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The study of the ionic wind blower with multi-needles/ring type electrodes disposed on inner wall of the cylindrical blower

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ABSTRACT

Corona discharge is one of many methods that convert electrical power into mechanical force. It has been studied for various industrial fields because of its many advantages over conventional motor, such as its no moving parts, simpler structure, minimizing size and so on. In this paper, a discharge system with multiple corona electrodes disposed in a ring format, is studied by focusing on the electrical and mechanical characteristics. Effective ionic wind generation is due to the corona discharge which depends on electric field. Therefore, the electric field is affected by the voltage, discharge spacing, and distance between each corona electrodes.

1. Introduction

Ionic wind induced by a corona discharge is one of many methods that convert electrical power into mechanical force. This is defined as electrohydrodynamics (EHD) gas flow. The physics of the net unidirectional EHD blower or ionic wind blower is reasonably well established [1,2].

Many studies for utilizing EHD applications have been performed in a variety of fields, such as aerodynamics, heat and mass transfer, and other applications [3–10]. Conventional electric machines are based on electric motors; they are very useful on account of their strong power. However, aside from their power, electric motors might exhibit some disadvantages, such as noise, abrasion, a large scale, and maintenance by moving parts.

On the other hand, the EHD system, the ionic wind blower in this paper, can be used for thermal management of electrical power apparatuses as well as micro scaled electronic devices [3,10]. This is because the sizes of the flow channel and blower can be reduced to a micrometer scale. In addition, the gas flow control and generation operates with minimal noise and no moving components. Therefore, the EHD blower engenders a variety of applications in various industrial areas. However, these applications require maximizing the flow velocity and capacity of the EHD gas blower and studies to address this requirement are needed [11–16].

The focus of the present study is to investigate the novel potential of the proposed multi-needle-type discharge electrode as a wind blower. The effect of this discharge electrode on the ionic wind flow and energy efficiency of flow generation is experimentally investigated. Generally the fastest ionic wind velocity is obtained near the geometric extension line of central corona electrode; otherwise, gas velocity gradually decreases, in the case using single-needle-type corona electrode disposed on the central axis [5]. On the other hand, ionic wind generated at the inner surface of the wall of the gas flow pathway induces the second ionic wind at the center region by utilizing a multi-needle and ring type discharge electrode disposed on the inner surface of the ionic wind blower. Accordingly, the region of ionic wind generation is relatively evenly expanded into a full-scale region.

2. Experimental set-up

Fig. 1 shows the schematics and photographs of the experimental set-up. The set-up consisted of corona discharge electrodes, an induction electrode, a DC high-voltage power supply, electric current and voltage measuring equipments, and a gas flow measuring equipment. The discharge electrodes and a sensor for the gas flow measurement were placed at the central axis of the flow pathway, which was horizontally situated. Air entered from an opened inlet, and ionic wind pushed out toward the funneled outlet, as shown in Fig. 1(a).

An adjustable DC high-voltage power supply (Spellman SL30P600, 0–30 kV, 20 mA) was applied between the corona

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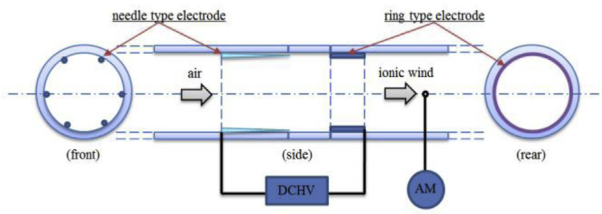


(a) Schematics of the experimental set-up

(4 needles) (6 needles) (8 needles)

