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ELECTRICAL POWER ENGINEERING

An Experimental Visualization of Electrohydrodynamic

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Abstract _ **An experimental investigation have been conducted for electrohydrodynamically (EHD) induced from corona discharges in the cylinder. The flow of velocity field as vortex action are flowing that capetured virsualization of digital sequental images with CCD camera between the two electrodes difference. The result of ionic wind from AC corona discharges in gas phase where these conduct vortex in clockwise rotation by contraries. The flow velocity distribution is experimentally measured to electric wind as sequential digital images by using the green laser shot on the tip of the needle when applied voltage is high voltage from o to 4.0kV.**

Keywords**: Electrohydrodynamics, gas phase, flow visualization, corona discharges**

I. INTRODUCTION

An electorhydrodynamic flow is a flow of electrically neutral gas caused by corona generated charge particles (ions) drifting through it. High voltage applied between high curvature corona electrode and low curvature collection electrode provides condtion for ionization of gas modules in the nearest vicinity of corona electrode surface. Corona discharges usually involve two asymmetric electrodes; one highly curved (such as the tip of a needle, or a small diameter wire) and one of low curvature (such as a plate or the ground (3). The electorde system and the visualization system will be used to observe the local ionic wind motion in a corona discharge field. It was appered as a local gas phase movement simultaneousy occured with the progressing of corona discharges along the needle electrode axis toward the plate electrode side. The positive corona operating in ambient air is using to accelerate an air flow using the ionic wind effect.

Steady electrohydrodynamic fluid motion measurement under surface corona discharge was investigated with Schlieren Photographs susccfully observation (2). The Gas Phase AC corona discharge induced electrohydrodynamic liquid flow in a stratified fluid investigated the EHD liquid flow direction on an electrode axis is not from needle to plate electrodes axis when the needle position was liqud layer and the flow velocity disrtibution by a particle image velocimetry (PIV) with image processing (1).The ionic wind analysis of electrohydrodynamic airflow control along a flat plate by a dc surface corona discharge (velocity profile and wall pressure measurements) that shown the velocity of the ionic wind at the wall incease with the discharge current (2).

II. EXPERIMENTAL MODEL

Fig. 1 shows the experimental setup on laser induced caputering technique for visualizing ionic wind profiles. A needle electrode system with a gap distance of 10 mm was set in a cylinder tank with 50 mm diameter. The needle electrode was made of steel of 1 mm in a diameter. and plate electrode was made of brass metal in 50mm. The needle electrode was connected to an AC high voltage source and the plate electrode was connected to the ground via a current measurement device. The air gas was filled in chamber and the parafe gas was filled in the cylinder tank to generate smoking that to capture the images during green laser (600nm) shoot places between electrodes with progressive CCD camera (Photoron Co., Photocam 120) attached a camera lens (NIkon F1.8) and a personal computer . The distance of two eletrode was 10 mm in the ionic wind along the needle straightly. The set of laser-lens, laser optical path was synchronized during generation of smoking and justified the pressure valve from chamber for air gas. An exposure time on digital images in capturing was fixed to 1/120 sec. An exciting location on the laser beam was focused on the symmetrical axis z of electrode system and the location was used as a variable parameter for measuring the ionic wind velocity in these directions.

