Comparison of ozone production by DBDP reactors: difference external electrodes

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Abstract. Research on ozone generator performance technology of dielectric barrier discharge plasma (DBDP) has been conducted. The study was carried out by using two models of reactor configuration. The first model uses a wire mesh - aluminum foil configuration. The second model uses the wire mesh electrode configuration - wire mesh wrapped in aluminum foil. Ozone was generated using AC high Voltage. Oxygen that source of ozone has been taken from the water. The ozone was produced by DBDP reactor with voltage variation from 0.5 to 14 kV and a fixed air flow rate of 10 L/min. The first models of the reactor was Be Able to produce ozone of 138 ppm at a voltage of 14.3 kV with a maximum temperature of the inner reactor at 49 °C. The second model of ozone produced with concentration of 163 ppm at a voltage of 14.2 kV and a maximum temperature of the inner reactor of 52 °C. We found that reactor with wire mesh electrode configuration - wire mesh wrapped in aluminum foil can produce more high ozone concentration with the same voltage.

I. Introduction
Dielectric barrier discharge plasma (DBDP) is one of the most effective technologies in producing ozone [1,2]. The plasma dielectric barrier discharge (DBDP) reactor produces ozone by utilizing the plasma glow that occurs between the active electrode and the dielectric barrier. The air passes through the gap will ionize, recombination and dissociate by a collision mechanism between electrons with airborne particles or oxygen molecules [3,4]. Ozone production is generally affected by stress, electrode material, reactor geometry, reactor configuration, pressure, gas flow rate, frequency, humidity, power source, temperature, and gas source in reactor [1-13].

The production of ozone using DBDP cylindrical-cylindrical electrode configuration has been studied in reference [2,5,6,7]. Ozone production for industrial applications has also been studied [8,9]. Suraadin et al [7], studied the DBD ozone generator with a variety of electrode materials in stainless steel, galvalume, and copper. In reference [3], the DBDP reactor characteristics using stainless steel wire mesh electrodes has been analyzed to produce ozone. In this study, the active electrode of stainless steel wire mesh can be used to produce ozone with considerable capacity.

In this paper, we studied the performance of two DBDP reactors that have similarities to the inner electrodes but differ in their outer electrodes. The first model configured electrodes in stainless steel cylindrical wire mesh and outer electrodes are made of stainless steel wire mesh wrapped in aluminum foil. The second model has configured electrode in stainless steel cylindrical wire mesh and aluminum foil outer electrode.
2. Experimental Methods
The research scheme is shown in Figure 1. The DBDP reactor used consists of 2 models. The first model uses an electrode in stainless steel wire mesh cylinder configuration with a length of 19 cm and an outer aluminum foil electrode with a length of 20 cm. The second model uses an electrode in a stainless steel wire mesh configuration with a length of 19 cm. Outdoor electrode wire meshes stainless steel cylinder configuration wrapped in aluminum foil with a length of 20 cm. DBD reactor blocker uses Pyrex glass with a length of 23 cm, diameter 2.7 cm in diameter and 3.1 cm outside diameter.

The power supply uses high voltage AC with frequency 203 Hz and voltage variation of 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 12.2, and 14.3 kV. The gas source uses free air with a flow rate of 10 L / min. The heat generated in the DBD reactor, ie inside the reactor and at the end of the reactor output, is measured using an infrared thermometer. Measurement of ozone concentration using titration method. The ozone concentration can be calculated using the equation [14,15]:

\[ C = \frac{24 \times V_t \times M \times 1000}{\text{flow rate} \times t} \]  

with \( V_t \) is the volume of titrant (sodium thiosulfate) in liters, \( M \) is the molar of titrant (sodium thiosulfate) in grams / L, \( t \) is the time of exposure of ozone to the KI solution.

