INFLUENCE OF THE ELECTRIC FIELD CONFIGURATION IN THE DISCHARGE INTERVAL ON CHARGING OF DIELECTRIC MATERIALS

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The analysis of distribution the electric field intensity in the interelectrode intervals at corona and barrier kinds of the discharge is carried out. It is revealed that significant distinction in electric field intensity at configurations of sharply-nonuniform and weakly nonuniform fields accordingly causes various intensity of electrodischarge effect on the sample of a dielectric material and, as consequence, various values density of the electric charge which has been saved in the material.

Introduction

Now, along with become traditional applications of an electricity in industrial technology, starts to get the increasing role use of strong electric fields and discharges[1]. This fact is connected with considerable advantages of these technologies before traditional methods of effect on the treated material. Electrodischarge treatment of materials causes changing purposefully its properties, modifying a surface, carrying out accumulation of electric charge on the material's surfaces and volume. At that use of nonequilibrium kinds of the electric discharge, such, as corona, decaying, torch and barrier considers the most effective [2].

In a number of works it was noted by us [3,4], that at electric discharge effect on inorganic, polymeric and composite dielectric materials there is accumulation of electric charges takes place. And at the same time the density of saved charge is various, depending on a kind of the used discharge under approximately equal other conditions (sort of gas, voltage, current, temperature, pressure, etc.)

In the table the density values of the saved electric charge (the average values of 10 measurements) for 10 various samples of film PVDF by thickness of 180 microns after effect the corona and barrier discharges are presented. Applied voltage is 12 kV, corona discharge current is 50 mA, barrier discharge current is 80 mA.

At corona discharge effect on the samples the cell (electrode system - corotron) which schematic circuit is shown on fig.1 was used. The barrier discharge was carried out by means of cell which is shown on fig.2.

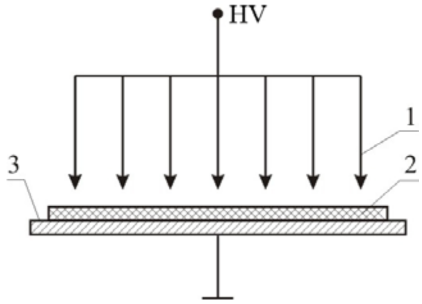

Fig.1. The cell of corona discharge (corotron)
1- coroning electrodes; 2 - PVDF film sample;
3 - earthed electrode

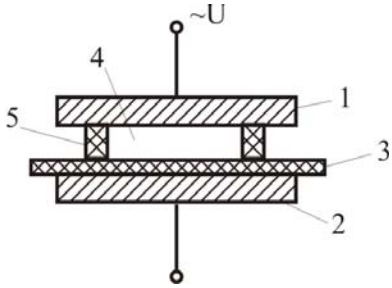

Fig. 2. The cell of barrier discharge 1,2 - metal disk electrodes;
3 - dielectrical barrier of pyroceramics; 4 -air gap;
5 - lining of pyroceramics.

]The table. Values of the saved charge density in the PVDF film samples processed by the corona and barrier discharges.

The samples No.	1	2	3	4	5	6	7	8	9	10
σ,10^{-8} C/cm^2, corona discharge	2,8	3,3	2,3	2,7	3.9	3,1	2,4	2,6	2,2	3,2
σ,10^{-8} C/cm^2, barrier discharge	7,8	8,5	7,0	9,5	10,7	9,2	11,2	8,8	12,0	9,4

From the table it is visible, that in all samples formation of the significant saved charge takes place, at that charge density is higher in case of processing by the barrier discharge. It is obvious, that the specified difference in the values of the saved charge density in a film is caused by various configurations of an electric field in an interelectrode interval and, hence, various values of intensity of a field in the discharge gaps.

Results and discussion

Let's consider the distribution of electric field intensity in the interelectrode intervals at corona and barrier kinds of the discharge.

Calculation was carried out for the interelectrode intervals configurations which are shown on fig.1 and fig.2 according to its simplified schemes presented on Fig.3a and 3b.

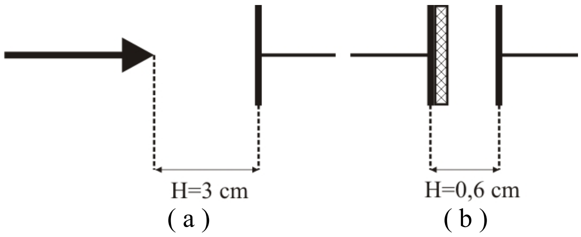

Fig.3. The simplified schemes of interelectrode intervals configurations

a – the sharply nonuniform electric field (corona discharge);

b- the weakly nonuniform (quasi-uniform) electric field (barrier discharge)

From the simplified schemes it is visible that at corona discharge the sharply nonuniform electric field configuration, and at the barrier discharge the weakly nonuniform electric field configuration are accepted.

At calculation it is accepted:

- for corona discharge gap (Fig.3a): radius of coroning electrode r_0=0,025cm;
- interelectrode distance H=3 cm;
- applied voltage U_a =12 kV;
- for barrier discharge gap (fig.3b): thickness of a barrier d_b =0,1cm (pyroceramics);
- thickness of an air gap d_a =0,5cm;
- applied voltages U_a =12 kV; U_b =2 kV.

