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# Effect of distance tip gap on screw electrode of ozone generator: simulation and experimental study

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**ABSTRACT**

Ozone generation using screw-type electrodes with different distance peak to peak was studied, with the view to comparing the effectiveness of the two technologies in improving for high ozone concentration. Current density, heat flux, and distribution electric potential were performed by using simulation software Ansys. These simulations indicate that the screw-type electrode with a distance of 2 mm generates the higher current density, the result is the same as the initial assumption that the screw distance 2 mm will be better than distance 1.5 mm because it has lower heat flux. Experimental work confirms that a screw model with a distance of 2 mm also has high ozone concentration than a distance 1.5 mm screw model due to current density making electric field strength also higher to produce high ozone concentration, as was also noted by previous authors.



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## 1. INTRODUCTION

Ozone is strong oxidizing agent that is widely used in variety of applications including food sterilization, air purifier, water treatment, disinfection [1]-[6]. Ozone is produced by applying high-voltage to dielectric barrier discharge reactor. Dielectric barrier discharge is one of the electrical discharges types that use a barrier on 1 electrode or both sides of the electrodes. In dielectric barrier discharge, a dielectric layer composed of glass soda lime, quartz, ceramic, or polymer materials is placed between the electrodes [7]-[10]. Ultraviolet radiation, ozone, and hydroxyl radicals can be generated by dielectric barrier discharge [11], [12]. Ozone generation is one of the most popular dielectric barrier discharge study topics [13]-[18]. Experimental studies of ozone generation are influenced by electrode materials, dielectric materials, input gas, flow rate input gas, pressure, power supply, gap spacing [19]-[23] have been widely studied to obtain high ozone concentration. Many research had already been studied to get high ozone concentrations.

Cylindrical dielectric barrier discharge is one of the dielectric barrier discharge types that use cylinder glass and electrodes. These types are widely used due to being considered efficient in producing ozone concentration [24]-[26]. In this study, an ozone generator using cylindrical dielectric barrier discharge with different distance peaks to the peak has been developed. This paper discusses the comparison of different distances in electrodes by using simulation and experimental to get optimum high ozone concentration.

## 2. METHOD

Ozone is formed primarily through three-body collisions in which an oxygen atom and an oxygen molecule collide with the third particle. Since three-body collisions are rare at low pressures, this type of reaction is obviously more efficient for electrical discharges at atmospheric pressure [13].

$$O + O2 + M \rightarrow O3 + M(where\ M\ could\ be\ O2\ or\ N2) \quad (1)$$

The most important reactions that lead to ozone decomposition are:

$$e + O3 \rightarrow e + O2 + O \quad (2)$$

$$O + O3 \rightarrow 2O2 \quad (3)$$

In this study, simulation using Ansys software program 18.2. The geometry used in this simulation represents a solid model of the screw. The various the screw use pitch distance variations, including 0.5 mm; 1.0 mm, 1.5 mm, 2.0 mm Figure 1. Meshing or discretization in finite element analysis (FEA) is the process of converting a continuous solid domain into a discrete computational domain thus electrical equations can be solved using numerical methods, in this case using the finite element method Figure 2 or FEA.

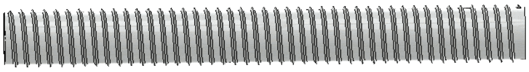

Figure 1. Model geometry screw

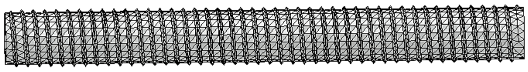

Figure 2. Nodes model mesh visualization screw

The electric potential difference input is used to determine the magnitude of the potential difference in this case. In this simulation, the potential difference is varied with values of 5 kV, 6 kV, and 7 kV. The experimental setup is shown in Figure 3. The ozone generator was made by using cylinder glass and electrodes that applied alternating current (AC) high voltage. The electrode materials used are stainless steel and cylinder glass used is pyrex glass with 1 mm diameter. Oxygen is used as input gas in the reactor. Ozone concentration was produced using ozone analyzer bmt 964-bt.

