BARRIER DISCHARGE IN MAGNETIC FIELD: THE EFFECT OF MAGNET POSITION INDUCED DISCHARGE IN THE GAP

by Fri Murdiya

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***Abstract*— The study of the effect permanent magnet (PM) position induced discharge in the gap of Dielectric Barrier Discharge (DBD) was carried out. The PM position influenced the plasma discharge. It is shown that the plasma intensity in the model I was higher than other models. The currents discharge in the model III and IV were higher than model I and II. However, the discharge current in the model II was lower than the model I. The ozone gas was generated for all models. The concentration ozone in the model II and III are higher than model I and IV. It is shown that the plasma progressed in the gap of DBD was influenced by the PM position.**

***Keywords*— DBD, Magnetic Field, Position, Discharge Current, Ozone Generator**

I. Introduction

The dielectric barrier discharge (DBD) generator supports the process in many areas such as in physics, medical, chemistry, etc. The components installed in this technology such as high voltage power converter, metal electrodes and solid insulator as dielectric. The electron discharges or gas ionization is the unsuccessful point of the dielectric to be itself as insulator/ dielectric. Barrier discharge occurred in the gap between two electrodes and dielectric leads to ionize the gas insulation (air) and it results the ozone molecule. The barrier discharge promotes the micro plasmas in the gap and the eyes can catch them. The dielectric materials were always chosen such as ceramics, mica, glass, acrylic, granite, quartz and nylon,

Osawa and co-workers, and Shimizu and co-worker reported that the application of high voltage barrier discharge technology to produce ozone, sterilization of drinking water and also the destruction of NOx gas compounds from diesel engine smoke [1, 2]. A.A. Abdelaziz and co-workers [3,4] reported the application ozone generator to destruct the dangerous naphthalene material. This experiment used a needle and plane electrode and they were separated by a mica material as dielectric. Peter Luks and co-workers [5] designed a tube electrode with a solid dielectric made of aluminum material (Al_2O_3) to initiate micro discharge in the water. The ac and dc power supplies were commonly used in the high voltage plasma generator to generate the ozone molecules [6,7,8]. There are some configuration of dielectric and electrodes as barrier discharge generator. The dielectric barrier discharge configurations are presented in Fig. 1.

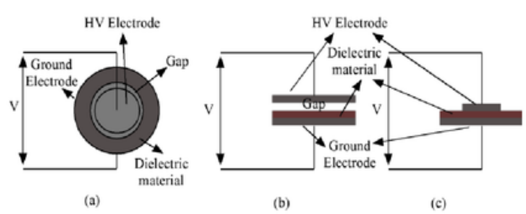

Fig. 1. (a). Cylindrical DBD, (b) Planar DBD, (c) Surface DBD [1,6].

The effect of magnetic field on plasma progress between electrodes and dielectric was investigated by Park. Park used multi needles as high voltage electrodes, which were positioned in the gap between electrode and dielectric [9]. Pakarek investigated the effect of permanent magnet on plasma progress in the gap between the needle electrode and dielectric. The needle electrode position was parallel to the permanent magnet. It is shown that the effect of magnetic field influenced the movement of ionic molecules of gas [10]. Liu initiated a study to investigate the comparison of planar dielectric barrier discharge in the magnetic field and without magnetic field. Liu also concerned on the nanosecond pulse power that was connected to a high voltage electrode. This experiment result was concluded that the plasma progress on solid dielectric that influenced by the magnetic field was slightly different phenomena compare to the planar dielectric barrier discharge without magnetic field [11].

In this research, we proposed to use a tile/ floor ceramic as dielectric for plasma producer in the gap. We also made a comparison on the influence of magnetic field induced plasma in the gap by varying the permanent magnet position and the conventional dielectric barrier discharge without magnetic field. We chose to install the high voltage power supply (with voltage level of 8 kV and frequency of 25 kHz) that was connected to an anode electrode. We also modified the gap between anode and cathode electrodes by putting a tile on the cathode electrode. The plasma will progress in the gap between anode electrode and dielectric. In order to produce ozone gas, we injected the air into the gap by a mini fan. We recorded the data such as discharge current, plasma photographs for several position of PM and ozone concentration by considering the influence of magnetic field in the DBD and the conventional DBD without magnetic field.

II. Experimental Procedure

The scheme of experiment is presented in Fig.2. The DBD was designed with the permanent magnet (PM) position under and above electrodes. The positions of PM are presented in Fig.3. Model I is DBD without PM, model II is DBD with PM and the position of PM is under cathode electrode, model II is DBD with two PMs that are above anode electrode and under cathode electrode and they are at attraction condition and model IV is DBD with two PMs that are under and above for each electrode and they are at repulsion condition.

