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DEVELOPMENT OF CYLINDER DIELECTRIC BARRIER DISCHARGE WITH STAINLESS STEEL FOR OZONE PRODUCTION

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ABSTRACT

This paper presents the development of dielectric barrier discharge research. In order to investigate the optimum conditions for ozone production, measurements of ozone concentration were carried out for various conditions such as type electrodes and distance density between peak to peak of the electrode. It discusses the performance of the different types of electrodes, i.e. helix and screw. This research analyzed the results obtained from two different types of electrodes while the screw-type has higher ozone concentration than the helix type. This occurred due to the influence of sharp edge effects that increases the electric field around the angle of the helix. Another effect for ozone production is peak to peak distance density on the electrode winding. The high ozone concentration is indicated by the density of the 2 mm distance from peak to peak. This development cylinder dielectric barrier discharge is able to produce ozone product at more than 2000 ppm by using 6kV.

I. INTRODUCTION

The development of high voltage technology has been widely used in various fields. One of the most researched high voltage technology developments is ozone (O_3). Utilization of ozone is currently widely used for various activities such as water treatment [1], sterilization [2], and as a microorganism killer [3-5]. Ozone has a high oxidation potential due to it being able to produce hydroxyl radicals in systems. Ozone is commonly used for disinfection of bacteria, oxidation of inorganic and organic compounds, including taste, odor, color, and particle removal [6].

Ozone is a type of non-thermal plasma. Ozone can be produced by reacting air / oxygen (O_2) which is exposed to high voltage using a Dielectric Barrier Discharge (DBD) reactor. Exposure to high voltage will increase the voltage which results in an electric field in the electrode gap. The electric field will continue to increase and cover the oxygen, and thus the ionization process will occur. The important parameters in ozone production are gas flow rate, discharge power, oxygen concentration, distance between electrodes, volume of discharge chamber [7].

Electrodes that are exposed to high voltages will produce an electric field that is not homogeneous, thus discharge will arise before the total breakdown occurs which is able to distribute the electric field around the electrode. Discharge requires a high voltage in use or the electric field must be high enough to cause a breakdown of the gas [8]. The basic design of the Dielectric Barrier Discharge reactor consists of two electrodes separated by a dielectric barrier between them. Dielectric Barrier Discharge is a closed reactor system that will produce plasma discharge between two stainless electrodes as a positive electrode on the inner side of the tube and the outer electrode as a negative electrode [9]. To get the optimum ozone concentration, the Dielectric Barrier Discharge reactor must be suitably designed [10].

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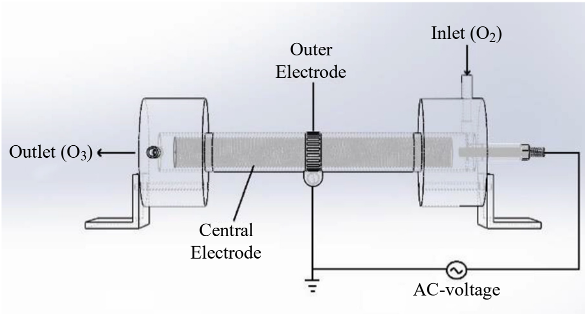

