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OZONIZER WITH TWO BARRIERS PULSE DISCHARGE

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Abstract- In this paper two dielectric barrier ozonizer fed from the generator of high-voltage impulses of nanosecond duration is described. It is shown when ozonizer feed by the pulse voltage of nanosecond duration the ozone yield from not drained atmospheric air is higher, than at feed by microsecond impulses.

Keywords: Ozone Synthesis, Ozonizer, Dielectric Barrier, High Voltage Electrical Discharge, Generator of Pulse Voltages.

I. INTRODUCTION

The Ozone (O_3) is allotropic form of the oxygen and formed in all processes accompanied by occurrence of atomic oxygen. Ozone is a non-polluting oxidizer, disinfectant and deodorant, and in this quality, more and wider application in various branches recently finds the industries, agriculture, medicine, etc. Among various ways of development of ozone, the most economic and widespread way is its electro discharge synthesis from atmospheric air (or oxygen) in special devices ozonizers (ozone generators) in which the electric discharge is carried out in gaps between electrodes with use of dielectric barriers.

There is a set of types of the ozonizers, different in the sizes, the form, design features, a kind of electric voltages, its frequency and the ways of input of air and output of ozone etc. Now for ozone electro synthesis use various kinds of electric discharges. In each specific case, apply such version of the discharge where the certain elementary processes, which are responsible for conditions of a current flow through gases, are required. The main requirement for all ozonizers is reduction of losses of energy in an active zone, i.e. power efficiency of productivity. From this point of view, it is expedient to use in reactions of ozone synthesis the low-temperature no equilibrium electric discharges which general similarity is the small expense of embeddable energy on material heating [1].

As a result of numerous researches on use of various kinds of the gas discharge for electro synthesis of ozone the ozonizers using three forms of the discharge are more applicable:

1- The barrier discharge the big set of pulse micro discharges in a gas interval in length of 1-3 mm between two electrodes at a food of electrodes by a variable high voltage by frequency from 50 to several kHz.
2- The surface discharge developing along a surface of the rigid dielectric at a food of electrodes by an alternating voltage by frequency from 50 Hz until 15-40 kHz.
3- The pulse discharge-the streamer corona discharge the arising in an interval between two electrodes at a food by pulse voltage by duration from hundreds nanosecond to units of microseconds.

In the past years, the barrier discharge is basically used at the ozonizers creation. In some works essential influence on ozonizers productivity of frequency and the form of the enclosed voltage [2] is specified. It is noticed that the pulse form of feeding voltage is more favorable from the point of view of increase in productivity of an ozonizer in comparison with the sinusoidal form [3]. It is connected by that pulse electric durability of an interelectrode gas interval considerably above its durability at sinusoidal voltage that allows to increase amplitude of feeding voltage and, thereby, productivity of an ozonizer.

Other factor influencing productivity of an ozonizer is the frequency of feeding voltage because is with frequency growth productivity of an ozonizer increases also at the set productivity the dimensions, weight and cost of the gas-discharge reactor decrease. Besides, due to small duration of discharge impulses influence on formation of ozone of humidity of air, and also connections of nitrogen and other impurity containing in it is almost excluded that allows to spend more effectively electro discharge synthesis of ozone directly from atmospheric air without its preliminary drying.

Therefore, it is recommended to be guided by creation of power supplies with the pulse form of output voltage at developing the power supplies of ozonizers. In [4] results of comparative experiment with the one-barrier ozonizer which food from sinusoidal voltage by frequency of 50 Hz and from the generator of pulse voltage with duration of impulses 200-300 nanosecond are resulted. It is shown that productivity of an ozonizer at its pulse food it is considerable above, than at the sinusoidal.

II. EXPERIMENT AND DISCUSSION

In the present work, physical processes in a discharge interval of an active element of the two-barrier ozonizer presented in works [5, 6] are considered. Two-barrier ozonizers in most cases possess more low productivity on ozone than one-barrier, demanding besides higher voltage at identical lengths of discharge interval. Nevertheless, two-barrier ozonizers are characterized by better structure of a synthesized product because their electrodes, as a rule, are covered by qualitative dielectric, or divided by a glass tube with enough high dielectric permeability, and also because of absence on an outlet of harmful heavy atoms and inclusions materials of electrodes erosion.

