Behavior of Electrical Parameters, of a Pulsed and Continuous Corona Discharge

D. RAOUTI[1], A. TAHTAH[1], R. MEZIANE[1], A. BOUANANE[1]

[1]Université Dr Tahar, MOULAY, Saida, Algérie

E-mail : raouti1@yahoo.fr

Abstract **-**In this work, we are interested in studying the electrical behavior of the corona discharge of a positive point-to-plane configuration under continuous and pulsed power supply. This study is based jointly, on the one hand on practical measurements of different electrical quantities carried out on a mono-point-plane corona discharge reactor and on electrical models representing the discharge under the two modes of continuous and pulsed electrical power supply. The electrical parameters of the discharge under the two power supply modes are obtained by simulation of the models, and then the variation trends of these parameters obtained under the two types of power supply are analyzed. We finally compare the behavioral aspects of the electrical parameters obtained on the same operating conditions and on the same operating points chosen in order to arrive at a global synthesis on the electrical behavior of the discharge under the two power supply modes.

Keywords **-** Corona discharge, discharge parameters, electrical behavior.

I. INTRODUCTION

Under certain conditions the state of totally or partially ionized and electrically balanced gases is considered as a fourth state of matter which is called electric plasma [1].

Depending on the temperatures of the electrons and ions within the plasma, the latter are categorized into two types; hot plasmas, if both species are energetic and cold plasmas if only the electrons are energetic [2].

The corona discharges that are placed among this second type have the particularity that their generation is possible by applying a very low voltage compared to the other discharges belonging to this type. This characteristic is mainly related to the high values of the electric field created under non-symmetrical geometrical configurations. The point-plane corona discharge is the easiest to implement, either under a continuous or pulsed voltage [3].

In terms of industrial application, the latter covers more volume per contribution to the first thus producing more active reaction radicals [4].

In this work, we will study the electrical behavior of the positive corona discharge created under a planar tip configuration under a continuous power supply and under a pulsed power supply.

This study is based on one side on practical measurements of different electrical quantities carried out on a single-point-plane corona discharge reactor and on electrical models representing the discharge under the two continuous and pulsed electrical supply modes [5].

Initially, the simulation of the models makes it possible to obtain the electrical parameters of the discharge which are the resistance of the plasma medium and the capacity of the reactor recorded during the development of a discharge pulse under the two power supply modes.

Secondly, we analyze the variation trends of the two parameters obtained under the two types of power supply.

Finally, to arrive at a synthesis on our final objective, we compare for the two power supply modes, the behavioral aspects of the electrical parameters (capacity and resistance) of the discharge.

II. MODEL AND EXPERIMENTAL OPERATING CONDITIONS

The experimental device is a mono and multi-point-plane corona discharge reactor as is shown in Figure 1.

This device includes the following elements : (1) a discharge chamber - (2) a continuous supply HT included an adjustable DC generator connected in series with a load resistor R = 25 MΩ - (3) gas filling and emptying system - (4) adjustable and recording data system for current and voltage measurements. This experimental device can support a fast camera used for the optical analysis of the discharge.

The experimental conditions of this work are: the ambient temperature of the enclosure 25°C, the atmospheric pressure 1at, the inter-electrode distance which varies between 5 to 25 mm, the applied voltage which varies between 5 to 25 kV, depending on the fixed inter-electrode distance. Synthetic air (N2 80%, 02 20%), the tip curvature radius ρ=20 μm.

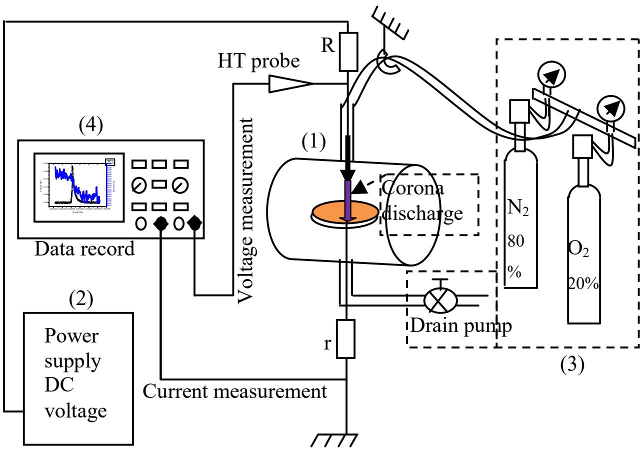

Fig. 1. Mono and multi-point-plane corona discharge reactor [5].