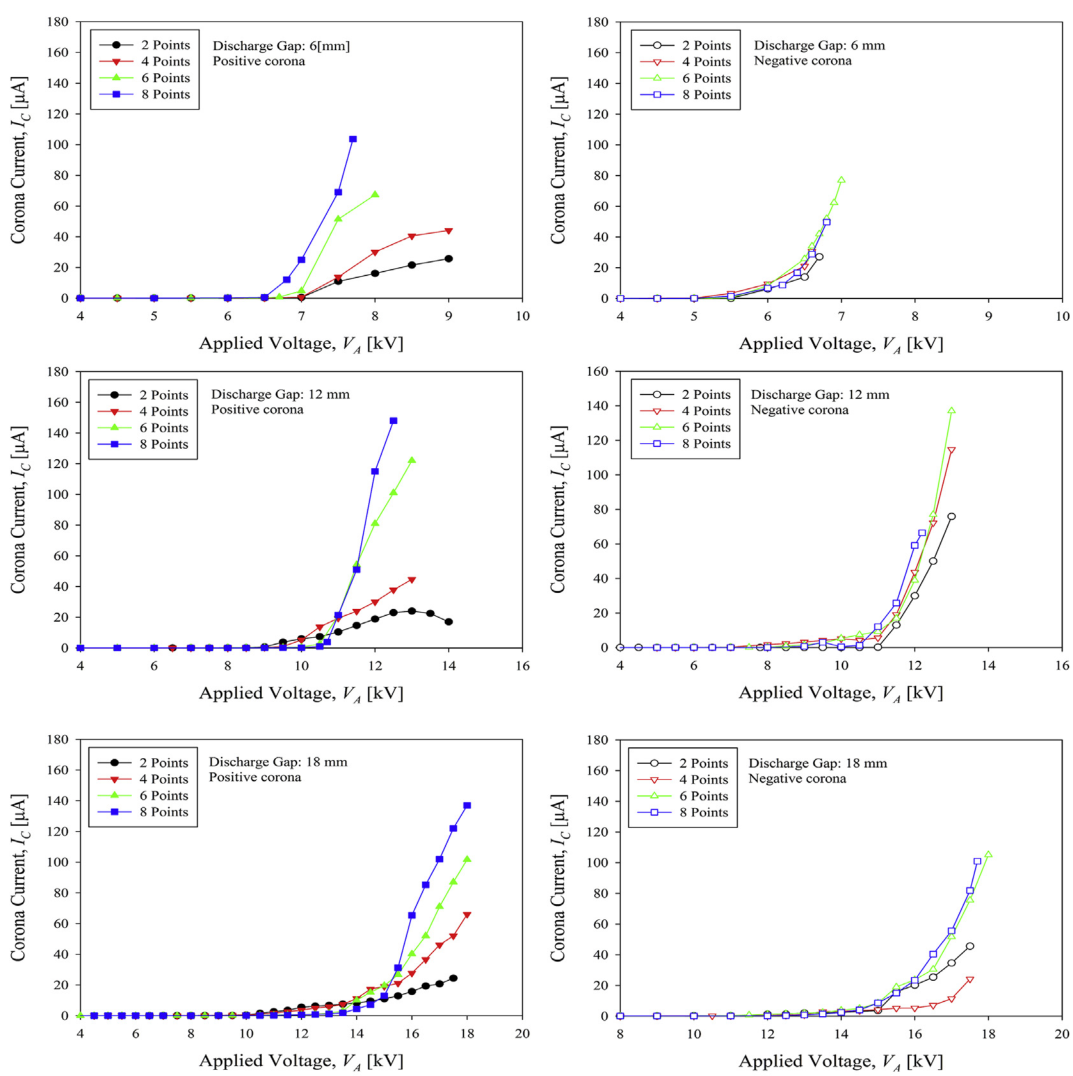
(b) Photographs of multi-needle type corona electrode

Fig. 1. Experimental set-up for the ionic wind blower.

discharge electrode and the induction electrode. The applied voltage and discharge current were measured by multi-meters(Fulke 79), an DC high voltage probe (HP, 1000:1, Tektronix, P6015A), and a shunt resistor (R = 1.00 kΩ). The ionic wind velocity (with a precision of ±0.1 m/s) was measured by an anemometer (Testo 425, thermal probe type) at the central axis 200 mm downstream of the induction electrode in the flow pathway.

For all experiments, all gas flow velocities and electrical data were measured under equivalent conditions, except the number of discharge electrodes varied. All experiments were measured in a temperature- and humidity-controlled chamber.

The ionic wind blower part consisted of a multi-needle-type corona electrode and a wide-ring-type induction electrode. The former corona electrodes type was comprised of three kinds and had four, six, and eight stainless steel needles, respectively, as shown in Fig. 1(b). The latter induction electrode type was made of aluminum. These two types of electrodes were disposed on the inner wall of the cylindrical blower chamber with a variable inter-electrode distance of 6.0–18.0 mm, as shown in Fig. 1(a). An acrylic cylinder was used as the blower chamber, 25 mm inner diameter, 160 mm long, and 5 mm thickness. All experiments were carried



(a) Positive corona (a) Negative corona

Fig. 2. I–V characteristics of the ionic wind blower for the needle numbers of the multi-needle type corona electrode.