

THE ELECTRIC FIELD FORMULATIONS IN THE PLANE-KNIFE CONFIGURATIONS

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Abstract

In this paper, we calculate enormous electric field produced by the plane-knife configuration of the plasma generator. The value of electric field is calculated by two ways of configurations, the first is the almost perpendicular form of the Capacitor plates and second the perpendicular one. The result of calculation is the plates perpendicular form will produce higher electric fields than the almost perpendicular case.

Key words : Plasma generator, plane-knife configuration, electric field.

Introduction

The corona plasma discharge is a efficiency energy source which has not yet been used maximally by human and it have characteristic type with low gas temperature and high-electron temperatur. The important usefulness of the corona plasma discharge can remove pollutant gases by using the small energy source as in accumulator energy level. The corona plasma generator with the plane-knife configurations is a plasma generator that is made to reduce gas pollutant from vehicle muffler until 80%[1]. The some examples of the plasma generator research which have been done are wire-plate discharge system of the plasma [2,3], the electric field analysis of the corona plasma with the tip-plane [4] and ring-plane [5] configurations for application of electrical discharge Nur et al used Dielectric Barrier Discharge Plasma Technology for Ozone Generator [6].

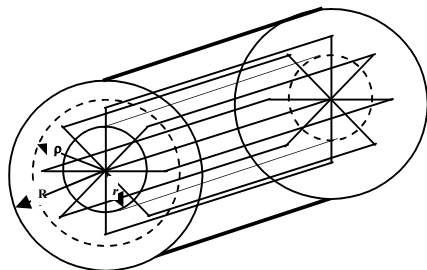


Figure 1. The corona plasma generator with the plane-knife configurations [1].

In this paper, we investigate the formation of plane-knife configuration to produce very strong electric field. In this case, we consider two main problems, first an almost perpendicular form of the plates of capasitor and second the perpendicular one. The benefit of the study is to obtain a plasma generator that can produce strong electric field and can be applied to reduce air pollutan and can be used for controlling environment contaminated by emission gass like NOx, Cox and Sox [1].

The almost perpendicular Form of the plates Capasitor

A plate capasitor of lenght a and wide b carries a total positif charge Q is placed in the position almost perpendicular to another plate. If end of the first plate surface is made to be very sharp as shown in fig.2, and distance between two end plates surface is c then we can make a differential distance h as a function of x length size and an inclination angle of ϵ between the anode plate and a vertical axis can be written as

$$h = x \tan\left(\frac{1}{2}\pi - \epsilon\right) + c = x \cot \epsilon + c. \quad (1)$$

The boundary condition of x has a minimum value of zero if the first plate is perpendicular to the second plate and has a maximum value of b if the first

plate is parallel to the second plate, that can be written as follows

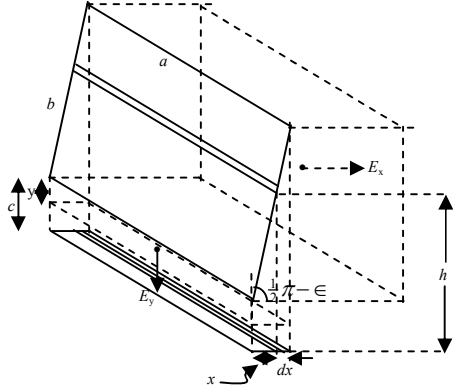


Figure 2. Position of the anode and cathode plates in the a capacitor system with the anode electrode has a inclination angle of ϵ to the vertical surface.

$$0 < x < b \cos\left(\frac{1}{2}\pi - \epsilon\right). \quad (2)$$

If we evaluate an element capacitans with respect to an element area of dA and the length of h is

$$dC = \epsilon_0 \frac{dA}{h} = \epsilon_0 a \frac{dx}{h}. \quad (3)$$

By using h value of equation (1) and the integration boundary condition of x in (2), we get the value of C as

$$C = \epsilon_0 a \ln \left| \frac{b \sin\left(\frac{1}{2}\pi - \epsilon\right) + c}{c} \right|. \quad (4)$$

