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CALCULATION VARIANTS OF ELECTRIC FIELD AMPLIFICATION FACTOR ON PERIODIC HETEROGENETICALTY OF ELECTRODES

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Abstract- In this paper justifying the expediency of smooth surfaces of internal electrodes of ozonizers to construct the internal electrodes with periodic variable structure is presented to forming the artificial created relief of a surface. The offered constructions promote amplification of the field due to heterogeneity on the ledges of relief's with coefficient of amplification of the fields for 4.25 and 7 in various internal electrodes. The factors of amplification of the field are discussed for tip and autocathodes with nanotubes have sizes more than 50 and 490, accordingly.

Keywords: Amplification, Electrode, Hetrogenetic, Ozonizer.

I. INTRODUCTION

As it is known for effective productivity of electrosynthesis equipments (ozonizers, equipment of electrosynthesis of various polymers and copolymers) heterogeneticalty creation of the big factors of amplification of electric field is required. Besides, these requirements are important for obtain electrons in discharge gap with a wide spectrum of the energy, providing speed corresponding reactions of synthesis.

Currently electrosynthesis of ozone are used in the various kinds of electric discharges. In each concrete case application of such version of the discharge are required in the certain elementary processes which are responsible for conditions of passage of a current through gases. The main requirement for all ozonizers is reduction of losses in an active zone, i.e. power efficiency of productivity. For the electric materials applied in reactors of synthesis, it is expedient to use activation in low temperature and nonequilibrium electric discharges such as corona, decaying, barrier, combustion, which general similarity is the small expense of putting energy to the heating of the material [1].

II. THEORETICAL DISCUSSIONS

Nonequilibrium discharges are characterized by the strong tear of electronic temperature from temperature of ions and neutral atoms, i.e. $T_e>>T_i>T_n$. In these kinds of energy discharge received from an electric field by the "hot" electrons, the excitation and dissociation of gas molecules at presence of discharge gap of small dispersion dielectric filler is also expensed to the processes of ionization, and the atoms of a superficial layer.

All these processes lead to create in volume of favorable conditions for increasing of speed of formation of ozone in ozonizers. The above nonequilibrium in the less energy is expenseed for heating of gas. For example, the arc discharge for synthesis of ozone is unsuitable because of a small degree of nonequilibrium as the basic part of the energy putting in the discharge, going to the heating of gas or limiting of reactor surfaces. Based on literary data , the degree of nonequilibrium is possible to arrange discharges as the following [2]: Cover of corona discharge, barrier, combustion, decaying, spark, arc. Electric discharges at ultrahigh frequencies, depending on speed of input of energy and its "channels" of dissipation, can have a various degree of nonequilibrium.

All nonequilibrium forms of the discharge are developed in discrete intervals in the fields of high intensity nonequilibrium and strong fields which these two conditions are indissolubly connected with each other. Physically reduction of a degree of nonequilibrium, i.e. reduction of difference T_e-T_i, can occur only at decreasing in intensity of a field in an active zone of the discharge condition.

In the past years, at creation of ozonizers, basically, using of barrier discharges is familiar. Depending on values of multiplying of pressure p and extents of the gas gap d ($p.d$), the barrier discharge can exist in two forms [3]. The atmospheric pressure of gas value ($p.d$) for all real gaps is practically always more than some critical value $(p.d)_{cr}$, i.e. separate sites of reactor surface "are charged" through multiavalanche formation independently from each other. The size of microflashes and distances between them are the same order, as thickness of the gas gap d. In microdischarges localized charged particles have high energies, therefore separately microdischarge possesses destructive actions are localized, destroying molecules up to free atoms and radicals. The primary active particles which have formed here (basically electrons) quickly get in low temperature environment in accelerate processes of ozonization.

Dielectrics which putted by a uniform layer on the surface of electrodes in the barrier discharge, except for an intensification of the discharge, play a role of stabilizing resistance. At greater voltage between the metal electrodes, the equipotentiality is achieved «spreading» on a surface and the microdischarges arise chaotically in casual places [4] and natural microheterogeneity, the roughnesses which are available even on smooth surfaces of internal electrodes of ozonizers. For avoidance of localizations of discharges it is offered to apply various periodic variable structures to internal electrodes [5].

In this paper, justifying the expediency from smooth surfaces of internal electrodes of ozonizers to construct with the internal electrodes is presented in periodic variable structure, formed with artificial created relief of a surface.

In Figure 1, two variants of realization of such periodic heterogeneity are shown: a) on internal electrode is putted carving, so that each of elements represents a triangle with height 1.5 mm and b) on internal dielectric electrode by the spiral metal wire with radius 0.25 mm is densely reeled.

