STADY OF THE CHARACTERISTICS OF BARRIER FLAT OZONIZER WITH THE USE OF PULSE SUPPLY

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The characteristics of the barrier reactors of flat ozonators with the use of pulsed power supply have been investigated. The experimental data on the total, active and reactive powers were taken as well as the ozone yielding rate for reactors with various dielectrics used dependent on the air flow rate at different high-voltage pulse repetition rate was calculated.

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1.INTRODUCTION

At present time the utilization of discharge at atmospheric pressure with dielectric barrier attracts considerable attention. It is utilized for ozone generation, cleaning of different tools, application of coatings as well as for modification of various surfaces. As for ozone generation techniques a number of experiments are being carried out using various discharges and power supplies. The main characteristics of discharges were investigated with the purpose to obtain the optimum ozone concentration and its yielding rate dependent on the air flow rate and pulse repetition period of the applied voltage. Up to now, the authors have emphasized on experiments based on low power generators to produce ozonators [1,2]. At present research we have investigated a reactor module operated at 400 W for the following production of ozonator.

2.EXPERIMENTAL

The scheme of the glow barrier discharge under atmospheric pressure is shown in Fig.1. Dry air served as a working gas. The discharge was generated between two water-cooled flat electrodes (180 Ч 100 mm). Both electrodes were coated with dielectric material. Two types of dielectrics were used: the glass plates 2 mm thick with dielectric coefficient equal to 7 and glass-enamel - 0,2mm thick with the same dielectric coefficient. One of the electrodes was grounded whereas the high-voltage pulses with regulated on-off time ratio were applied to another electrode. The resulting current flowing through the discharge was measured by changing the voltage on (R1) resistor. The shift current was determined by measuring the current flowing through a known capacitor in the discharge circuit.

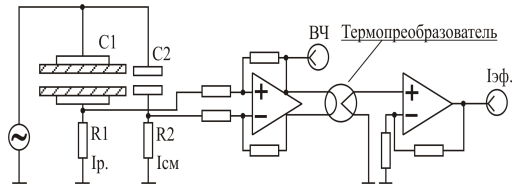


Fig.1. Measuring circuit of effective current in the barrier discharge

The efficiency of the active current through the discharge gap was obtained by subtracting the shift current from the line current with the help of operational amplifier. From the amplifier outlet the dedicated HF-signal of the active current was yielded on a thermo element where it was converted in a voltage proportional to the current.

The amplified signal was measured using analog-digital converter via computer line. The measuring of the ozone-yielding rate was carried out with the help of atomized spectrometer described in [3]. The common view of the reactor is shown in Fig.2.

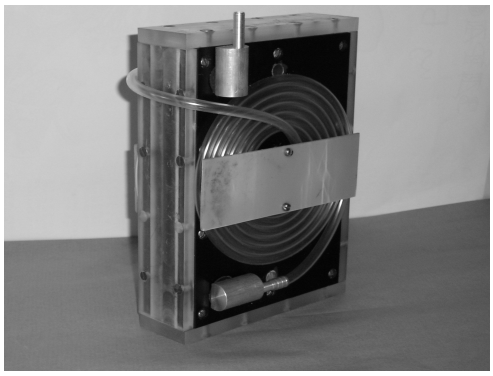


Fig. 2. Module of ozone barrier reactor with the water cooling

3. RESULTS

The active power (P_{act}) is one of the main characteristics, which determines the intensity of ionization processes in the discharge gap of the barrier reactor as well as the ozone formation processes. Fig. 3 depict the shapes of high-voltage pulses applied to the reactor and the active current in the reactor. The obtained experimental data allowed determining the active power in the reactor.