Fig. 1 Design cylinder DBD

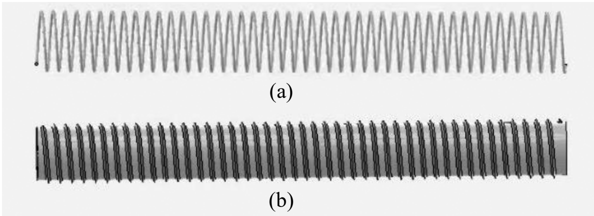

Fig. 2 Electrode (a) Helix type, (b) Screw Type

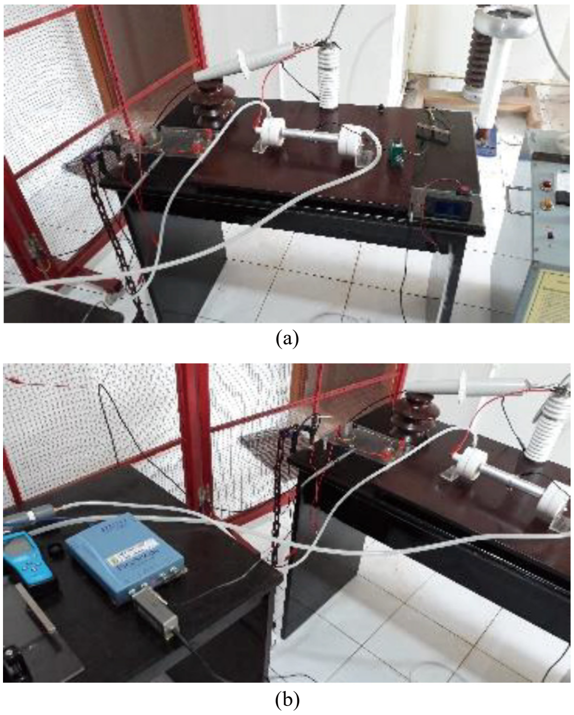

Fig. 3 (a) and (b) Experimental setup DBD reactor

Research related to ozone production has been carried out, especially using the DBD method. Suraidin *et al.* [11] used DBD with a cylinder–cylinder configuration by using galvalume, stainless steel and copper for ozone production. Other researchers also studied ozone with DBD but used a different material made of steel and an outer electrode made of aluminum, using dielectric glass with a diameter of 6 mm and a thickness of 1 mm, and using a voltage between 1–20kV and frequency of 10–30 kHz [12].

The electrodes in the Dielectric Barrier Discharge function to create an electric field, thus a large electric field will increase the ozone produced. The different types of electrodes used can affect the formation of O_3. Based on several previous studies, this research was conducted using a helix and a screw type with stainless material. This study uses stainless steel as it has advantages including high thermal conductivity, and is thus able to produce a high electric field and is resistant to corrosion. In addition, the electrode coils in research is conducted by placing electrode on the inside of the DBD reactor tube, where there will be differences in the treatment that has been carried out by previous researchers by placing the electrodes on the outside of the DBD reactor tube. However, there is no research that discusses getting high ozone concentration [12-14] despite being able to provide benefits for various applications. In this research, the objective is to obtain high ozone concentrations by using two different types of electrode windings.

II. METHOD

In this study, electrode has been developed by designing a chamber as shown in Fig. 1, using screw and helix type electrodes separated by a distance of 1 mm which has a glass dielectric barrier of 1 mm thickness.

In Fig. 1, the designed chamber has a length of 200 mm, consisting of a tube with a diameter of 24 mm and a core electrode using stainless steel material. The electrode coil is placed in the middle of the Pyrex glass tube at a distance of 1.5 mm for each coil. The electrode coils that are used have two different types of electrode coils, namely the helix type and the screw type. Helix type (Fig. 2a) is the type like a spiral staircase whereas the screw type (Fig. 2b) is type like spiral staircase but has sharp edges at the peaks.

Fig. 3a and 3b show the experimental setup that will produce ozone. The equipment needed in the experimental setup consists of a high voltage input, an oxygen input and a chamber. The research work process uses oxygen input and high voltage input which is slowly increased and flowed into the chamber through the electrode coil, thus ionization, dissociation and recombination of O_2 molecules and O atoms form ozone due to the presence of free electrons in the reactor. The ozone concentration will be measured using an ozone analyzer BMT 964bt.

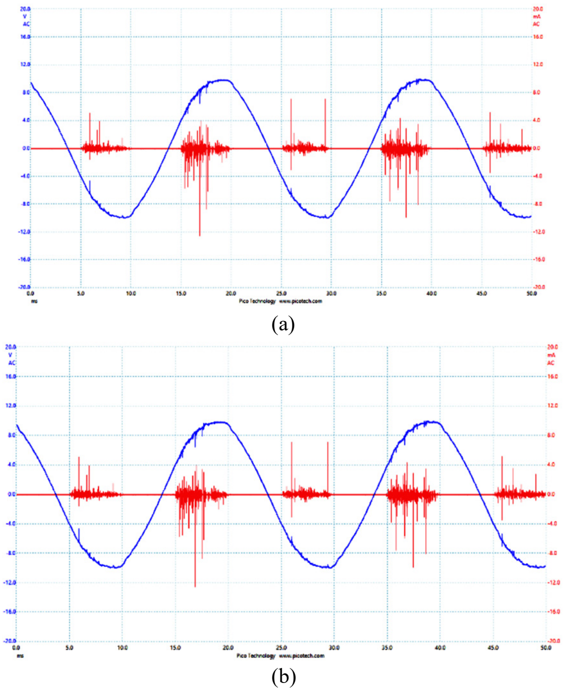

Fig. 4 The effect of voltage and current on ozone concentration (a) Screw 1.5 mm (b) Screw 2 mm