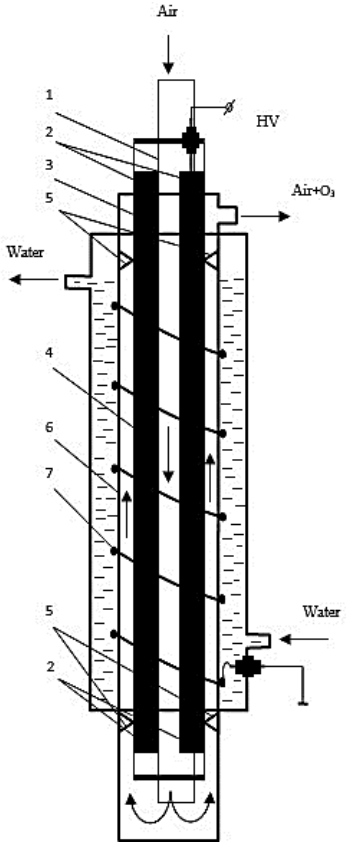

Figure 1. Cross-section of an active element of a pilot model of a multi-element two-barrier ozonizer

In Figure 1, the cross-section, section of an active element of a pilot model of a multi-element two-barrier ozonizer is shown. An internal high-voltage electrode (HV) is the central hollow cylinder from stainless steel (1) through which cleared and cooled air from top to down is blown. Dielectric washers with a carving (2) serves for consolidation of the coal grains (4) which are between the cylinder (1) and glass tube (3), playing a role of a dielectric barrier. Between the central electrode and the second barrier (6) in the form of a glass tube, the dielectric rings (5) for maintenance of a constancy of a discharge interval and coaxially all system as a whole are inserted.

Air blown through the hollow cylinder (1) passes in a return way through a discharge interval. A low-voltage electrode is the flowing water, which also served for cooling of a discharge interval. For uniform distribution of potential along a water electrode, the metal spiral is reeled up on the second barrier (7). The discharge interval is equal 1.5 mm, and the length of an active zone makes 1000 mm.

If pulse voltage is enclosed to electrodes with the amplitude, exceeding breakdown voltage of a gas interval in it there is a discharge consisting of a great number of separate micro discharges, discrete in space and in time.

Feature of the barrier discharge is local accumulation of a charge on a surface of a dielectric barrier at development of each separate micro discharge [7]. With increase in frequency of impulses, and, hence, reduction of duration of intervals between them, time necessary for a relaxation of stains of a charge on a surface of a dielectric barrier decreases that allows to receive discharge process at smaller values of initial voltage.

Besides, subsidence of charges on a barrier gives the chance to take part in the reactions leading to formation of ozone, not only the charges formed as a result of current discharge process, but also the charges which were late on the dielectric after the previous discharge. It should lead to increase in a yield of ozone with reduction of duration of impulses of applied voltage and growth of frequency of their following. Really, it is known [1] that in the barrier discharge the time constant of charge running off on a dielectric surface $t = \tau = \rho_b \varepsilon_0 \varepsilon_b$, where r_b and ε_b specific resistance and dielectric permeability of dielectric accordingly, ε_0 dielectric permeability in vacuum.

In work parameters are taken from [8] $\rho_b \sim 10^{10}$ Ohm.m, $\varepsilon_b = 7.5$, $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m. were used. For the specified material $t = 0.66$ s. Comparison of the obtained value of charge running off time t with impulses durations of applied voltage is in limits (~ 150-0.3) μs shows that the stains of the charge which has settled on dielectric are not in relax time in time between two subsequent impulses. It allows the charges, which have remained from the previous discharge processes to participate in ozone formation reactions in a discharge interval that leads to increase in ozone yield.

In considered system, the pulse voltage 25-30 kB applies between electrodes and the internal electrode is the cathode, since at a negative corona ozonizer productivity more than at positive [7]. Productivity of an ozonizer depends on quantity of energy receiving from the power supply in a discharge zone, and last depends on amplitude, frequency and form of feeding voltage. Experiments were spent on the developed installation on electro discharge synthesis of ozone from atmospheric air in which an ozonizer's power supply came out from a source of the high-voltage pulse discharge of nanosecond duration. As ozonizer's feed source the high voltage four cascade pulse voltages generator (PVG) was designed [9] (Figure 2).

