Multipoints Cylinder Corona Reactor New Design

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Abstract - This paper aims to develop new designs of multipoint-cylinder corona reactors. The current-voltage characteristics of the discharge are studied experimentally and are examined for both positive and negative polarities depending on the arrangements and the number of tips. The experimental study is completed by numerical calculations of electric field using Comsol Multiphysics. The tip arrangements double the current when the number of needles doubles and maximum current can be obtained with minimum energy without passage to electric arc.

Keywords - Corona reactors, Electric arc, Electric field, Discharge

I. INTRODUCTION

Pollution is one of the problems facing the environment at the heart of acclaimed industrial development. Many different types of discharges may be used as reactors for pollution control [1]. Many reactor designs use electrodes such as small diameter wires, needles or sharp edge metals that promote strong electric fields. Corona reactor, which by applying the high voltage between two types of well-chosen electrodes obtains corona discharge. Depending on the type and configuration of the electrode, there are several models of corona reactors, either; wire plate, wire cylinder, cylinder -cylinder, multi-point on plane [2-4].

The electrode configuration commonly used is the point- plane configuration for its simplicity of study and analysis [5-7]. Multipoints plane configuration is practically important allows to draw a more powerful current and expand the treatment area [8-11]. Multi wire cylinder configuration and coaxial cylinder wire are preferred because they offer symmetric structure and ensures uniform electric field [12].

Mingjiang et al [13] Show the investigation of the wire cylinder configuration for the realization of an electrostatic precipitator Back corona discharge. It should be noted that BCD results inan increase in the power consumption of the ESP for all stages. Kantouna et al [14] Show that a cylinder-wire-cylinder electrode configuration with the right cylinder closer to the wire produces efficiency relatively higher than a typical wire cylinder arrangement.

Results obtained by Sahraoui et al [15] using a cylinder point electrode configuration show the influence of the geometrical and electrical parameters on the corona discharge, so that the adopted values of these parameters provide a sufficient electric field to initiate the corona discharge and give maximum current and optimum power consumption. multiplication of the number of points, using a multi-point cylinder (2p, 4p) electrode configuration, where the points are arranged in a symmetrical manner with respect to the cylinder increase the current and optimize the power, avoiding the transition from the corona discharge to the electric arc.

To obtain a higher current and further optimize the power we propose a new multipoint cylinder configuration. Points are arranged in a symmetrical and parallel way, the number of points is 12.

The electric field computation at the points is done by Comsol based on the finite elements method. This theoretical study helps providing means to test different geometries and parameters to determine their relevance and feasibility. In this work, we calculate the electric field using the voltage value applied to moment of appearance of the filament at the top of needle. The value of the electric field is the maximum value indicated at the level of the needle head at the time of the appearance of the corona discharge filament, this value corresponds to the ignition voltage of the corona discharge. The electrode configuration is simulated in 3D electrostatics. The electrode dimensions are the dimensions quoted in experimentation: The boundary conditions are the outer limits at 0, the peak in potential V, the cylinder is grounded.The resolution is based on the finite element method. The current, the minimum voltage and the optimal power P = UI, belong to the most important factors in the optimization of a corona reactor [16].

II. EXPERIMENT SET UP

The experiment set up is shown in Figure1. The high voltage DC power supply have both positive and negative output polarity and 30 kV maximum output voltage, the maximum current is 10 mA. The multipoints cylinder configuration consists of a cylinder (cathode) which is a copper tube; diameter D = 22 mm connected to ground, and the needles (points) connected to the high voltage electrode (anode). Each needle radius of curvature is r_c= 0.002 mm placed perpendicularly with gap distance d from the cylinder. A high voltage probe for multimeter is placed at the high voltage electrode. To measure current with a multimeter, a measuring resistance R_{mes} = 110 kΩ, is plugged in series with the ground electrode. The resistance R = 10 kΩ is used to limit current.

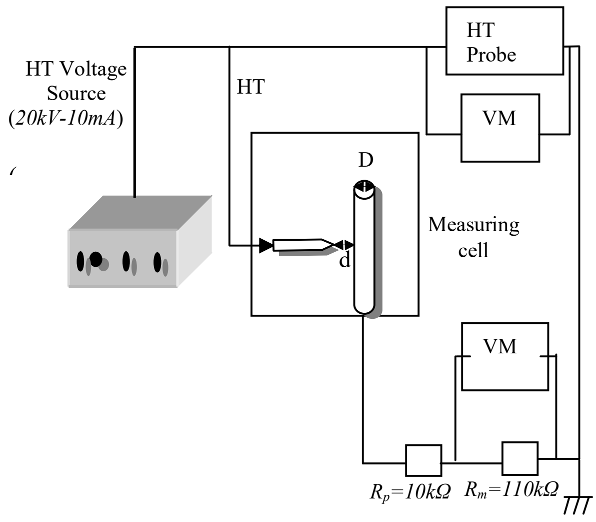

Fig. 1. Simplified schema of the Multipoint's cylinder system

While serial circuitary is built, the experiment planning consists of preparing a test program according to positive and negative polarity. We took as values: inter electrode distance d = 5 mm, the distance between points by moving vertically h = 5 mm, number of points equal twelve. The electrical parameters voltage and current are indicated on the front panel of the multimeters. Angle between points is either α = 120° or 90°.