Initial field intensity for corona discharge in the air interelectrode gap representing the sharply nonuniform electric field configuration, we calculate under the Peak formula [5] (at the air relative density equal of 1).

$$Ei = 30{,}3 \cdot (1 + \frac{0{,}298}{\sqrt{r_0}}) = 87.4 kV / cm \qquad (1)$$

The initial voltage of corona discharge ignition is [6]

$$Ui = Ei \cdot r_0 \cdot ln \frac{2H}{r_0} = 12 kV \qquad (2)$$

In an interval between electrodes “a needle - a plane” (fig.3a) the value of electric field intensity for any point is determined as follows

$$E = \frac{U}{x \, ln \frac{2H}{r_0}} (kV / cm) \qquad (3)$$

where *x* is distance from an axis of the coroning electrode up to considered point (cm);

r_0 is radius of the coroning electrode (cm);

H is distance between the electrodes (cm);

U is voltage between electrodes which in our case will be equaled to the initial voltage of corona discharge *Ui=12kV*.

At calculation of the electric field intensity inside the interval (*H*=3cm) the value of x should will change from 0,025 cm up to 3 cm.

When $x = r_0$= 0,025 cm, the maximal field intensity on a surface of coroning electrode is equal

$$E_{max} = Ei = \frac{Ui}{r_0 \, ln \frac{2H}{r_0}} = 87.4 kV / cm \qquad (4)$$

When *x=H=3* cm, the minimal field intensity on a surface of external (flat) electrode is equal

$$E_{min} = \frac{Ui}{H \, ln \frac{2H}{r_0}} = 0{,}67 kV / cm \qquad (5)$$

The received maximal and minimal values of electric field intensity represent that at r_0=0,025 cm the sharply nonuniform electric field is created between the electrodes.

Calculation has been carried out by means of MATHCAD program. Calculations results for distribution of electric field intensity in the intervals of both configurations are presented on fig.4, where curve 1 is concern to the barrier discharge and curve 2 is concern to the corona discharge.

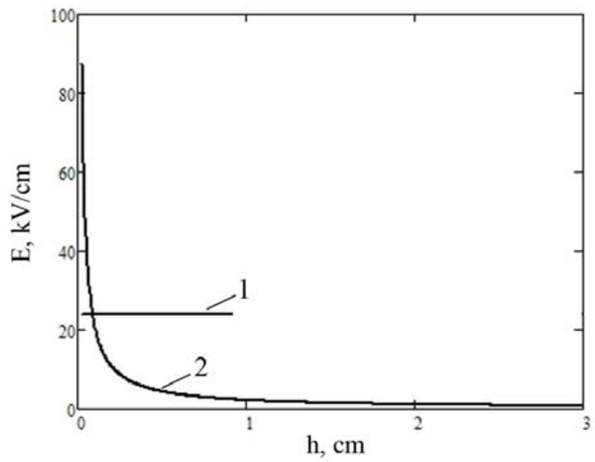

Fig.4. Calculations results for distribution of electric field intensity in the interelectrode intervals: 1 – at the barrier discharge; 2 – at the corona discharge.

From fig.4 it is visible that only in immediate proximity to a surface of coroning electrode the field intensity is great. In remaining interval the field intensity sharply decreases. At that the value E_{max}=87,4 kV/cm considerably exceeds the value E_{min}=0,67 kV/cm. Accordingly, efficiency of electrodischarge processing the surface of the PVDF film sample is considerably weakened that affects on the value of charge which saved in the film.

In the weakly nonuniform electric field of the barrier discharge (fig.3b) maximal and minimal intensities in the air interval differ from each other a little, i.e. it is conditionally possible to consider distribution of the electric field practically uniform

$$E_{av} = \frac{U}{d} = \frac{12}{0{,}5} = 24 kV / cm \qquad (6)$$

As it is visible from Fig.4, the electric field intensity E_{av} practically in all interval has equally high value (24 kV/cm), as causes more effective electrodischarge processing of the samples in the weakly nonuniform electric field and, accordingly, higher values of the saved charge density.

Conclusion

Thus, the analysis of distribution the electric field intensity in the interelectrode intervals at corona and barrier kinds of the discharge is carried out. It is revealed that significant distinction in electric field intensity at configurations of sharply-nonuniform and weakly nonuniform fields accordingly causes various intensity of electrodischarge effect on the sample of a dielectric material and, as consequence, various values density of the electric charge which has been saved in the material.

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R.N. Mehdizadə

QAZBOŞALMASI ARALIĞINDA ELEKTRİK SAHƏSİNİN KONFİQURASİYASININ DİELEKTRİK MATERİALLARIN ELEKTRİKİ YÜKLƏNMƏSİNƏ TƏSİRİ

Məqalədə elektrodlararası boşluqda tac və arakəsməli elektrik qazboşalmalarına müvafiq kəsgin qeyri-bircins və zəif qeyri-bircins elektrik sahələrinin paylanması araşdırılmışdır. Göstərilmişdir ki, elektrik sahəsinin müxtəlif qiymətlərinə uyğun olaraq materiallar da müxtəlif təsirlərə məruz qalır və müvafiq olaraq materiallara daxil olan elektrik yüklərinin sıxlığı da müxtəlif olur.

Р.Н. Мехтизаде

ВЛИЯНИЕ КОНФИГУРАЦИИ ЭЛЕКТРИЧЕСКОГО ПОЛЯ В РАЗРЯДНОМ ПРОМЕЖУТКЕ НА ПРОЦЕСС ЗАРЯДКИ ДИЭЛЕКТРИЧЕСКИХ МАТЕРИАЛОВ

Проведен анализ распределения напряженности электрического поля в межэлектродных промежутках, образующих конфигурации резконеоднородного и слабонеоднородного поля при коронном и барьерном видах разряда. Показано, что значительное различие в величинах напряженности электрического поля в указанных конфигурациях обуславливает различную интенсивность электроразрядного воздействия на диэлектрический материал и, как следствие, различные значения плотности электрического заряда, внедренного из разряда в материал.

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