INVESTIGATION OF PLATE-TYPE BARRIER OZONIZERS WITH AC AND PULSE POWER SUPPLIES

V.V.Krasnji, S.P. Gubarev, V.D. Kotsubanov, D.P. Pogoghev, O.T. Sokolova, V.S.Taran, V.I. Tereshin, O.M.Shvets

Institute of Plasma Physics of National Science Center "Kharkov Institute of Physics and Technology," Akademicheskaya St., 1, 61108 Kharkov, Ukraine

In this paper the experimental results on the investigation of plate-type reactors operated on the base of barrier discharge have been presented. Different reactors with planar, strip, and trench electrodes were investigated. Such reactors operated under atmospheric pressure with ac and pulse power sources with voltage of up to 10 kV, frequency up to 12 kHz. Using atomized spectroscopy system the measurements of the main specifications of the reactors such as ozone yielding rate, the temperature in the reactor and the air flow rate were carried out.
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1. INTRODUCTION

Ozone technologies are widely applied in different areas: from medicine to agriculture, from domestic application to industry. For the better understanding of the ozone formation processes a series of experiments are being performed with the aim to obtain the optimal ozone yielding rate [1-4]. At present, commercial ozonizers have an energy yield of 90 and 180 g/kWh for dry air and pure oxygen gas, respectively. Since the theoretical limit of the energy yield is 1200 g/kWh, about 92.5% of the energy in a glow discharge is lost as heat[2]. In general case the yielding rate and output concentration of the ozonizers depend on many factors, which are tabulated in the Table.

Table. Basic factors which have an influence on O_3 yielding rate

Type of barrier discharge	glow surface
Constructional features of the reactor	parallel-plate, strip (wire), trench, concentric
Temperature in the reactor	$O_2+e \rightarrow O+O+e$ $O+O_2+M \rightarrow O_3+M$ $O_3+M \rightarrow O_2+O+M$
Gas flow rate	air, oxygen
Type of the dielectric	glass organic film

The ozone formation process consists of several stages. Generally, there are at least 70 reactions connected with ozone formation and its decomposition [5]. But, there exist the basic reactions without which the ozone formation is impossible. The basic reaction is the process of oxygen molecules dissociation with free electrons. The prolongation of such a process is of several nanoseconds. Next stage is the formation of ozone molecule in which presents the third particle – M: molecule, ion, electron or atom in neutral or excited state (the ozone formation required 10 microseconds). Besides the ozone formation, the decomposition of the 0_3 molecules takes place during the gas flow. In this case the ozone yielding rate depends on the relationship of ozone formation and decomposition. Furthermore, the higher the gas temperature, the more intensive flows the reaction. In this case the yield rate depends from relation between the intensity of the formation and decomposition of ozone. The time when the parcel of gas is localized in the discharge gap depends on a gas flow rate in the reactor. This means that the number of discharges, developing in the each parcel of gas flowing through the reactor depends on the applied voltage.

In the paper the ozonators of different type operating on the base of glow barrier discharge have been investigated.

2.EXPERIMENTAL

2.1 Apparatus for ozone measuring

The schematic block drawing of the experimental apparatus and date acquisition system used to test the reactors are shown in Fig.1.

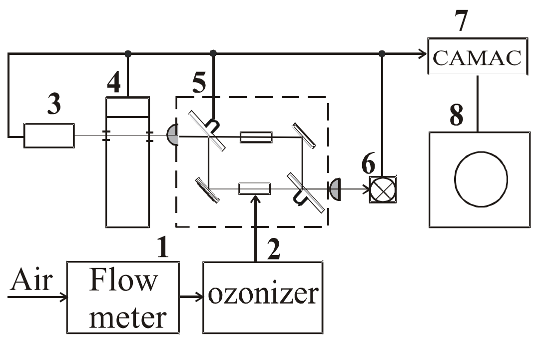


Fig. 1. Schematic block drawing of the experimental apparatus: 1-flowmeter; 2-ozonizer; 3-fotomultiplier; 4-monochromator МДР – 2; 5-the optical system with two quartz pans, glasses, stepper motor; 6-the UV stable source (mercury lamp) (λ = 253.7 nm); 7-crate Camac with modules: supply, amplifiers, synchronizers, multiplexing, ADC; 8- PC

The test equipment permits the control of the ozone yielding rate on the base of absorption UV irradiation. Ozone passes through a pen and its output concentration is calculated according to Lamberta-Bera law. The inlet and outlet temperatures of the ozonator were measured by thermocouples. The air flow rate was measured with a flowmeter.

2.2. Reactors

For the experiment we used the reactors of such types: (parallel plate, trench, strip/wire, concentric) which are presented in Fig.2. Figure 2a shows a parallel plate planar reactor. A kHz electric field is applied between two plane-parallel metal plates, at least one of which must be insulated to permit the charge build-up which maintains the plasma from one half-cycle of RF to the next. The electric field required to initiate the discharge is 6 kV for air. Both electrodes have a solid aluminum face (characteristically 4 x 6 cm) and one or both may be covered with glass insulating plates (thickness 1.5 mm) or organic film (thickness 0.2 mm). Figure 2b shows a trench reactor.

The trench type discharge reactor is barrier discharge with trench shaped aluminum electrode placed parallel position face to dielectric glass on the surface of plate aluminum electrode, as is shown in Figure 2b, and operated by a 5 kV pulse voltage power supply. Air flows between each triangle flow channel under high gas flow condition. In the trench type discharge electrode arrangements, the most of discharge occurs at the strong electric field region at sharp edges contact to barrier electrodes (surface discharge and chemical reaction take place at gas flow where relatively lower gas temperature and electric field. Since, this type of barrier discharge generates intensive discharges. Figure 2d shows a strip wire reactor. Metal plate electrode covered from both sic dielectric plates. From opposite sides of the pl titanium strip wire electrodes.