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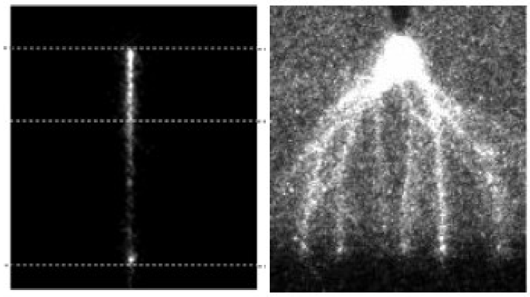
III. IMAGERY OF DISCHARGE UNDER BOTH CONTINUOUS AND PULSED POWER SUPPLY MODE

As shown in figure (2-a) and (2-b), we can observe that:

- Under continuous power, the discharge present as a pulses which develop as a unifilament lighting channel with a stable frequency [2, 5].
- Under an impulse supply this discharge develops in an arborizing form with a common trunk [4].



a) b)

Fig. 2. Imagery of a) continuous and b) pulsed point-plane corana discharge [5].

IV. CURVES OF THE ELECTRICAL QUANTITIES RECORDED

we can observe, that discharge voltage distribution presents a voltage drop which begins at the instant where the current begins to increase, it is clear that the voltage drop in the continuous case is very rapid (Fig. 3) than that recorded in the pulsed case (Fig. 4) contrary to its value which is significant in the pulsed case from 9.300 to 9 kV and less important continuous 9.9 to 9.97 kV.

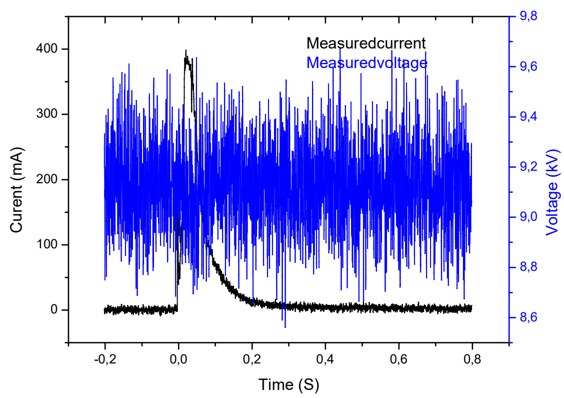


Fig. 3. Measured current and voltage of a contiues point-plane corona discharge (E_{app}= 10 kV, d = 9 mm).

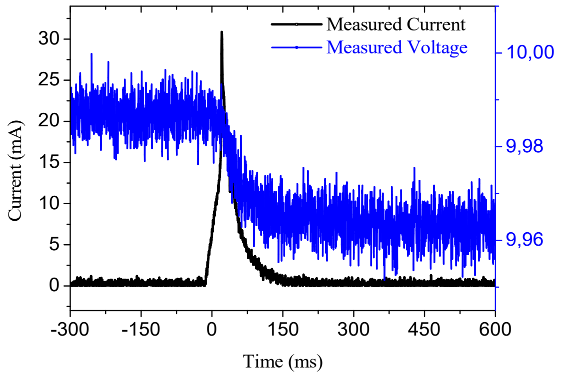


Fig. 4. Measured current and voltage of a impulse point-plane corona discharge (E_{app} = 10 kV, d = 9 mm).

Watching at the currents of discharges, the maximum value recorded in impulse is very important, more than ten times greater compared to that recorded in continuous discharge. compared to the currents of discharges, the maximum value recorded in impulse is very important, more than ten times greater compared to that recorded in continuous dicharge.

V. Behavior and Electrical Models of the Discharge under the Two Power Supply Modes

Continuous and pulsed corona discharges take the form of pulses with stable repetitive frequencies, in the order of a few kilohertz.

In continuous supply, the unifilamentary channel progressively short-circuits the inter-electrode gap with a positive charge at the head which increases in quantity arriving at the total short-circuit of the gap.

We have adopted confirming this evaluation behavior a series model detailed in reference [1, 2, 6], whose discharge is represented by a variable resistor in series with a variable capacitance.

In pulsed power supply, the discharge begins with a trunk from the anode tip which branches out going towards the cathode, each branch advances by accumulating more charges which gives rise to capacities parallel to the departure of the heads of the branches and to mutual capacitive effects between these braches. We adopt for its behavior a parallel model which comprises a variable resistor with an equivalent variable capacity [7, 8].

For both models the electrical parameters (variable resistance and capacitance) of the discharge are identified based on the experimental measurements of the electrical quantities, applied voltage and current of the discharge by applying the recursive least squares algorithm RLS, as it is detailed in reference [5].

VI. RESULTS AND ANALYSIS

To study the parametric behavior of the tip-plane discharge under the two supply modes, we compare the tendencies and quantitatively the electrical parameters obtained in the two cases.

This comparison is carried out on the same operating conditions and on the same selected operating points.

Each operating point is characterized by its applied voltage ‘Eapp’ and its inter-electrode distance ‘d’.

In general, the variations of the electrical parameters obtained in pulsed and continuous discharge reflect the physics of the corona discharge phenomenon under such conditions.