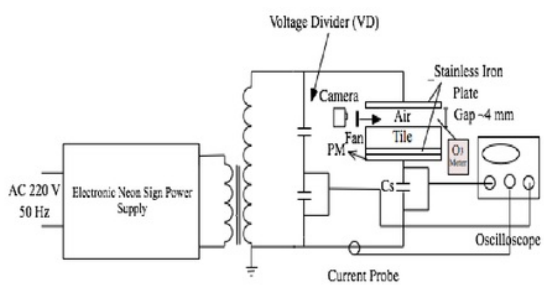

Fig.2 The scheme of DBD test

The magnetic field density of PM is 315 mT and it was measured with FH 51 Tesla Meter. The solid dielectric arranged on cathode electrode was a tile (Platinum made in Indonesia). The dimensions of tile were length of 200mm, width of 200mm and thick of 8mm, respectively. In order to initiated the plasma between anode electrode and solid dielectric, we set the gap distance between them at about 4 mm.

Electronic Neon Sign Power Supply (ENSPS) made in China with output voltage 8 kVrms and frequency 25 kHz was installed in this experiment. The anode and cathode electrodes were connected to ENSPS. The voltage divider (VD) SEW made in Taiwan was equipped on anode termination and it was connected to a digital oscilloscope Hantek 6204 BC. The ratio of VD is 1,000 : 1. The current discharge was measured by a current probe Hantek CC65.

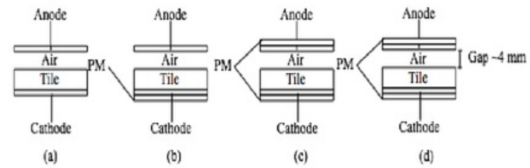

Fig.3. The positions of PM. (a) Model I, (b) Model II, (c) Model III, (d) Model IV.

In this research we also simulated the producing ozone by injection of natural air. We used a mini fan to blow the air into discharge area. The concentration of ozone was recorded by an ozone analyzer HT-E-O3 made in Hongkong.

III. Result and Discussion

A. *Plasma Pictures*

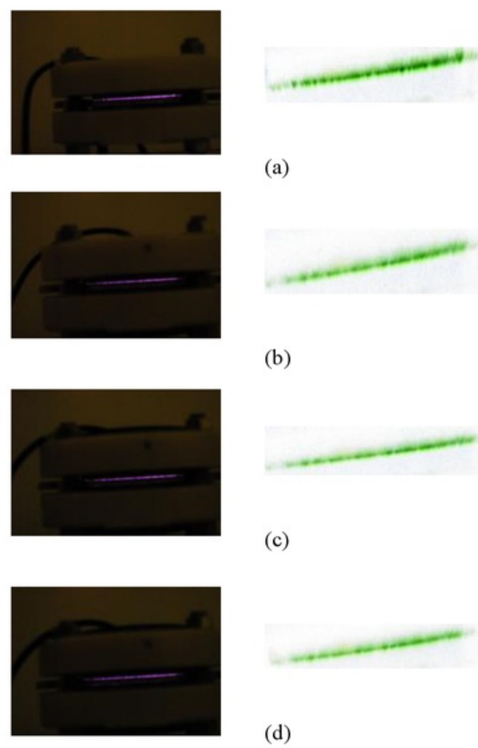

Fig. 4 Plasma Photographs (left side is the real colors and right side is the inverting colors). (a) Model I, (b) Model II, (c) Model III, (d) Model IV.

The plasma pictures are presented in Fig.4. The plasma developed clearly in the gap for all models. Pictures in left side is real photographs. However, the pictures in right side is the inverting color. In the model I, the intensity plasma is higher rather than other models. It was indicated by black color (at right side pictures). The lowest intensity is the model IV.

B. Voltage and Discharge Current

The discharge currents and voltage are presented in Fig.5. The discharge current was recorded after several minutes discharge. The discharge current in the model I is higher than model II. However, the discharge current in the model III and IV are higher than model I and II.