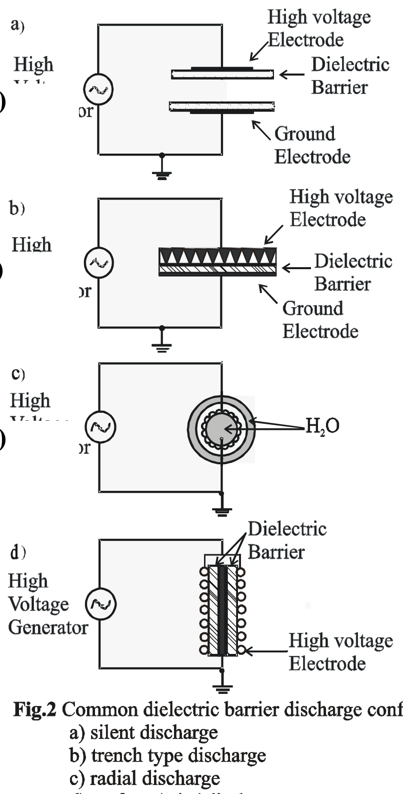
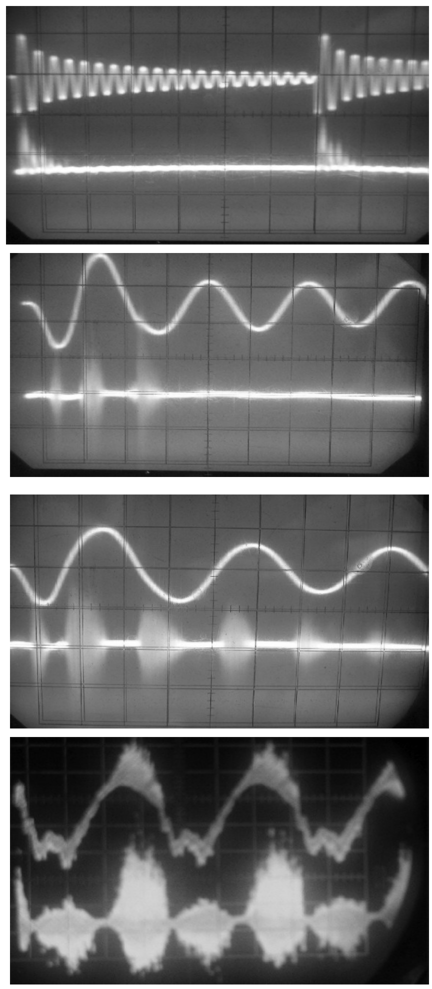


Fig.2 Common dielectric barrier discharge configurations:
a) silent discharge
b) trench type discharge
c) radial discharge
d) surface (wire)discharge

Figure 3a shows the instantaneous voltage and current for plate reactor operated at voltage of 6 kilovolts, and a pulse interval 680 μsec. At the early stage of the process shown in Fig 3b. The voltage was measured at the power supply output with a high voltage probe having the requisite frequency response. The current through the high voltage power cable was measured with a high bandwidth, inductive coil. The noisy region at the peaks of the current waveform represents the plasma initiation, during which a normal glow discharge briefly exists between the electrodes. There was a noticeable variability electrodes. The plasma ignition appears once per cycle or twice per cycle in the current waveform for the various panels and excitation voltages.

Figure 3d represents the current and sinusoidal voltage in the reactor of 3 kV and 3 kHz as well as plasma noise. The increase of the frequency of the applied voltage increases the ozone yielding rate. Figures 4 and 5 depict the dependence of the O_3 concentration as a function of power pulse period and the ambient air flow rate respectively. Figure 6 depicts the energy yield as a function of the ambient air flow rate.



a) b) c) d)

Fig.3. Time variation of the discharge voltage and current waveforms

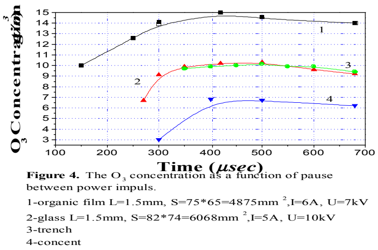


Fig.4. The O_3 concentration as a function of power pulse period: 1-organic film, 2- glass, 3- trench, 4-concentric

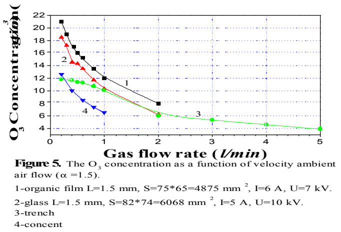


Fig 5. The O_3 concentration as a function of the ambient air flow rare (α=1.5): 1- organic film, 2- glass, 3- trench, 4- concentric

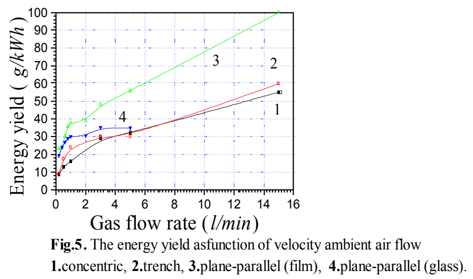


Fig. 6. The energy yield as a function of the ambient air flow rate:1- concentric, 2-trench, 3- plane-parallel (film), 4- plane-parallel (glass)

CONCLUSION REMARKS

1. The ozonators with reactors of various type based on glow barrier discharge have been developed.
2. There were developed and investigated the pulse and a.c. power sources. The comparative characteristics of such sources were considered for ozone generation. The pulse power source is an optimal choice for the ozone yielding rate.
3. The date acquisition system for the investigations of ozone characteristics was developed.
4. The optimal conditions for ozone output were determined for these ozonators.

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