3. Results and Discussion

3.1. Characteristics of current as a function of voltage
Picture. 3, showing the electric current characteristic curve as a voltage function of the DBDP reactor. The characterization was performed on an outer electrode reactor of stainless steel wire mesh wrapped in aluminum foil (reactor B) and the aluminum foil outer reactor (reactor A), using a 10 L / min flow rate. The addition of voltage can increase the electric current as the charge changes in units of time. This is because increasing the voltage will produce an electric field is getting bigger. Large electric fields are capable of accelerating the movement of electrons accumulated around the activating electrodes impinging air molecules resulting in ionization, dissociation [3.10]. The characteristics of the voltage function current in reactor B and reactor A have the same upward trend. Electric current at reactor A is always lower than reactor B. At the same voltage that is 14 kV electric current at reactor B of 8.91 mA or close to double the reactor A.

3.2. Power as a function of Voltage
Figure 4. It is the power curve as a function of voltage. The addition of voltage also affects the amount of reactor power consumption. The input power can be calculated by multiplying the input voltage with measured electrical current. In reactor B as the addition of voltage causes the power consumed also increases. Voltage 8 - 14 kV happened quite rapid increase. The reactor power consumption A has the same trend with a value that is always smaller than that of reactor B. At 14 kV, the input power of reactor A is 64 watts or almost half of reactor power B.
Figure 3. Electric current as function of voltage

Figure 4. Power as function of voltage

3.3 The effect of stress on ozone production

Figure 5 shows the variation in ozone concentration as a function of voltage. The concentration of ozone increases with the addition of voltage for both reactor models. Fang et al [2] also provide similar results for cylinder-cylinder configured DBD reactors. The voltage between 3 - 7 kV shows the result of the ozone concentration of the reactor A production is higher than ozone production using reactor B. Voltage from 7 - 14 kV shows the opposite trend. Ozone production using reactor A is always smaller.

Figure 5. concentration as function of voltage

Figure 6. concentration as function of power

3.4. Effect of power consumption to produce ozone

The ozone concentration of DBDP reactor production as a power function is shown in Figure 6. In the two reactor models, the greater power consumed affects ozone production, which increases its concentration and capacity. Reactor A requires a minimum power of 1.8 watts to produce ozone, while reactor B requires a minimum power of 3.2 watts. Input power between 1.8 - 64.8 watts seen ozone production using reactor A is always higher. Production of ozone at a voltage of 14 kV, reactor A produces ozone with a concentration of 138 ppm and reactor B produces ozone with a concentration of 163 ppm. Figure 7, shows the resulting ozone capacity also has the same trend. Reactor A has the highest ozone capacity of 75 grams / h with a power consumption of 0.06 kW. While reactor B requires a power input of 0.12 kW to produce ozone with a capacity of 98 grams/hour.

The mechanism of ozone formation in the DBDP reactor has been presented by previous researchers [2,11]. The process of formation begins with the collision of electrons with oxygen molecules passed in the reactor to produce oxygen atoms, then binds to oxygen molecules to form ozone.
3.5. **Temperature change in the reactor**

Figure 8. shows that the temperature change in the reactor and the reactor output tip increases with the increase of operating time at a voltage of 11 kV. Furthermore, the temperature at different places the results are also different. Reactor B has a maximum temperature of 39 °C at the output end and 52 °C in the reactor, after operating time of 270 minutes. While reactor A has a lower maximum temperature change of 37°C at the output end and 49°C in the reactor, after operating time of 280 minutes. Boonduang et al [6], provides an analysis that the surface temperatures of the ozone reactor will increase during extended operating times. In addition, the heat generated inside the reactor is not uniform. This increase in temperature occurs due to convection heat transfer from hot air ion air. As the air flows around the active electrode, the plasma generates the heat to be carried toward the reactor output [13].

4. **Conclusion**

Ozone production using DBDP reactor with wire mesh electrode configuration - wire mesh wrapped in aluminum foil able to produce ozone with the concentration of 163 ppm and 98 gram/hr capacity at 14 kV with 126.5-watt power consumption. The maximum temperature inside the reactor is 52°C after being operated for 270 minutes. If ozone production using DBDP reactor with wire mesh - aluminum foil electrode configuration can produce ozone with 138 ppm concentration with 78 gram/hour capacity at 14 kV voltage. The power input consumed by this model reactor is 64.8 watts. After 280 minutes of operation, the maximum temperature inside the reactor is 49°C.

5. **References**

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