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EFFECT OF INTER-ELECTRODE GAP PROPERTIES ON THE COURSE OF AN OZONE SYNTHESIS PROCESS

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A b s t r a c t. An effect of wire packing on ozone generation has been experimentally studied and discussed from the viewpoint of efficient generation of high ozone concentration for an air-fed ozonizer. On the basis of the obtained measurement data essential parameters that influence the obtained ozone concentration depending on a discharge zone design have been determined.

K e y w o r d s: ozone generation process, ozonizers, discharge gap configuration, wire packing.

INTRODUCTION

A rapidly growing demand for ozone can be continually observed. Aside with already known and practiced ozone applications new ones have shown up lately like its application to the production of paper or within organic synthesis technologies. Ozone generation is characterized by a high rate of energy consumption and only 10-15% of the energy gets consumed for the very production of the gas which makes a justification for developing research into finding more efficient ozone synthesis technologies.

Presently, there are a few trends that dominate within fundamental and technological research concerning ozone generation in silent discharges [1-3]. They are related to some essential but still not entirely fathomed problems like an ozone formation mechanism, an application of new materials as electrodes, dielectrics, catalysts, attempts to generate new forms of discharges (silent, corona, surface ones and other) whose common feature is maintaining a relatively low temperature (close to ambient temperature) of the gas that is subdued to the discharge action with the electron energy being higher than the dissociation energy of oxygen molecules and without any necessity of pressure reduction and even with a possibility to run the synthesis under a slightly elevated pressure.

New trends in designing ozone generating installations of high efficiency lead to a considerable increase of supplied power per surface unit of ozonizer electrodes which can be obtained mainly in ozonizers fed with a current of elevated frequency that makes a quantity that energy consumption, ozone concentration and gas temperature in a discharge gap depend on.

Investigations hitherto performed by our team have been mostly focused on analyzing the effect of such factors as a kind of the applied substrate gas (air or oxygen), intensity of the gas flow through an ozonizer, electrical quantities with voltage and power of discharges in particular, frequency and shape of feeding current, and a design of an ozonizer. Within the last mentioned case much attention has been paid to the dielectric - its kind, thickness and location in the system of silent discharge generation. A factor that has never been analyzed for the set of tested ozonizers is the absence of packing in a discharge zone which - according to theoretical assumptions and literature data - should have much greater effect on the ozone decomposition kinetics than on the synthesis course.

EXPERIMENTAL

Tests have been performed in a tubular ozonizer with a polyethylene-terephthalate (PET) dielectric barrier [4,5] and in an ozonizer with a conducting packing in its discharge zone [6]. Characteristics of ozonizers used in the tests are presented in Table 1.

Table 1. Characteristics of ozonizers.

Ozonizer with PET as a dielectric dielectric thickness g= 0.15 mm		Ozonizer with a wire packing (copper ϕ=2 mm)	
Discharge gap [mm]	total capacity C_c [nF]	Discharge gap [mm]	total capacity C_c [nF]
1.3	0.526	6.0	0.346
2.2	0.310	12.5	0.463
3.4	0.198	Discharge gap length L=0.3 m	
4.4	0.158		
discharge gap length L=0.5 m			

The following parameters have been variable in the experiments: discharge gap size, voltage supplied to the ozonizer and volumetric flow rate. Air dried up to the dew point of -60°C has been used as a substrate gas. Diagram of the applied electrical feeding and a measurement system is presented in Fig. 1.

