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A Comparative Numerical Analysis of Electric Field Distribution in Simple and Multi-Tube DBD Ozone Generators

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ABSTRACT

This paper introduces a comparative investigation between two ozone generators. The first generator features a design comprising a cylindrical stainless steel electrode grounded, an inner aluminum electrode connected to high voltage, and a glass tube serving as a dielectric barrier discharge. Conversely, the second generator, termed a multi-tube ozone generator, was also study. In this design, a stainless steel electrode is grounded as the first electrode, and a high-voltage aluminum electrode with a glass tube functions as the dielectric barrier discharge. It is noteworthy that both generators share an equal discharge volume, estimated at 4.27 cm^3. The investigation utilized the simulation program Comsol Multiphysics 5.6. Analysis of the simulation results for the electric field strength in the two generators indicates that the multi-tube ozone generator exhibits a superior electric field distribution compared to the first ozone generator, implying increased efficiency in ozone generation.

Keywords: ozone generator; electric field distribution; dielectric; electrode, multi-tube.

1. Introduction

Pulsed dielectric barrier discharge (DBD) has attracted some recent attention due to its significant advantages in the field of ozone generation. Pulsed DBD, namely the use of very short highvoltage pulses combined with a dielectric layer placed adjacent to one of the electrodes, results in a short lifetime of the streamer. As a result, less energy is transferred into ions and neutral gas, which obviates the need to use an elaborate cooling system to remove the heat from electrodes, with a consequent decrease of energy cost for ozone generation. Baldus [1] investigated experimentally and numerically the 1D-spatial distributions of atomic oxygen and ozone in air parallel-plate pulse DBD, and the temporal evolution of neutral species was also obtained. Wei [2]established a plasma fluid and chemical model to investigate numerically for the spatial-temporal distributions of species and electric field in oxygen parallel plate pulsed DBD for ozone generation. In this study, a comparative study was conducted between two ozone generators, namely a multi-tube ozone generator and a simple ozone generator based on the application of Comsol Multiphysics 5.6 through the electric field in pulsed oxygen (DBD) to generate ozone.

2. Numerical Model

The study was conducted on two ozone generators. The first is a simple ozone generator. A cylindrical stainless steel electrode was used as the electrode connected to the ground, and an aluminum electrode was connected with high voltage. A glass tube was chosen as a dielectric barrier discharge. Figure 1(a) shows the geometry of the simple generator. The second ozone generator is called a multi-tube ozone generator, where a cylindrical stainless steel electrode was used as a ground electrode and an aluminum electrode as a high-voltage electrode. The generator contains four generators with the mentioned specifications, linked together as shown in Figure 1(b). The two generators studied have the same rated discharge volume of 140.74 cm^3

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Figure 1: a) Design of simple ozone generator b) Design of multi-tube ozone generator

Figure 2.b shows the computational domain adopted in a simple ozone generator. The domain is divided into four parts: a high-voltage aluminum electrode, glass dielectric layer with a thickness of 2 mm, a discharge gap of 1 mm and a stainless steel grounding electrode with a thickness of 2 mm. The simulation domain is discretized with triangular meshes. Taking into account the grid quality and computation resource.

Figure 2.a shows the computational domain adopted in the multi-tube ozone generator. The generator contains four generators, and the computational domain for each of them has four parts. The domain is divided into four parts: a high-voltage aluminum electrode with a thickness of 1 mm, an dielectric layer of glass with a thickness of 2 mm, a discharge gap of 1 mm, and a stainless steel grounding electrode with a thickness of 2 mm. The simulation domain is discretized with triangular meshes. Taking account the grid quality and computation resource