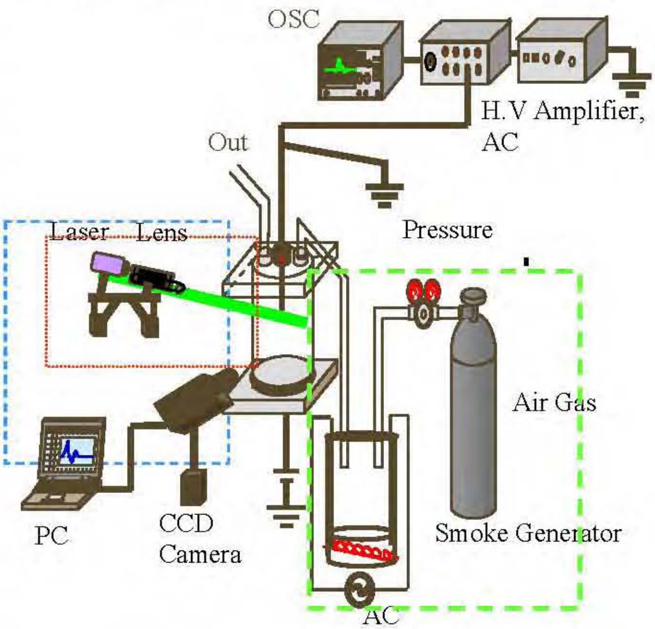


Fig. 1 Schematic Diagram of Experimental Setup

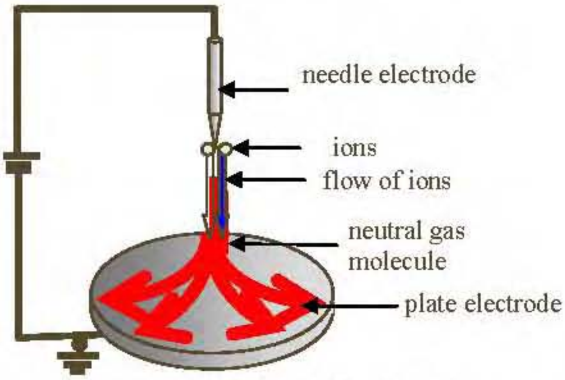


Fig. 2 Illustration of Ionic Wind Flow

The Electrohydrodynamic (EHD) phenomena are involving the interaction of electric fields and flow fields as medium in a dielectric fluid. The electic body force or EHD force per unit volume is generated with the electic field strength in a fluid of dielectric permittivity, Ions drifting from corona wire to collecting electrodes, gorund electrodes cause bulk interaction flow as media motion form discharge to collect electrode as shown in figure 2. In where, the current density consists of the three combined contributions, such as the Coulomb force causes a drift current, the movement of the ambient gas accelerated the charge particles that causes a transport current and this tend to achieve steady state causes diffusion current.

III. EXPERIMENTAL RESULTS OF IONIC WIND

The ionic wind velocity at each positon on the corona electorode axis was proportional to the square roof of corona discharge current. This result resembles of M. Robinson [3] as shown,

$$v = k_z \sqrt{I} \quad (1)$$

the ionic wind velocity at an arbitrary positon can be assumed by calculting constant kz of this (1). The following equation is used to analyse the ionic wind velocity. UEHD is and EHD characteristic velocity based on the discharge current. EHD Reynolds number ReEHD evaluates the ratio of viscous power and inertia force. EHD Rayleigh number E1 evalutages the ratio of driving power and the viscous power generated by the current (5).

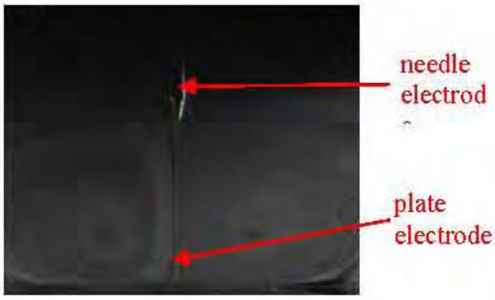
$$U_{EHD} = \sqrt{\frac{D.J_p}{\rho.\mu}} \quad (2)$$

$$\mathrm{Re}_{EHD} = \frac{\rho.U_{EHD}}{\nu}\sqrt{\frac{D^3.J_p}{\nu^2.\rho.\mu}} \quad (3)$$

$$E_1 = \mathrm{Re}_{EHD}{}^2 = \frac{D^3.J_p}{\rho.\nu^2.\mu} \quad (4)$$

where D: Electrode distance Jp:Discharge current density ρ :Fluid density μ :Ionic miblity. ν : movement viscosity

Δ t = 1/120 sec



Δ t = 2/120 sec

Δ t = 184/120 sec

Δ t = 185/120 sec

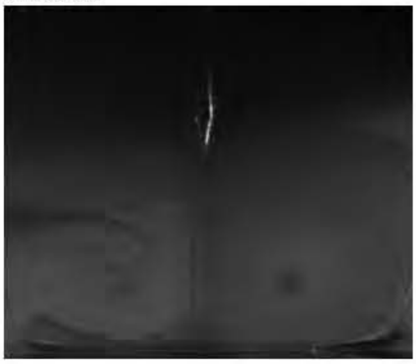


Fig. 3 Visualization of Ionic Wind Flow

The result images at 2.25kV AC are ionc wind flowing in votex action that captured from induced from corona discharges. It is captured along the needle straight between two electrodes in gas phase. The electric field intensity and fluid visocus will be analyzed with PIV. The Coloumb theory is proved the electric field intesity between two electrodes conducton. The corona characteristic doplet on tip of needle flow directly to plate electrode and then flowing x direction as whale or vortex form. The capture expoure time is 1/120 sec that is the total image are 185 figures from one shoot CCD camera when the green laser shooting in gas phase drafting region. The figure 4 shows the current field intensity in ionic wind phenomena at voltage gradually increase from 0 to 4.0 kV. The electric field phenomena was found as positive and negative cycle initating function and end of one cycle situation in between two electrodes during AC corona discharges in gas phase.

