



**PROCEEDINGS OF  
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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 virtualization of digital sequential 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 0 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 simultaneously ocured 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 liquid 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 caputerimg 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.

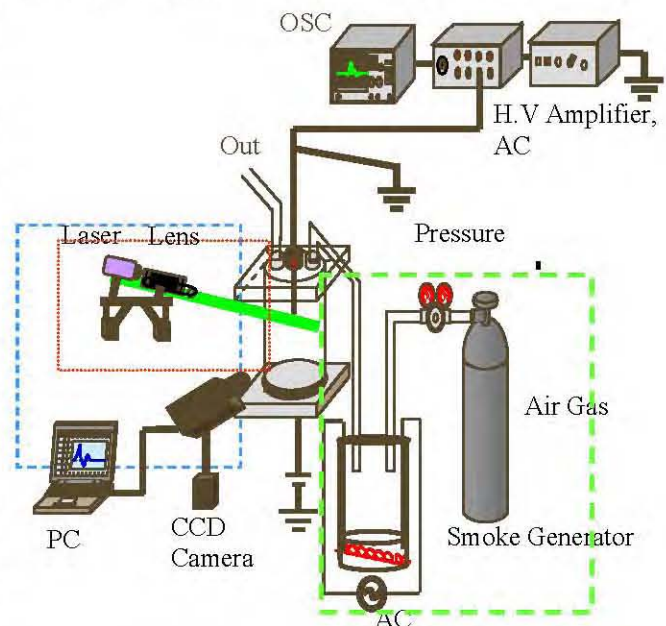


Fig. 1 Schematic Diagram of Experimental Setup



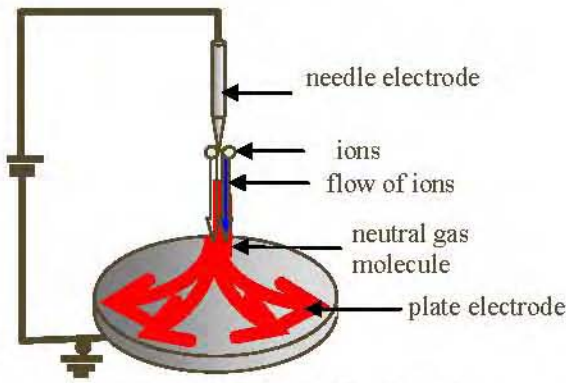


Fig. 2 Illustration of Ionic Wind Flow

The Electrohydrodynamic (EHD) phenomena are involving the interaction of electric fields and flow fields as medium in a dielectric fluid. The electric body force or EHD force per unit volume is generated with the electric field strength in a fluid of dielectric permittivity. Ions drifting from corona wire to collecting electrodes, ground electrodes cause bulk interaction flow as media motion from 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 position on the corona electrode axis was proportional to the square root 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 position can be assumed by calculating constant  $k_z$  of this (1). The following equation is used to analyse the ionic wind velocity. UEHD is an EHD characteristic velocity based on the discharge current. EHD Reynolds number  $Re_{EHD}$  evaluates the ratio of viscous power and inertia force. EHD Rayleigh number  $E_1$  evaluates the ratio of driving power and the viscous power generated by the current (5).

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

$$Re_{EHD} = \frac{\rho \cdot U_{EHD}}{\nu} \sqrt{\frac{D^3 \cdot J_p}{\nu^2 \cdot \rho \cdot \mu}} \quad (3)$$

$$E_1 = Re_{EHD}^2 = \frac{D^3 \cdot J_p}{\rho \cdot \nu^2 \cdot \mu} \quad (4)$$

where  $D$ : Electrode distance  $J_p$ : Discharge current density  $\rho$ : Fluid density  $\mu$ : Ionic mobility  $\nu$ : movement viscosity

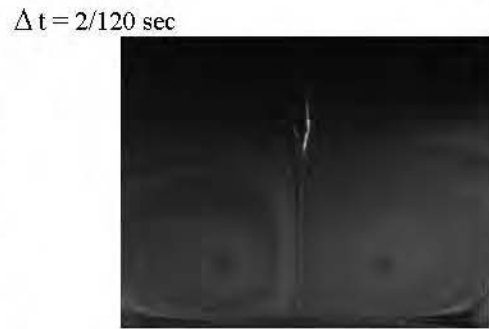
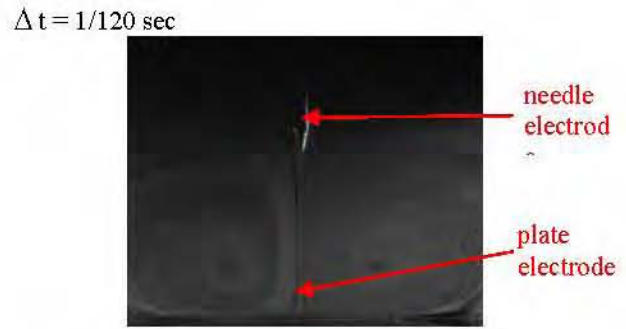


Fig. 3 Visualization of Ionic Wind Flow

The result images at 2.25kV AC are ionic wind flowing in vortex 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 viscosity will be analyzed with PIV. The Coulomb theory