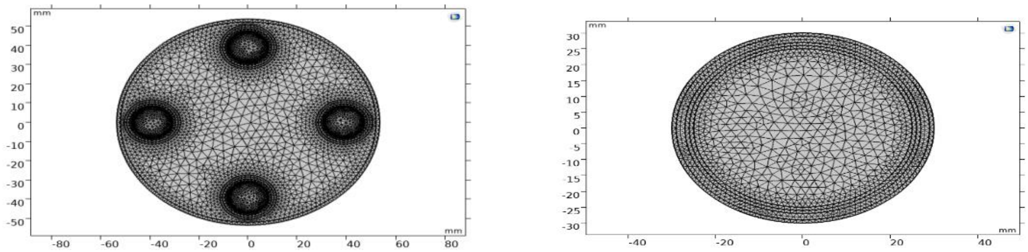

Figure 2: a) Computational domain of Multi-tube generator b) Computational domain of simple generator

3. Results and Discussion

For each ozone generator, the maximum electric field was estimated in the vicinity of the high voltage electrode, 0.1 millimeters from the dielectric barrier outside the glass tube

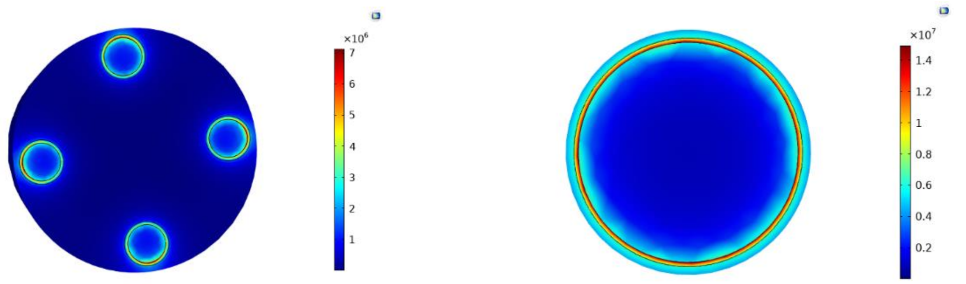

Figure 3:.a) surface distribution of electric field in multi-tube ozone generator b) surface distribution of electric field in Simple ozone generator

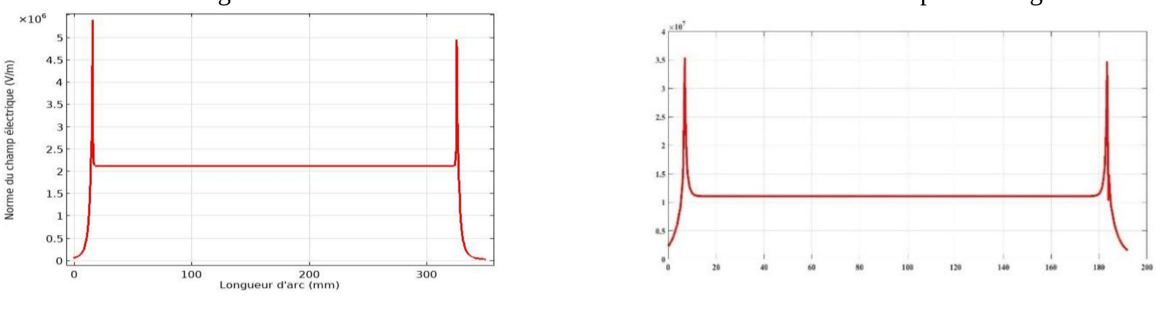

Figure 4: electric fields in the simple generator b) electric fields in Multi-tube generator

Through Figure 3, we can notice that the electric field is distributed in the discharge gap of each of the studied generators with varying values where the multi -tube ozone generator shows four areas to distribute the electric field according to the discharge gaps. Through Figure 4, which represents the distribution of the electric field in the two generators, we can notice two peak in both of them. Through Figure A, the maxuimem value of the electric field in the simple ozone generator has reached 5 v/m, while we can notice from Figure B that it reached 3.5 v/m in the multi -tube ozone generator

4. Conclusions

The results obtained indicate that the electric field in the case of a multi-tube generator is significantly higher than for the simple generator, which means greater efficiency for generating ozone. The maximum values of the electric field are approximately 5 v/m and 3.5 v/m for simple generator and multi-tube generator respectively

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