A Gauss surface that is made between the cathode and anode plates in the figure 2, can be written as

$$A = a b \cos\left(\frac{1}{2}\pi - \epsilon\right). \quad (5)$$

The electric field in the direction of y -axis, E_y can be calculated by using the Gauss law with the its Gauss surface is defined in (5), we get

$$\epsilon_0 \iint \vec{E}_y \cdot d\vec{A} = \epsilon_0 E_y ab \cos\left(\frac{1}{2}\pi - \epsilon\right) = q. \quad (6)$$

By using relation $q = \Delta V C$, where the Capasitans value is defined in (4) and ΔV is potential difference that is given

by external source (such as a battery or an accumulator), we get the E_y value is

$$E_y = \frac{\Delta V}{b \cos\left(\frac{1}{2}\pi - \epsilon\right)} \ln \left| \frac{b \sin\left(\frac{1}{2}\pi - \epsilon\right)}{c} + 1 \right|. \quad (7)$$

Potensial value in direction of y -axis is located on the surface between anode and cathode as is shown in Fig. 2, can be computed by using relation,

$$\begin{aligned} V(y) &= - \int E_y(y) dy \\ &= \Delta V \frac{(b \sin\left(\frac{1}{2}\pi - \epsilon\right) + y)}{b \cos\left(\frac{1}{2}\pi - \epsilon\right)} \{1 - \ln |b \sin\left(\frac{1}{2}\pi - \epsilon\right) + y|\} \\ &\quad + \frac{\Delta V}{b \cos\left(\frac{1}{2}\pi - \epsilon\right)} \{y \ln |y| - y\}. \quad (8) \end{aligned}$$

The Perpendicular Position of Anode to Cathode

From eq. (4), we can calculate formulation of Capasitans for the case of anode position is perpendicular to cathode position ($\epsilon \cong 0$) as

$$C_1 = \epsilon_0 a \ln \left| (b/c) + 1 \right|, \quad (9)$$

where figure 3 shows the plates formation of the Capasitans formulation in eq. (9). From the eq. (9) above, we can see that C_1 is a highest value of capasitans value of C in eq. (4) with respect to the ϵ angle value. The other factors will cause the high capasitans value at the maximum values of length and wide of anode plate, a and b respectively and the minimum distance between the anode and the cathode of c .

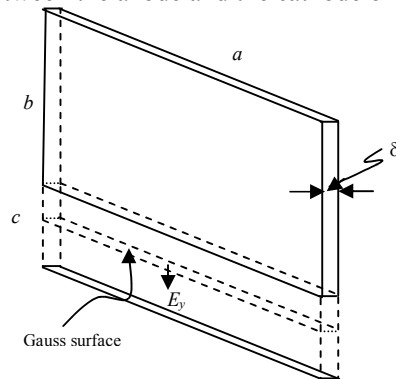


Figure 3. The anode position is perpendicular to the cathode position.

In the fig. 3, the plate thickness is very sharp, $\delta \rightarrow 0$. Using the Gauss law, we get the electric field value in y-direction as

$$E_y = \frac{q}{\varepsilon_0 A} = \frac{\Delta V}{\delta} \ln |(b/c) + 1|. \quad (10)$$

where the Gauss surface is $A = a \delta$, and $q = \Delta V C_1$. From the eq. (10), we get a very strong electric field value E_y caused by very sharp plate, $\delta \rightarrow 0$. Also, the strong electric field value is determined by the maximum value of the plate wide of b and the minimum value of the distance between the both plates of c .

Conclusion

In two cases of Capacitor plates formation as is shown in fig. 2 and 3, the electric field value that is produced by the perpendicular form of the Capacitor plates is higher than the almost perpendicular one. In the corona plasma generator with the plane-knife configurations as is shown in fig. 1, there are two formation of Capacitor plates position so that there are electric fields values in the various places of the generator with the maximal value of the high electric field is produced by the position of perpendicular form of the capacitor plates. The maximal value of the high electric field source is used to eliminate dangerous free radicals like air pollution. It changes pollutant gas to become some larger particles therefore it will not be dangerous to human live.

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