III. RESULT AND DISCUSSIONS

Twelve needles connected to a high-voltage electrode, are laid symmetrically in relation to the cylinder. The cylinder of diameter D = 22 mm is connected to the ground electrode as shown in Figure 2. Points are disposed in triangular angle α = 120° (Figure 2 a,b,c), or in quadrature (Figure 2 d,e,f). The taken values of d and h are the optimum as they make the electric field homogeneous at the level of points, and the discharge developed uniform. Current and voltage measurements are done while multiplying the number of points with negative and positive polarity.

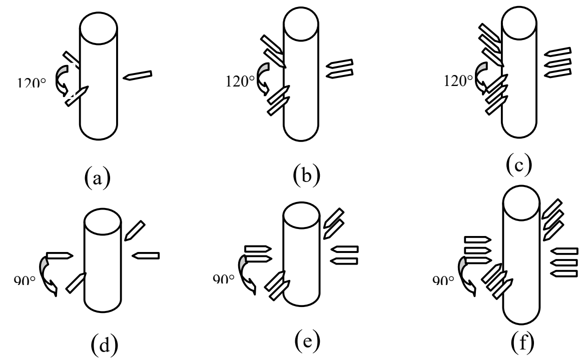

Fig. 2. Scheme of arrangement of cylinder multipoints

Results obtained shown in figure 3 and figure4, illustrate the influence of the number and arrangement in parallel of points while angle α=90° figure2 (d,e,f) on the variation of the current, in positive and negative polarity. It can be noticed that the current increases from the number of points depending on the applied voltage.

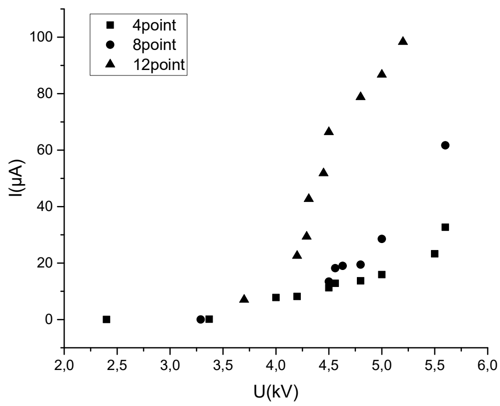

Fig. 3. Current variation as a function of the applied voltage for four and eight, twelve points in quadrature and parallel with respect to the cylinder, positive polarity.

The multiplication of the number of points[15], using a multi- point cylinder (2p, 4p) electrode configuration, where the points are arranged in a symmetrical manner with respect to the cylinder, makes it possible to increase the current and to optimize the power, avoiding the transition from the corona discharge to the electric arc.

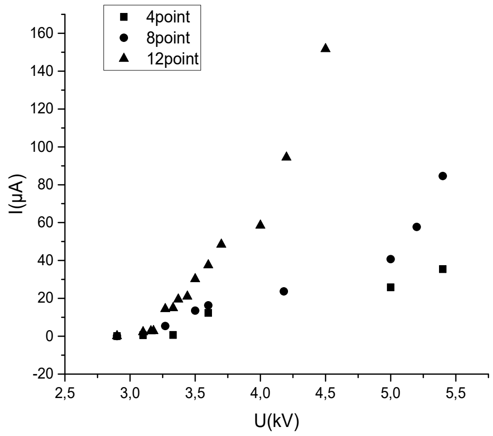

Fig. 4. Current variation as a function of the applied voltage for four and eight, twelve points in quadrature and parallel with respect to the cylinder, negative polarity.

The points are arranged in triangular and parallel in symmetry of angle 120 ° with respect to the cylinder figure 2 (a,b,c), in positive, negative polarities. The current increases with the increase of the number of points Figure 5, 6, and the voltage decreases with the increase of the number of points.

Voltage current characteristic show the maximum current of the corona discharge doubles from one stage to another for almost all the configurations carried out. The current obtained doubles (I 2 floor = 2I 1 floor) as the needles multiply from one floor to another (4,8,12) or (3,6,9) ; $I_{2n} = 2I_n$.

At negative polarity ,the corona current is important compared to the positive polarity, this is the property of the negative polarity.

Many works have focused on the study of negative and positive polarity, in particular : the work of [17] shows that the current of the negative polarity is important than that of the positive polarity for this reason the negative polarity is preferred in the corona discharge investigations.

