the breakdown voltage by a rod discharge:

■ Breakdown originating because of high local field around the surface of a rod discharge path. A rod discharge relaxes the field on the rod surface by short circuiting the two rods and bringing them to the same potential. However, if the discharge path is considered to be a thin conductor, the electric field strength around its surface may become sufficiently high to satisfy the threshold condition for initiating a breakdown towards the plane.

■ Change in direction of leaders: Before the occurrence of a rod discharge, electric lines of force in the vicinity of the maximum field strength run from the energized rod to the floating rod. Short circuiting the two rods abruptly changes the direction of these lines of force toward the grounded plane. Accordingly, if there are leaders branching from a rod discharge or independent of it, they may change their propagation direction and initiate a breakdown.

CONCLUSION

The reduction of the dielectric strength of a gap rod to ground due to a rod discharge or a local spark depends on the rod – rod distance d, the geometry of the third electrode, and on the rod-plane (or rod with different angles) distance L. The experimental results when the third electrode is a rod is surprising. Indeed in the phenomena using the discharges, the negative polarity is usually considered the less severe. It is in part this which explains that most of the studies make under positive polarity who is deciding in the dimension of the high voltage systems. The mechanism by which a rod discharge lowers the dielectric strength was discussed in terms of the discharge behaviour. The possible cause of a breakdown from a rod discharge would seem to be the high local electric field around the rod discharge arc enhanced by streamers protruding from its surface.

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