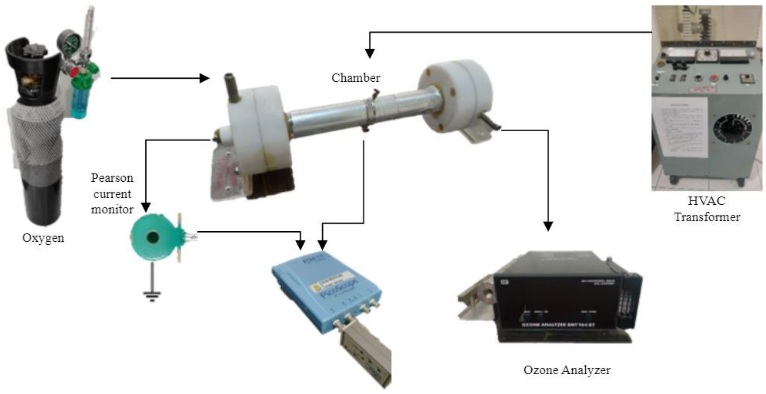


Figure 3. Experimental setup

## 3. RESULTS AND DISCUSSION

The simulation was carried out using the screw model with a pitch distance variation of 0.5 mm, 1.0 mm, 1.5 mm, and 2.0 mm. Simulation are carried out to determine the pattern of electric potential distribution, distribution of heat flux and current density. Based on Figure 4, Figure 5, and Figure 6 show the distribution of electric potential, heat flux, and current density. Input voltage from 5 kV, 6 kV, and 7 kV makes screw model with a distance of 2 mm have higher heat flux and current density than distance 1.5 mm. Heat flux in screw model with distance 1.5 mm is 0.55% higher than 2 mm distance peak to peak on 7 kV. Increasing heat flux in the screw model with a distance of 2 mm is 35.87% from 6 kV to 7 kV. Based on Figure 6, the current density of is screw model is 92% higher than the coil model of 2 mm distance peak to peak on 7 kV. Increasing current density in the screw model and coil model is 14.4% and 14.2% from 6 kV to 7 kV of 2 mm distance peak to peak.

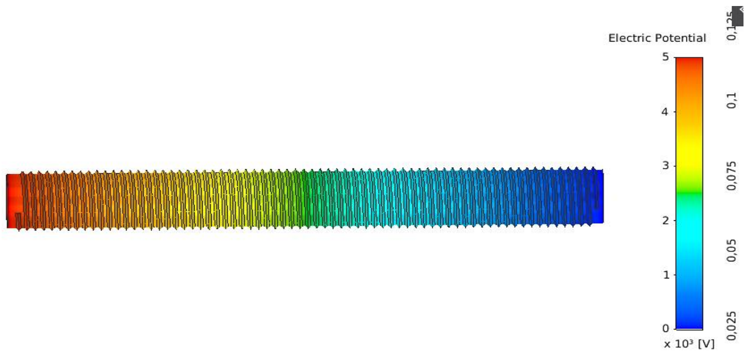


Figure 4. Electric potential distribution on the screw model

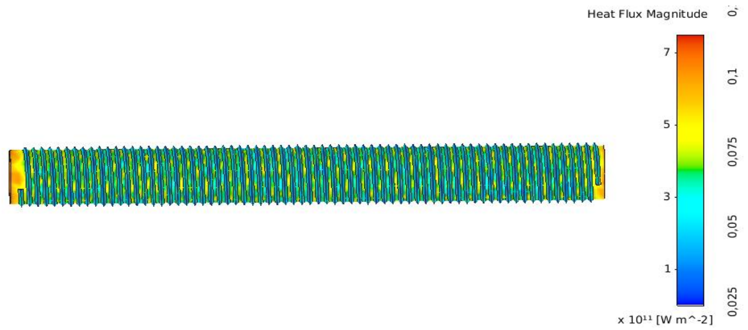


Figure 5. Distribution of heat flux on the screw model

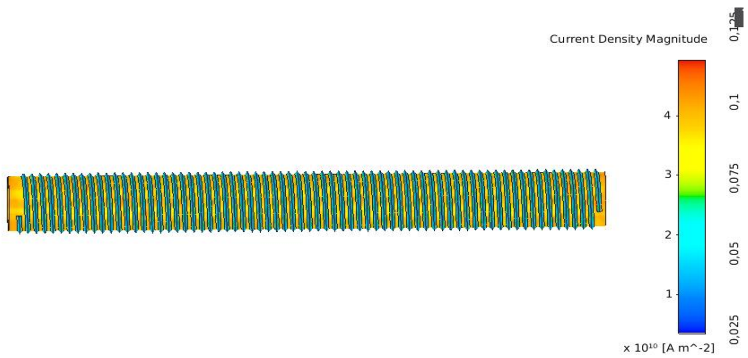


Figure 6. Distribution of current density on the screw model

Based on Figure 7 that the heat flux produced is also greater for the screw model since the greater the electric current, the greater the heat flux produced. This will affect the heating process of the system (the greater the heat flux, the greater the heat generated). However, based on Figure 8 that the screw model with distance tip 0.5 mm has a higher current density than distance tip 1 mm, 1.5 mm, 2 mm since the cross-sectional area of the electric current is larger, thus the resistance is getting smaller. With the same potential difference, the resulting current will also be greater.