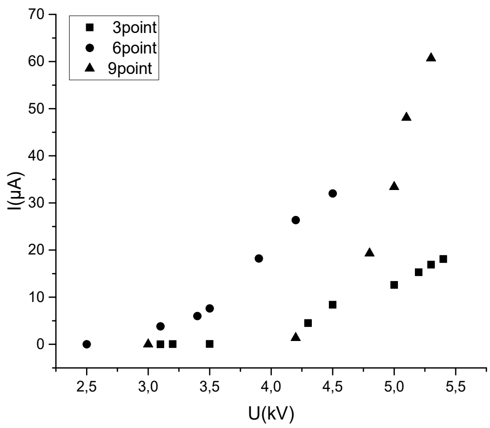

Fig 5: Current variation as a function of the applied voltage for tree and six, nine, points in triangular and parallel with respect to the cylinder, positive polarity

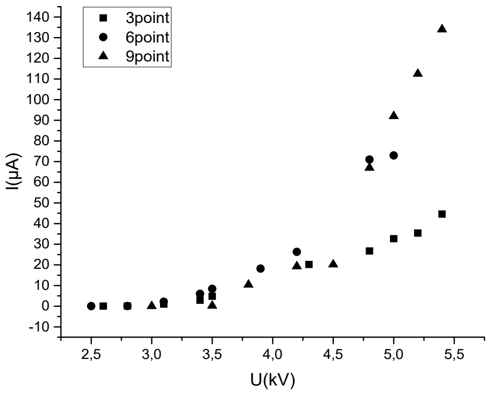

Fig. 6. Current variation as a function of the applied voltage for tree and six, nine, points in triangular and parallel with respect to the cylinder, negative polarity

Table1. Electric field at the points for an angle of symmetry 120° with respect to the cylinder for a fixed applied voltage and the inter-electrode distance.

3 point (fig2.d)	6 point (fig2.e)	9 Point (fig2.f)
6212 kV/cm	5652 kV/cm	5070 kV/cm
6245 kV/cm	5509 kV/cm	4985kV/cm
6126 kV/cm	5590 kV/cm	4931 kV/cm
	5628 kV/cm	5066 kV/cm
	5658 kV/cm	4836 kV/cm
	5541 kV/cm	50131 kV/cm
		5110kV/cm
		4879 kV/cm
		5109 kV/cm

Table 2. Electric field at the points for an angle of symmetry 90° level with respect to the cylinder for a fixed applied voltage and inter-electrode distance.

4 point (fig2.a)	8 Point (fig2.b)	12 point (fig2.c)
6155 kV/cm	5547 kV/cm	5289 kV/cm
6184 kV/cm	5534 kV/cm	5055 kV/cm
6151 kV/cm	5568 kV/cm	5344 kV/cm
6223 kV/cm	5543 kV/cm	5209 kV/cm
	5595 kV/cm	5106 kV/cm
	5583 kV/cm	5259 kV/cm
	5500 kV/cm	5282 kV/cm
	5688 kV/cm	5229 kV/cm
		5385 kV/cm
		5297 kV/cm
		5123 kV/cm
		5316 kV/cm

The computation of electric field strength at the points for an angle of symmetry respectively 120 ° and 90 ° angle is shown in Tables 1 and 2. Results gives similar and varied values in a narrow interval, which means that the field is uniform.

we note that for the same applied voltage and the same inter-electrode distance, the electric field takes almost the same values for each configuration of the points either in quadrature or in triangular.

The position of the needles limits the variation of the field, which makes the field proportional to the change of the number of needles for the same position.

The symmetrical arrangement of the points with respect to the cylinder figure 2 (a, d), limits the variation of the field, this one is uniform at the level of the points, under these conditions the corona discharge is stable and uniform,. If we double the number of points figure 2 (b, c, e, f), the current doubles too. We notice that the current increases and the voltage decreases with the increase in number of points and the decrease in the angle of symmetry between the points. Table 1 and table2 show that the angle of symmetry between the points influences the field variation as well as for the same applied voltage, if we decrease the angle between the points the field decreases.

IV. CONCLUSION

This work was devoted to an experimental and theoretical study of the corona discharge in air in order to adopt an optimal electrode configuration characterizing an optimal corona reactor. The results obtained using a cylinder points electrode configuration, show the influence of the the number of points and the manner in which points are disposed with respect to the cylinder on the corona discharge, in positive and negative polarization.

Multiplying the number of points, using a multipoint electrode configuration (12p), the points are arranged symmetrically with respect to the cylinder. The points are placed in superposition with respect to the angle cylinder 90 °, 120 °, this arrangement of points makes it possible to design two models of corona reactor. The negative polarity quadrature dot pattern pattern gives a large current.

This study gives the possibility of adopting an optimal electrode configuration that allows the design of a multi-points corona reactor optimal cylinder.

This study will continue for the realization of a corona reactor with optimum parameters, experiments will be conducted for other configurations.

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