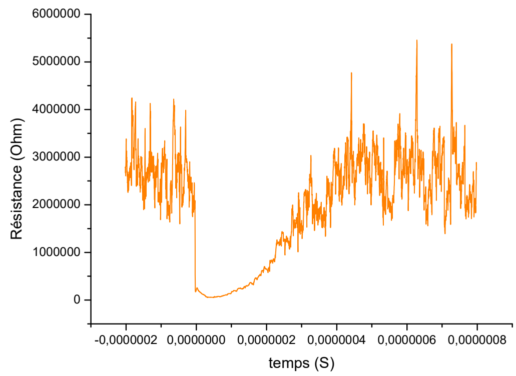


Fig. 5. Continuous discharge resistance identified for E_{app} = 6 kV, d = 6 mm

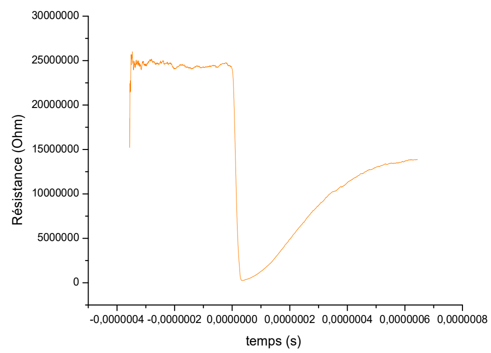


Fig. 6. Impulse discharge resistance identified for E_{app}= 6 kV, d = 6 mm

The resistance of the discharge decreases during the propagation of the discharge until a minimum value at the moment of the impact of the discharge, then it gradually increases towards its initial value before discharge.

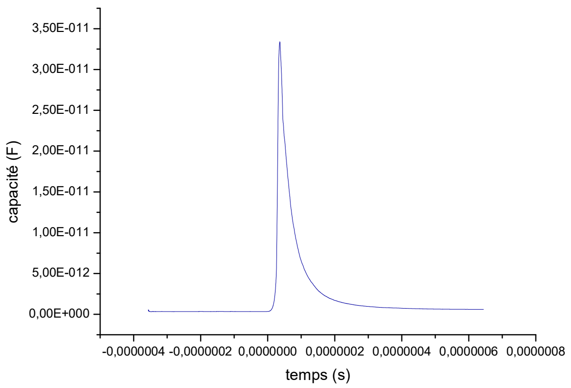


Fig. 7. Continuous discharge capacity, calculated for E_{app} = 6 kV, d = 6 mm

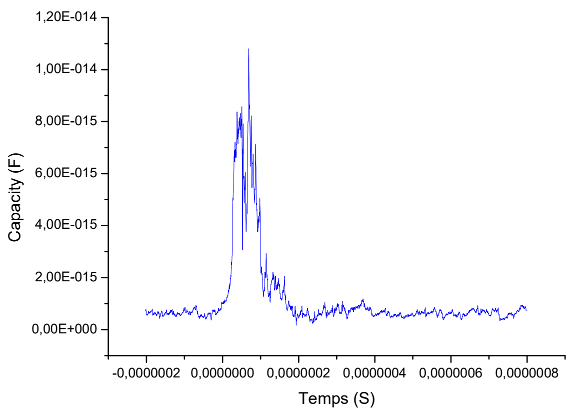


Fig. 8. Impulse discharge capacity, calculated for E_{app}= 6 kV, d = 6 mm

The capacitance increases rapidly as the discharge develops, reaching a maximum value at the instant of total short-circuit of the inter-electrode space then it decreases sharply towards its initial value which represents the geometric capacitance of the system. discharge.

Comparative analysis two by two, of the electrical parameters for the same operating points, case (E_{app} =6 kV, d=6 mm), under the two power supply modes shows that in terms of resistance, the initial value at the moment of triggering of the discharge, recorded in the impulse case (~3 MΩ), are too lower than those recorded in the continuous case (~25 MΩ). This explains the significant maximum value of the current reached in the pulsed case.

On the other hand In both supply modes when the current reaches its maximum value the resistance reaches its minimum because the inter-electrode interval is completely short-circuited

In terms of capacitance, the maximum value of the capacitance reached in pulsed is relatively lower recorded compared to that recorded in pulsed power supply are relatively lower compared to that recorded in the continuous case. It is probably due to the mutual capacitive effect between the branches of the impulse discharge

VII. CONCLUSION

We have presented a synthesis on the behavior of the electrical parameters of the corona discharge under two continuous and pulsed power supply modes. In this work we have based on the representative electrical models of the two types of discharge. Parameters are determined from experimental measurements of electrical discharges quantities. The comparative synthesis of the results is discussed and explained according to the nature of the applied voltage and the physical morphology of the discharge in both cases.

We find that the results obtained are in agreement with the physics of the discharge under the two power modes and the related studies in the literature.

VIII. ACKNOWLEDGEMENTS

All measurements of this work are carried out during a long-term training, at LAPLACE laboratory at the University of Toulouse in France, under the direction of Professor O. Eichwald, thanks.

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