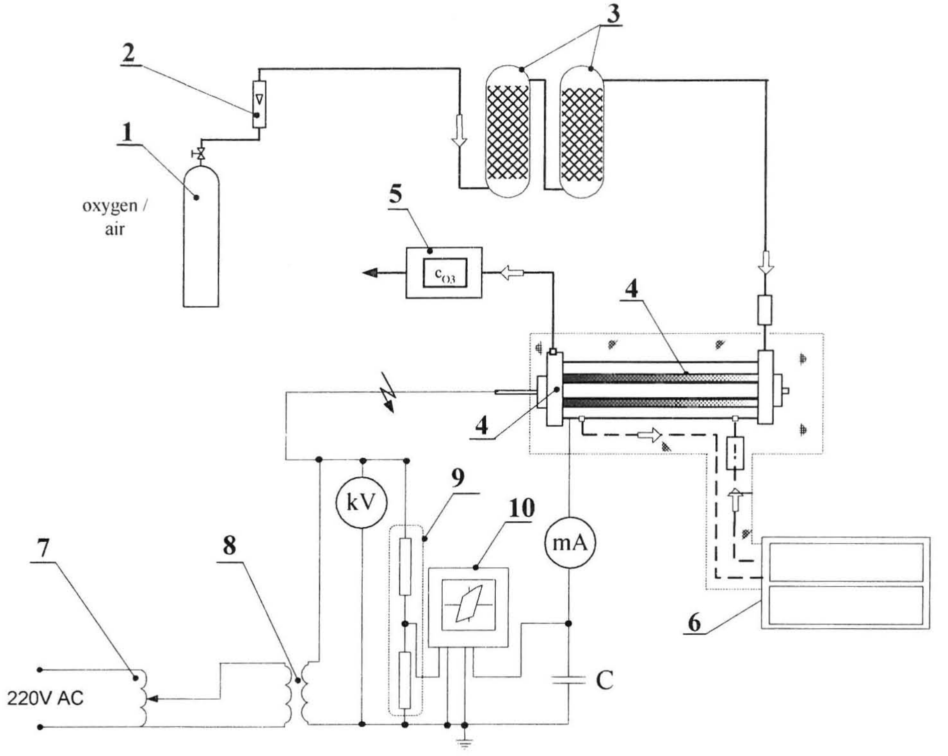

Fig. 1. Electrical circuit and a measurement system
1 – container of substrate gas, 2- rotameter, 3 – drying column, 4- ozonizer, 5- ozone concentration measurement, 6- thermostat, 7- autotransformer, 8- HV transformer, 9- voltage divider, 10- oscilloscope type TDS3012B.

RESULTS AND DISCUSSIONS

Figures 2 and 3 present voltage-current and charge-current electrical characteristics of an ozonizer with a thin-layer dielectric and of a one with a conducting packing. In Fig.3 additionally a total capacity of an ozonizer with a wire packing is given. Calculated values for an ozonizer without a packing are the following: for a gap of d= 6.0 mm, C_c= 0.0369 nF and d=12.5 mm, C_c=0.010 nF. The presence of a packing increases a total capacity of an ozonizer by over 8 times and according to the Manley formula at a constant values of feeding voltage and a dielectric layer capacity active power transferred to a discharge zone is greater.