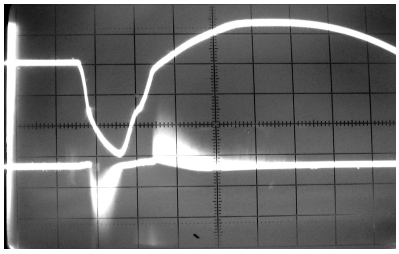


Fig. 3. Oscillogram of voltage (upper line) and effective current in the barrier discharge

The breakdown voltage in the discharge gap was determined to be from 7 to 8 kV. The obtained experimental data of the active power were compared with the method of measuring of the total power applied to the reactor. These data were identical. The electronic measuring scheme allowed selecting HF-signal of the active current at any shape of the applied voltage to the discharge gap. Figs. 4, 5 show experimental data of the total power, active power (1), reactive power and ozone yielding rate for reactors with two dielectric types at fixed air flow rates 1 – 3 l/min and with various repetition rates of high-voltage signal.

$$P_{act} = I_{effect} U_{effect}\,, \qquad (1)$$

$$U_{effect} = \sqrt{\frac{1}{T}} \int_0^{t+T} U^2 dt = \sqrt{\frac{t}{T}}\, U, \qquad (2)$$

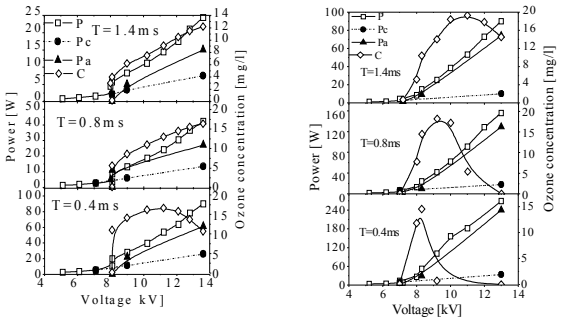
where T is the high-voltage pulse repetition rate, t – time of the active current and U – discharge voltage.

The output ozone concentration increases with increasing the active power. For each air flow rate exists critical power and after this point the ozone concentration tends to decrease. It is a result of ozone decomposition due to gas heating in a discharge gap leading to the following formation of nitric oxide. The plots also demonstrate an increase of output ozone concentration rate with decreasing the thickness of dielectric coating when selecting optimal on-off time ratio of the applied power pulses.

Fig.6. shows the reactors characteristics dependent on the dry air flow rate. These data allowed to determine the required power and flow rate taking into consideration the ozone concentration and its yielding rate. When operating with oxygen the ozone concentration rate was increased by 3.5 - 4 times with identical energy consumption.

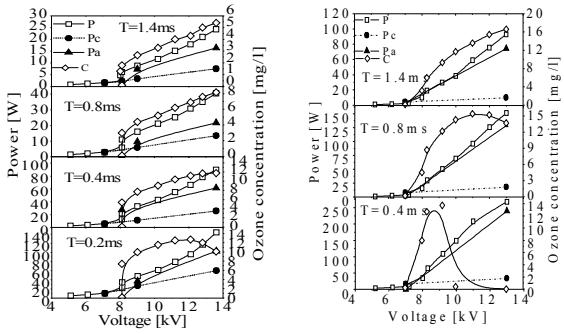
Taking into consideration the obtained experimental data, one can conclude that in order to improve the service characteristics of flat-barrier ozonators our main concern is to reduce the thickness of dielectric coating and to decrease the dielectric coefficient. The pulse repetition rate of the applied voltage should also be reduced. The optimal power for better ozone yielding rate can be obtained by regulating the pulse repetition rate of the supplying voltage. Numerous experiments are being carried out using preionization processes in the barrier discharge. In this case we deal with superposition of several discharges types. Basing on this idea a new reactor was developed in which two types of discharges (surface + DBD) were utilized. Two methods were proposed for surface discharge generation. In the first case, thin metallic stripes were deposited onto the surface of the electrode having a glass-enamel coating. In the second case the mica thin film isolated these stripes. In both cases the surface discharge was initiated at a voltage of 2 kV.

This initiates a breakdown of the main gap at 6 kV (with a direct barrier discharge 7 - 8 kV). It should be noted that in order to get optimal ozone concentration the distance between the electrodes of the surface discharge should be chosen properly.