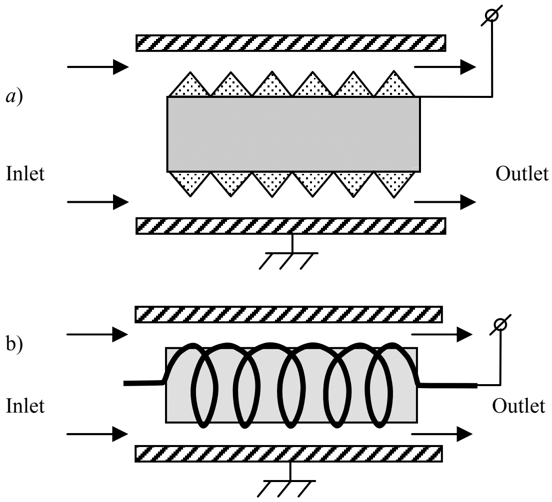

Figure 1. Periodical heterogeneticalty of active elements relief of reactors of electrosysntesis

Necessity of creation the periodic relief heterogeneity was an opportunity of creation the adjustable localization of microdischarges which are the source of high energy electron, participating in formation of ozone. On the other hand, the increasing of the area of a surface of an internal electrode leads to reduce the density of a current that promotes to reduce of heating and destruction of an electrode and consequently increases service life of ozonizers. Simultaneously, such structure provides multiple interactions of atoms and molecules to make up gas with periodic intensive zones of discharge gap, and turbulence of air current to promote more effective cooling of active zone.

Let's estimate a degree of heterogeneity of an electric field in both kinds of above stated constructions of the central electrodes. Usually, it is known from the literature [6], the degree of heterogeneity of a field f is defined by the formula $f = E_{\max}/E_{AV}$. The E_{AV} is average intensity of the field between electrodes and equals $E_{AV} = U/(R-r)$, where U is the enclosed voltage, $(R-r)$ is distance between external and internal cylindrical coaxial electrodes with radiuses R and r, accordingly, and $E_{\max}$ is the field defined by the formula, on a surface of an internal electrode. Such approach for defining f does not consider heterogeneity of the field created by a roughness of the internal surface of electrode. For calculation the heterogeneity of a field, it is necessary to take advantage of increasing the field near the sharp ledge which is characterized by the covered dielectric charges are not allocated [7]. The amplification of intensity of a field f at distance between electrodes L on a ledge with small radius of curvature is defined by expression:

$$f = A\frac{L}{a} \tag{1}$$

where A is the numerical coefficient close to 0.2. Thus, an electric field near to a ledge, which is characterized by the aspect relation L/a, (where L is the case distance between the cylindrical coaxial electrodes, equal R-r) is approximately equal to $0.2\,(L/a)$ which exceeds the average by volume value. It is necessary to note that the coefficient of amplification is sensitive to the geometrical form of a ledge.

III. EXPERIMENTAL RESULTS

Such ledges are the measured radius of curve of top carving cutting in internal electrode (a=0.1 mm) and the heterogeneity, created the thin metal wire densely reeled on a cylindrical glass tube of small radius. This wire creates a surface of dielectric ledges with radius of curve a=0.25 mm. Hence, for estimation of the heterogeneity of an electric field, it is necessary to use the equation (1). Estimations of heterogeneity for case (a) gives size of the order 7, and for case (b) as 4.25. It is accepted that [6, 8-9] sharply heterogenic fields are considered for coefficient of heterogeneity $f \geq 4$, but in poorly heterogenic fields $f \leq 1.6$-2. Thus, it is possible that in both types of constructions, it is possible to consider strongly the heterogenic field.

For heterogenic field, the average energy of electrons is participating in elementary acts of interaction in volume of a discharge gap and is approximately calculated by the formula [8]:

$$W_{E,AV} = 8.63\times10^{-4}\cdot T\left[21+33\log\left(\frac{0.5}{d}+44\right)\right] \tag{2}$$

where d is the length of discharge gap in centimeters, T is absolute temperature of gas and $W_{E,AV}$ is energy of electrons in electron volts.

It is noted that in ozonizers, the working range of discharge gap temperature is considers in the interval from 15 up to 32 °C. At high temperature the oxidation begins with nitrogen and the formation of ozone is stopped [9]. The calculations lead by the equation (2) and show that for both considered constructions the average energy of electrons varies from 18.83 eV at T=288 K up to 19.95 eV at T=308 K. This energy of electrons is quite enough for activation of processes formation.

The Measurements of ozonizers productivity have indeed shown that in other conditions, the output of ozone is artificially created periodic relief of a surface which essentially greater than of smooth structures.