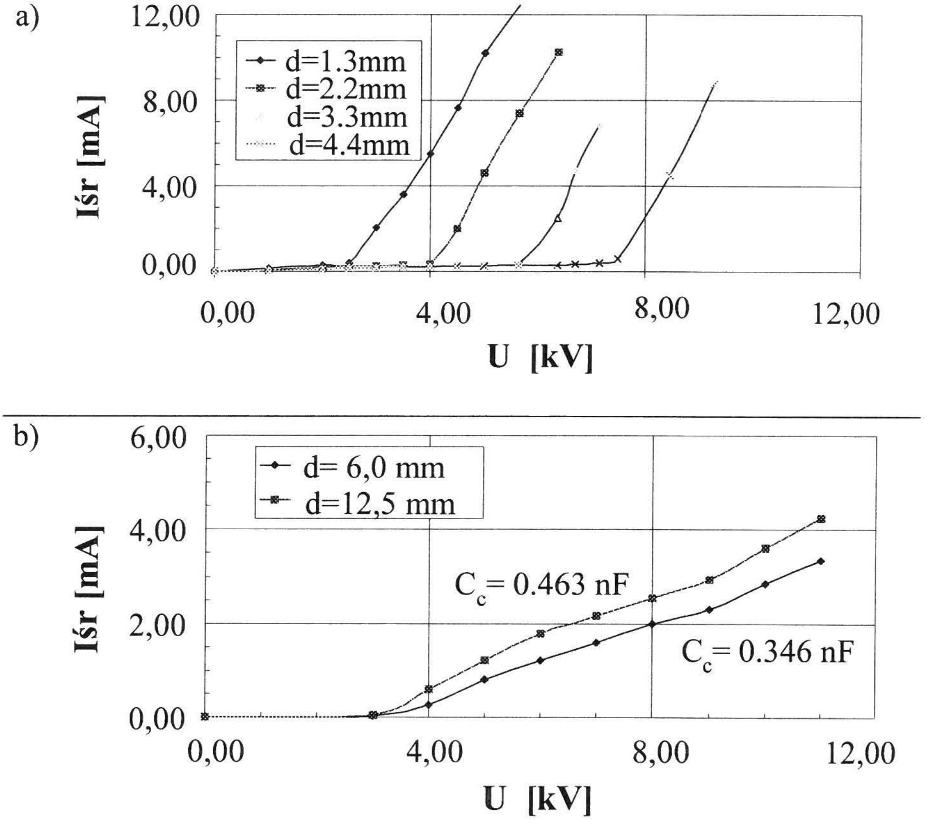

Fig. 2. Static operation characteristics of an ozonizer with a) PET and b) conducting packing.

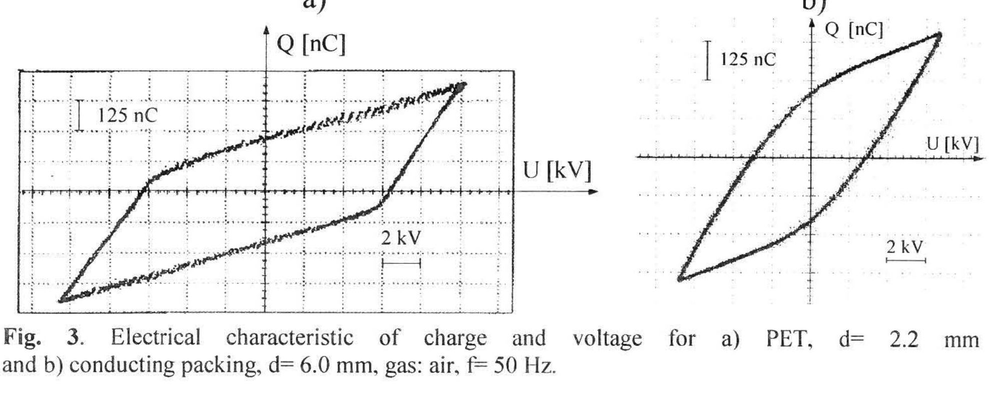

Fig. 3. Electrical characteristic of charge and voltage for a) PET, d= 2.2 mm and b) conducting packing, d= 6.0 mm, gas: air, f= 50 Hz.

It follows from an analysis of dynamic electric charge-voltage characteristics of an ozonizer with a conducting packing that the discharge character differs from classical silent discharges (Fig. 3a) which proves different operation of the apparatus and active role of the packing in an ozone synthesis process. There are no pulses reflecting individual microdischarge channels. Conducting packing enables a development of corona discharges at comparatively low voltage of the ozonizer operation. Selected dependences that characterize the ozone synthesis process course are presented in Figs 4 and 5.

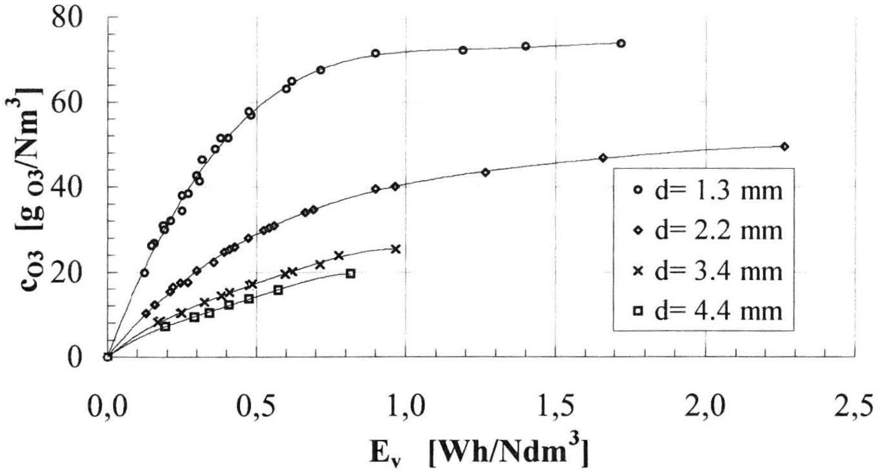

Fig. 4. Effect of specific energy density (E_v) on ozone concentration (C_{O3}) at varied discharge gap (d), gas: air.