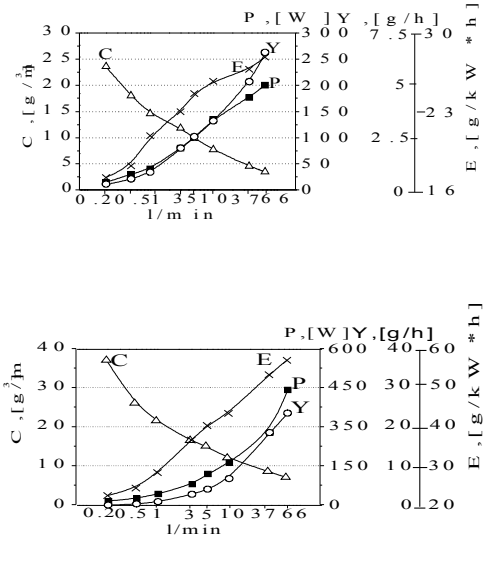
a b

Fig. 4. Dependences of the ozone concentration and discharge power for ozonizers with ((a) – glass, (b)-glass enamel) insulating plates as a function applying voltage. Air flow 1 l / min. T-repetition period of the pulses of the voltage. P - applying power, Pa – active power, Pc – reactive power



a b

Fig.5. Dependences of the ozone concentration and discharge power for ozonizers with ((a) – glass, (b)-glass enamel) insulating plates as a function applying voltage. Air flow 3 l / min. T-repetition period of the pulses of the voltage. P - applying power, Pa – active power, Pc – reactive power



a

b

Fig.6. Characteristics of ozone generation

(a -with glass dielectric, b -with glass enimel dielectric), C –ozone concentration, l – air flow rate, P – applied power, Y – yield rate, E – energy yield

A capacitor was used to regulate the voltage applied to the metallic stripes. In so doing one may speculate that the utilization of the preionization in the main discharge provides 5 – 10% increase of ozone output concentration. But reactors of such type are difficult to produce technically due to problems connected with a heat sink.

CONCLUSIONS

Optimization parameters of the barrier discharge at atmospheric pressure are scientific interest and due to various applications. The barrier reactors of flat electrodes with the use of two types of dielectrics and pulsed power supply has been investigated. The main characteristics of discharges were investigated with the purpose to obtain the optimum ozone concentration and its yielding rate dependent on the air flow rate and pulse repetition period of the applied voltage. The electronic original measuring scheme allowed selecting HF-signal of the active current at any shape of the applied voltage to the discharge gap, which made it possible to determine possible to determine active power in the barrier discharge**.**

The maximum concentration of ozone obtained 30 mg/l with the flow rate 0.2 l/min and 7 mg/l with the flow rate 40 l/min using pure air flow. On the basis of the conducted investigations is prepared the module of industrial ozonizer with the power 500 W.

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ИССЛЕДОВАНИЕ ХАРАКТЕРИСТИК ПЛОСКОГО БАРЬЕРНОГО ОЗОНАТОРА С ИМПУЛЬСНЫМ ПИТАНИЕМ

В.В. Красный, А.В. Клосовский, А.С. Кныш, В.С. Таран, О.М. Швец

Проведены исследования характеристик озонатора на основе барьерного разряда с плоскими электродами и импульсным питанием. Получены экспериментальные данные о соотношениях полной, активной и реактивной мощностях в барьерном реакторе, а также выходной концентрации озона и производительности в зависимости от скорости протока воздуха и частоты повторения высоковольтных импульсов питания.

ДОСЛІДЖЕННЯ ХАРАКТЕРИСТИК ПЛОСКОГО БАР'ЄРНОГО ОЗОНАТОРА З ІМПУЛЬСНИМ ЖИВЛЕННЯМ

В.В. Красний, А.В. Клосовський, А.С. Книш, В.С. Таран, О.М. Швець

Проведено дослідження характеристик озонатора на основі бар'єрного розряду з плоскими електродами й імпульсним живленням. Отримано експериментальні дані про співвідношення повної, активної і реактивної потужностей у бар'єрному реакторі, а також вихідної концентрації озону і продуктивності в залежності від швидкості течії повітря і частоти повторення високовольтних імпульсів живлення.