Using the multi-tips cathodes, the great value of optimum geometrical parameters of the cathode is providing achievement of critical intensity of the field on emitters at enclosed voltage of several hundred volts. The approached problem decision is dependent on amplification factor of the field from in the geometrical sizes of edges and their arrangements on a surface of the bases are executed in the research [10]. In this paper, the electric field in the infinite plane parallel to condenser is considered in one plate which located infinite numbers of flat edges with thickness 2*r*. The form of edges is close to the triangular with height *H* and radius at top *r*. Expression for factor of amplification of the field *f* at top of an edge looks like:

$$f = \left\{ \left[th(\pi H / a \right] \cdot \pi r / a \right\}^{\frac{1}{2}} \times \times \left\{ \left[th(\pi H / a' \right] \cdot \pi r' / a' \right\}^{\frac{1}{2}} \quad (3)$$

where a is distance between the numbers of tip and a' is distance between tip inline.

If tip on the cathode is body of rotating and $a = a'$, so

$$f = \left[th(\pi H / a \right] / (\pi r / a) \quad (4)$$

Optimum geometrical parameters of such plate can be found with satisfactory accuracy from following parities:

$$\pi H / a \approx 2$$

$$H \approx (2E_{cr} \cdot d \cdot r) / U$$

$$(E_{cr} \cdot d) / U = \mu$$

where U is applied voltage; d is gap between electrodes and $E_{cr} \approx 2 \cdot 10^6$ V/cm [11].

For the diode with voltage 250-300 kV and an inter-electrode gap 3-7 cm in case of the emitters executed in the form of a comb from a copper foil with thickness of 20 mm, the optimum parameters are as the following:
- Height of edges over a cathode surface: 3 mm,
- Distance between edges: 5 mm,
- Radius of a curve of emitters: 10 ÷ 60 mm.

Thus intensity of the field at tops of edges 0.9 ÷ 1.5×10^8 V/cm. Producing described above multi-tips plates aren't connected with attraction of difficult technical means and differs the big productivity [12].

In the past years the great attention is given to creation of electronic devices with cold cathodes on a basis of micro and nanostructures. This class of devices includes electronic displays, sources of x-ray radiation, luminescent light sources, etc. which differ from traditional analogs in low voltage, consume smaller capacity, have small weight and the sizes. Therefore, cathode on the basis of nanotubes carbon using in reactors, as multi-tips, can essentially operate in its low working voltage.

Let's apply the equation (4) for calculating of amplification of the field at the cathodes made from nanotubes carbon. Let's the diameter of nanotubes is equal $d = 2 \times 10^{-7}$ cm, height $H = 1 \times 10^{-4}$ cm, distance between nanotubes $a = 2 \times 10^{-4}$ cm, radius at top nanotube $r = 1 \times 10^{-7}$ cm.

$$th\left(\frac{\pi H}{a}\right) = th(1.57) = 0.92$$

$$\frac{\pi r}{a} = 1.57 \times 10^{-3}$$

The amplification of field is

$$f = \frac{th\left(\frac{\pi H}{a}\right)}{\frac{\pi r}{a}} = 590$$

Let's assume that the distance between the cathode and anode $L = 10^* H = 2 \times 10^{-3}$ cm, and voltage between them U=100 V. Then average intensity of the field between the cathode and anode $E = 1 \times 10^5$ V/cm that isn't enough for autoelectronic issue. Intensity field at top nanotubes $E^* = f^* E = 10^5 \approx 6 \times 10^7$ V/cm. Such field can be observed in strong autoelectronic emission.

IV. CONCLUSIONS

High emission properties of nanotubes carbon are attractive not only to the cathodes, in the conditions of high vacuum, but for the cathodes entering into design of discharged gas devices. However in working with conditions of the discharged gas device, the cathode surface is exposed to continuous ionic bombardment that leads to fast destruction of nanotubes and decrease the emission characteristics of the cathode. For this reason the cathodes on the basis of nanotubes carbon can be used in discharged gas devices only in certain frequency modes, particularly, in the ozonizers-ionizers working in the waiting mode. The autoemission cathode on the basis of nanofibers carbon is stable in comparison with nanotubes.

The basic idea of using nanofibers carbon consists rather than intensive bombardment of cathode working surface by created gas ions and supports in dynamic mode in developed relief, containing numerous high curve emitting center [13].

In this paper, the autocathode from nanofibers carbon is a destruction of the separate emissions centers of the cathode under the influence of ionic bombardment. However, in destroyed issue centers, owing to the structural nanofibers carbon, the new emission centers are automatically formed. Therefore, the emitting surface of the autoelectronic cathode from fibres carbon, despite action of destroying factors, tends to self-restoration. Restoration of the emission centers provides high stability of the emission current and high service life of the autoemission cathode.

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