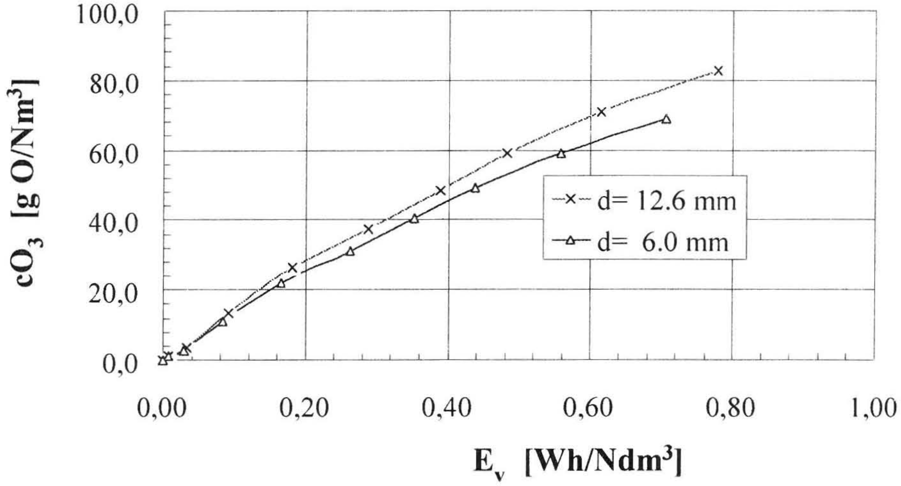

Fig. 5. Ozone concentration vs. energy density for an ozonizer with a wire packing, gas: air.

In ozone generators equipped with a conducting packing their discharge gap size does not influence the obtained ozone concentration so strong as it is in the case of ozonizers without a packing. Conducting packing causes a formation of a strongly asymmetric electrical field and conditions that a favorable for the development of streamers not only in the vicinity of an high-voltage electrode but also over the whole discharge area. Corona discharges initiate a process of low-temperature plasma generation and initial gas ionization while the proper ozone generation process occurs in a silent discharge. In tubular ozonizers of the Siemens type small discharge gaps of the 0.2÷0.8 mm order are applied to obtain high ozone concentration at comparatively low energy consumption.

CONCLUSIONS

The obtained dependences clearly indicate that a wire packing contributes to the increase of a total capacity of an ozonizer and thereby makes possible to supply greater power to the discharge zone at a fixed feeding voltage value. In ozone generators with a wire packing the discharge gape size effect on the obtained ozone concentration is not as strong as it is in the case of ozonizers without a packing .

The obtained results also prove that an effect of a conducting packing located in a discharge gap on the course of an ozone synthesis process and energy efficiency of the process is significant. and can make a prospective design solution for new types of industrial ozonizers.

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WPŁYW CECH SZCZELINY MIĘDZYELEKTRODOWEJ NA PRZEBIEG PROCESU SYNTEZY OZONU

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S t r e s z c z e n i e. Wpływ wypełnienia przewodzącego na syntezę ozonu był sprawdzany doświadczalnie i oceniany z punktu widzenia uzyskiwania wysokich stężeń ozonu w ozonatorach zasilanych powietrzem. Na podstawie otrzymanych rezultatów stwierdzono że podstawowe parametry wpływające na stężenie ozonu zależą od konfiguracji strefy wyładowczej.

S ł o w a k l u c z o w e: proces syntezy ozonu, ozonatory, konfiguracja strefy wyładowczej, wypełnienie przewodzące.