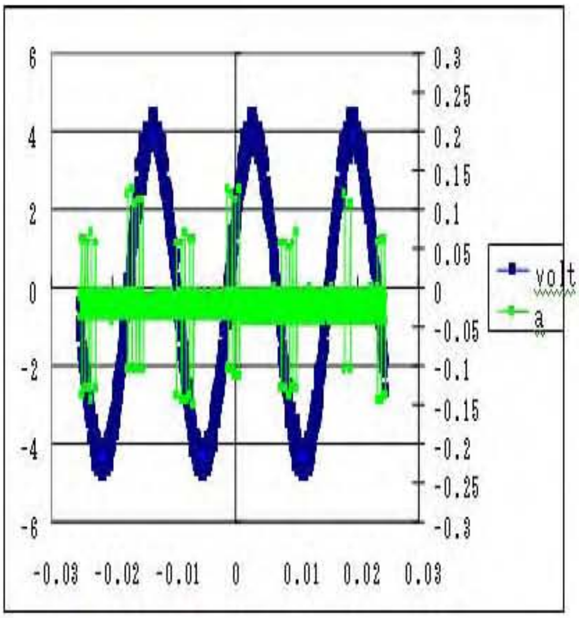


Fig. 4 Voltage and Electric Field Relation

TABLE I
RELATION OF TIME AVERAGE (MA) AND APPLIED VOLTAGE (KV)

2.5kV	3.5kV	4.0kV
0.00012 mA	0.00491 mA	0.00644 mA
0.00014	0.00493	0.00662
0.00016	0.00496	0.00669
0.00018	0.00500	0.00678
0.00020	0.00505	0.00688
0.00024	0.00510	0.00690
0.00026	0.00515	0.00696
0.00028	0.00518	0.00700
0.00030	0.00520	0.00705
0.00032	0.00525	0.00710
0.00034	0.00532	0.00715

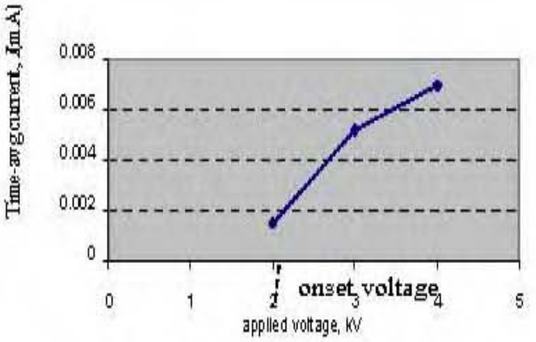


Fig. 4 Time-avg current as a function of applied voltage

In Table I and Fig. 4, the test results are analysised by using current transformer (CT-CE Tektronix 1000V (DC PK AC) Beaverjon, Oregon, U.S.A) attached with PC and two electrodes which are shown time average discharge current and a function of applied voltage. The onset voltage is investigated at 2.0 kVrms experimentally. This I-V characteristic was comfirmed increasing when this voltage for ionic wind generation with corona discharges also increased.

IV. CONCLUSION

The EHD images are captured with CCD Camera in gas phase which can be seen clearly that shown current density conduction between two electrodes. The Experimental consideration for EHD flow visualization measurements are in cylindrical form investigation and knowing of EHD structures. The fluid flow characteristics of EHD caused by the corona discharges, the velocity fields of the unsteady EHD fluid flow with neutral gas flow acceleration are demonstrated by smoke flow tests that are successfully obtained in experimental observation.

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REFERENCES

[1] Y.Okubo, R.Ohyama; Experimental Visualization of Corona Dicharge Progress for Gas- Liquid Two Phase EHD flow henomenon",Proc of SFE, pp. 341-344, 2004.

[2] R. Ohyama, K. Aoyagi, Y.kitahara, Y.Okube, "Visualization of the local Ionic Wind Profile in DC corona Discharge filed by Laser Induced Phosphorescence Emission", Journal of Visualiztion, vol.10. No.1, pp75-82, 2007.

[3] M. Robinson: "Movement of air in the electric wind of the corona discharge", Transactions of the American Institute of Electrical Engineers, Vol.80.pp.143-150,1961.

[4] J.S. Chang, J. Dekowski, J.Podlinski, D. Brocilo, "Electrohydrodymamic Gas Flow Regime Map in a Wire-Plate Electrostatic Precipitator under Positive Coronas".

[5] Y.Kitahara, K.Aoyagi. R.Ohyama," An Experimental Analysis of Ionic Wind Velocity Characteristics in a Needle-Plate Electrode System by Means of Laser-Induced Phosphorescence"