The effect of tip distance on current density in the screw model is that the more rapid the tip distance, the greater the current density. This is due to the shorter current mileage. While in the screw model, the tip distance does not really affect the current density. The greater the current density, the greater the heat flux. Meanwhile, the effect of voltage on current density and heat flux is linear, aimed at screw models for any tip distance.

The current density that occurs in 0.5 mm tip distance is higher than 1 mm, 1.5 mm, 2 mm tip distance. Current density affects the temperature rise. When the temperature increases the atomic bonding increases as a result the flow of electrons is inhibited. Thus, an increase in temperature causes an increase in the resistance of the conductor. The current density is inversely proportional to the cross-section of the conductor, the larger the cross-section of the conductor the smaller the current density.

Increasing heat flux affects the increasing temperature in the ozone generator. Increasing temperature makes ozone concentration decrease due to heat makes oxygen difficult for ionization, dissociation, and recombination of ozone formation. This research accordance with Seyfi *et.al.* [27], that ozone production efficiency when temperature decreased. Another study also confirm that sharp edge has increase ozone generation [28].

This study uses experimental to get ozone concentration. Based on Figure 9 that shown screw model with a 2 mm tip distance is higher ozone concentration than the screw model with a 1.5 mm tip distance. These results confirm that the screw model with 2 mm tip distance than the other (0.5 mm, 1.5 mm, and 1 mm).

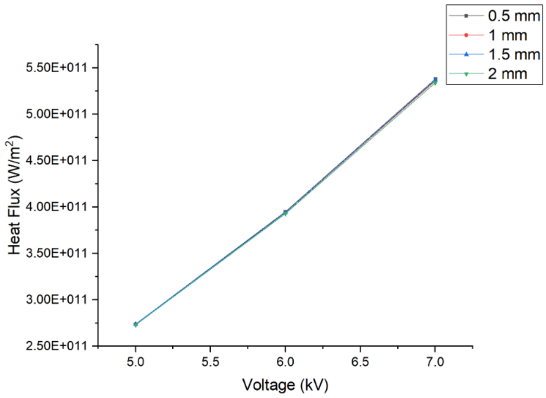


Figure 7. Effects heat flux and voltage on the screw model

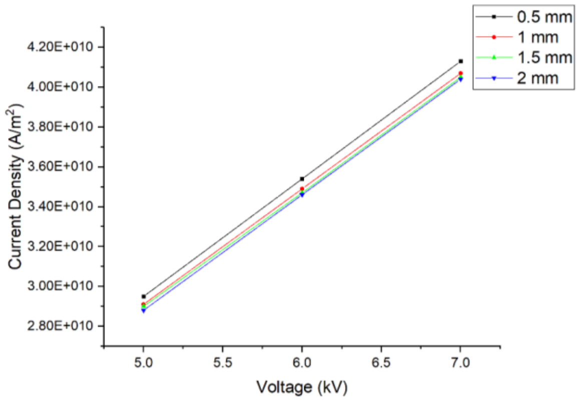


Figure 8. Effects current density and voltage on the screw model

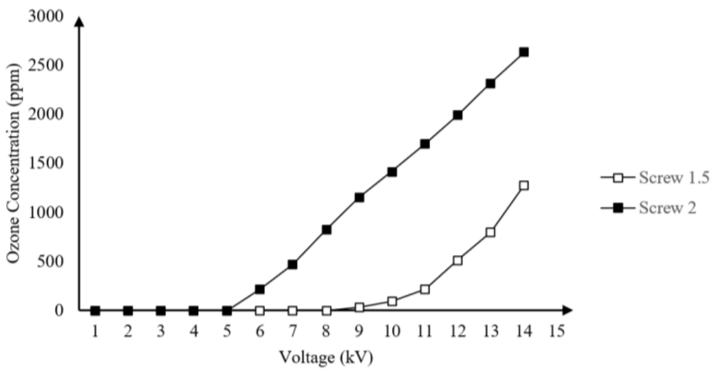


Figure 9. Effects ozone concentration and voltage on the screw model

## 4. CONCLUSION

The difference tip distance affects the results of the ozone concentration due to the influence of current density which produces high temperatures. The further tip distance makes higher ozone concentration than rapid tip distance. Rapid tip distance makes temperature increase and ozone concentration decrease due to heat making oxygen difficult for ionization, dissociation, and recombination of ozone formation. Efficiency tip distance in ozone generation use a measure of distance that is not rapid to reduce heat and ozone decomposition

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