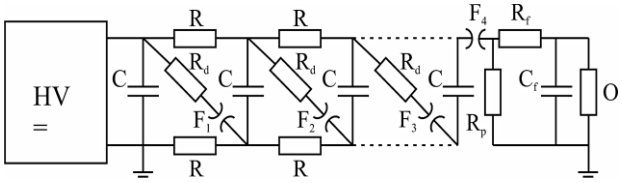

Figure 2. Principal electrical scheme of pulse voltage generator

Basic elements of generator are condensers *C*, connected through charge resistors *R* with a high-voltage source of constant voltage HV, spark arrestors F_1-F_4, discharge resistance R_p, front resistance R_f and capacity C_f. Group of 4 energy stores condensers *S* = 1000 pF, connected in parallel through resistance *R*, are charged from a source of constant voltage HV.

When voltage on condensers reaches the demanded value they are joined consistently by means of spark arresters F_1, F_2 and F_3 and voltages on the PVG's output are added (the multiplication scheme). After breakdown of spark arrestor F_4 total voltage of the generator arrives on loading through the block formation of front and length of impulse R_p, R_f, C_f. Thus, PVG works in two consecutive modes: a mode of condensers charging and mode discharge of consistently connected condensers on the load. In given work the generator provided reception of voltage impulses by amplitude 20 kV, following frequency 10 kHz, having the front duration ~ 40-50 nanosecond and impulse duration ~200-300 nanosecond.

In Figure 3, the typical oscillogram of a single voltage impulse of PVG by digital remembering oscillograph Tektronix TDS-754D with a pass-band of 500 MHz is presented. The scheme and design generator of generator allowed to regulate in certain limits the specified parameters of impulses by changing of parameters of the scheme: values of charge and discharge resistance, front resistance and capacities. For prevention of hindrances in measuring system from working generator in experimental installation, the careful screening was provided with grounding of the generator and ozonization system.

After adjustment of ozonization system and PVG, the installation got into gear, and electro discharge synthesis of ozone from atmospheric air was spent. For revealing of ozone synthesis efficiency at feeding of ozonizer from a source of pulse voltage of nanosecond duration a control series of experiments by means of the same ozonizer has been spent also at a food by pulse voltage 20 kV, but with impulses duration 150 microsecond and their frequency following of 900 Hz.

As a result of experiments on electro discharge synthesis of ozone from not drained air at atmospheric pressure following values of productivity of an ozonizer are received:

- An investigated series of experiments - 1600 mg/hour
- A control series of experiments - 929 mg/hour

The presented data is being averages from 5 experiences.

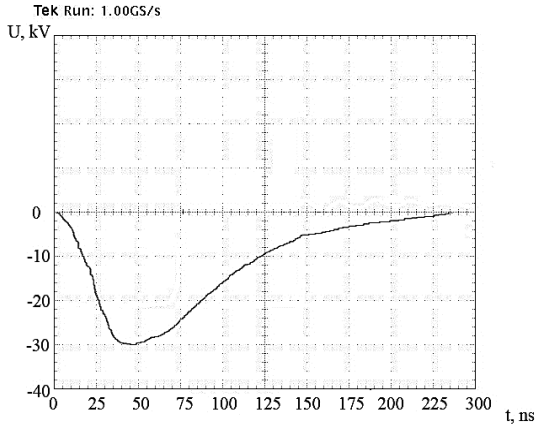

Figure 3. Typical oscillogram of single voltage pulse

III. CONCLUSIONS

As it is shown from the obtained experimental results productivity of an ozonizer at its food by nanosecond impulses considerably above than at a food by microsecond impulses, at invariable dimensions and length of discharge interval of the same ozonizer. The obtained results unequivocally testify advantage of use the pulse voltage of nanosecond duration to feed of ozone generators.

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BIOGRAPHIES

Nemat A. Mamedov was born in Baku, Azerbaijan, on June 30, 1938. He received the M.Sc. degree in Physics, in 1963 and the Ph.D. degree in Physical Plasma, in 1969 from Institute of Direct Currents, Russian Academy of Sciences, St. Petersburg, Russia. Currently, he is the Associate Professor in the field of Physics-Mathematics in Faculty of Physics, Baku State University (Baku, Azerbaijan). He has authored 130 scientific papers, 2 books and 4 patents. His research interests are in radio-physics, extreme high frequency electronics, and gas discharging apparatus and devices.

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