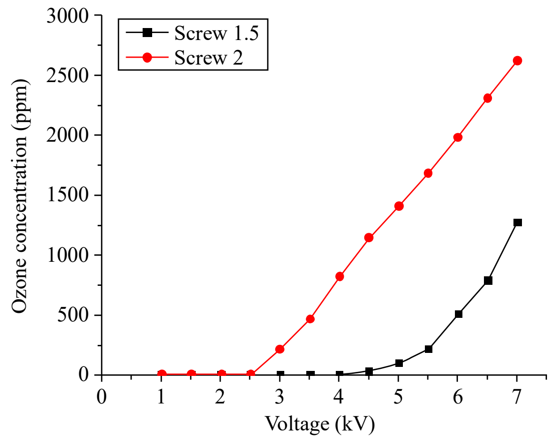

Fig. 5 The effect of voltage on ozone concentration

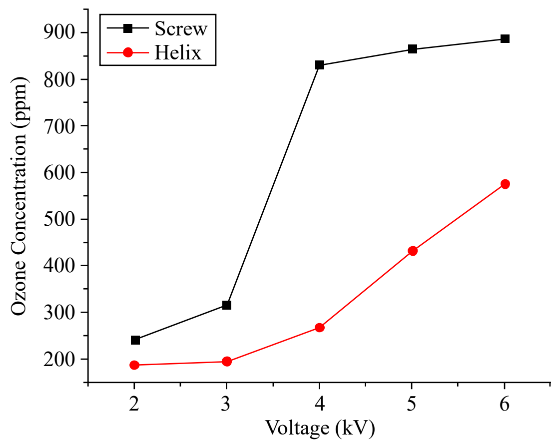

Fig. 6 Effect of voltage on ozone concentration with different types of electrodes (helix type and screw type)

III. RESULTS AND DISCUSSIONS

Fig. 4 showed the results using stainless steel material of screw type with two different types of distance peak to peak electrodes in the Dielectric Barrier Discharge reactor based on the experiment has been carried out in the laboratory.

Fig. 4a and 4b show the effect of voltage on ozone concentration which is influenced by the density of the distance peak to peak. The high ozone concentration is indicated by the density of the 2mm distance from peak to peak (Fig. 4b). The current density that occurs in Fig. 4a and Fig.4b affects the amount of ozone concentration.

Fig. 5 shows the effect of voltage on ozone concentration. These results indicate that an increase in voltage will be followed by an increase in current resulting in an increase in the amount of ozone concentration (Fig. 4b), since the surface area between peak to peak provides more space for the diffusion of charge to the electrodes.

In this study, results were carried out with two different types of electrodes. Fig. 6 shows the effect of voltage on ozone concentration with two different types. The results obtained show that the screw type electrode has a 35.1% higher ozone concentration than the helix type electrode shown in Fig. 6. The distance peak to peak of the electrode has the same length, but the peak on the screw has a sharp edge thus there is a sharp edge effect that increases the electric field around the angle of the screw. It can be concluded that the screw type produces a higher electric field because there are sharp edges to the side of the electrode. This result is in accordance with other research which states that electrodes that have sharp angled sides can produce high ozone concentrations [15-19].

IV. CONCLUSIONS

The difference between the two types of electrodes affects the results of the ozone concentration due to the influence of a sharp edge at the peak of the electrode which produces a high electric field. The distance peak to peak of the electrode has the same length, but the peak of the screw has a sharp edge, thus there is a sharp edge effect that can increase the electric field around the corner of the screw. The density of the distance between the peaks also has an effect on ozone concentration as the surface area of the space between the peaks makes the charge diffusion become larger, resulting in a high ozone concentration.

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