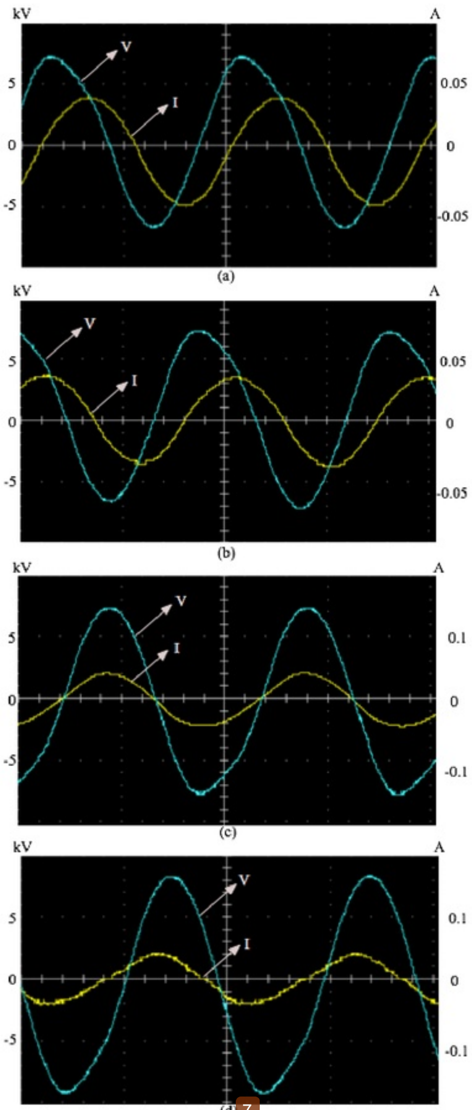

Fig.5 Voltage and discharge current, (a) model I,(b) model II, (c) model III and (d) model IV

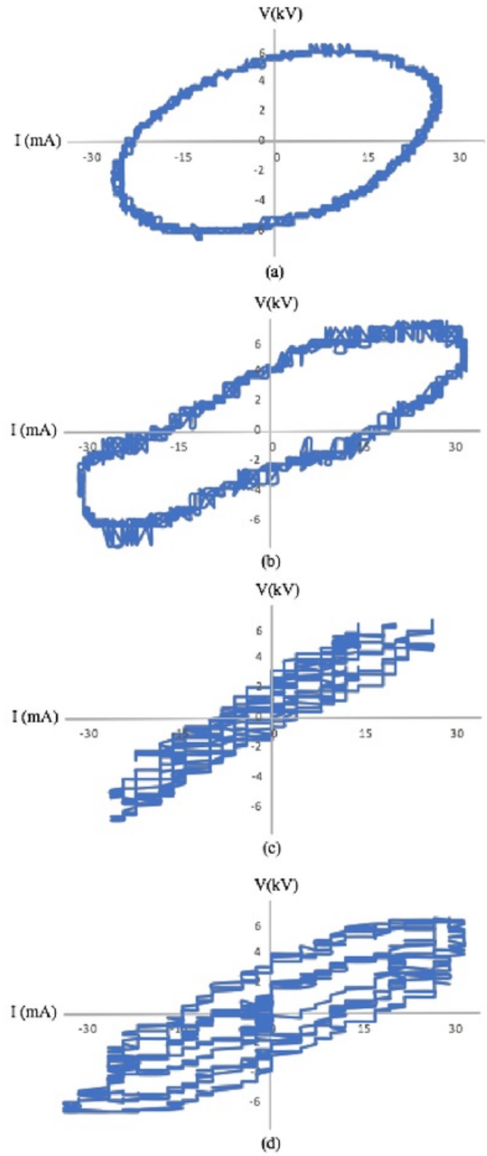

Fig. 6. Lissajous figures. (a) model I,(b) model II, (c) model III and (d) model IV

The Lissajous figures for all models are depicted in Fig.6. These graphs were measured by a digital oscilloscope and current and voltage probe after discharge developed until five minutes. It was difficult to fix these graphs because these discharges were very unstable. It is shown that the lissajous graphs for all models are sharply different. Many aspect should be considered to define the characteristics of dielectric barrier discharge. So that, the next investigation will be needed.

C. Ozone Generation

The ozone generation versus times is shown in Fig. 7. The concentration ozone is in ppm. The model II and III produced ozone are higher than model I and IV at time discharge until 9 minutes. The lowest concentration is model IV.

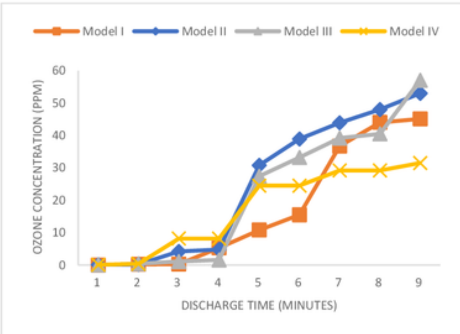

Fig.7 Ozone production for all models.

IV. Conclusions

There are some summarizes in this investigation:

1. The plasma can develop in the gap for all models. The intensity plasma in the model I is higher than other models.
2. The discharge current in the model I is slightly higher than model II. However, the discharge currents in the model III and IV are higher than model I.
3. The model II and III produced the ozone gas are higher than model I and IV.
4. The discharge progressed in the gap of DBD was very unstable for all models.

Acknowledgment

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