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Development of an Ionic Wind Generator with a Nail-to-Cylinder Electrodes Structure for Thermal Management of Electronic Devices

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A B S T R A C T

Heat dissipation in electronic devices is critical for maintaining safe temperatures and overcoming component failures. Temperature reduction is an important issue to enhance in electronic devices due to their small size. For heat reduction, a nail-to-cylinder ionic wind generator was built. The experimental approach proposed in this paper was used to evaluate the features of the ionic wind utilizing nail-to-cylinder electrodes. Ionic wind production is a novel method of cooling electrical equipment. The ionic wind generator's energy efficiency and wind speed are improved by altering the interelectrode spacing and voltage amplitude. Electrode spacing and voltage were varied under various situations, and ionic wind velocity within the device was measured. The investigations show that the installed ionic wind generators are an excellent means of cooling electronic gadgets. The findings of this study may be used as a valuable experimental reference for the design and development of ionic wind generators for thermal management.

Keywords: Ionic wind, Ionic wind velocity, Corona discharge, Nail-to-Cylinder electrode structure, Electronic devices, Thermal management.

Introduction

Every day, various technological advancements occur, and devices, particularly electronic devices, become more compact, making them more portable. Because they employ micro or nanotechnologies that are invisible to the naked eye, all electronic items get smaller and lighter as technology improves. Micro and nanoscale devices generate a lot of heat due to how they work these days, thus regulating it is a huge concern. [1] Electronic equipment cannot function correctly unless they have a mechanism in place to manage heat, which destroys their surfaces, decreases their working capability, and shortens their crucial life expectancy. [2] To ensure the long-term usage of electronic equipment with profit, heat management must be eliminated to avoid any type of failure to reach the needed output. However, despite the smaller size, heat transfer regulation remains a vital aspect in allowing such devices to operate efficiently within their optimal working temperature ranges. [3] The ionic wind, also known as corona discharge, provides a platform for cooling such small devices that do not have adequate space for huge conventional fans. Furthermore, they lack any vibrating structure that removes frictional losses and allows for forced convection. [4] Characterizing the parameters influencing the temperature decrease obtained is an eye-catching topic. By using ionic wind to provide forced convection heat transfer, an enhanced approach for the thermal management of compact-sized electronic components may be obtained. However, forced convection by ionic wind is also being researched in this area to improve the efficiency of these electrical devices over time. [5] Thermal management and flow control are two potential uses for nail-to-cylinder generators. More study has been undertaken in recent years on the use of ionic wind with different electrode arrangements to cool electronic equipment. [6]

Experimental Setup

Figure 1 shows the ionic wind generator structure of nail-to-cylinder electrodes.10 Iron nails with 0.6mm diameter and 10 copper cylinders with 22mm diameter are connected in such a way that they are manually adjustable according to the requirements as we are directed to vary the inter-electrode gap between electrodes i.e., nail and cylinder. Nails are used as emitter electrodes and cylinders are as collector electrodes.

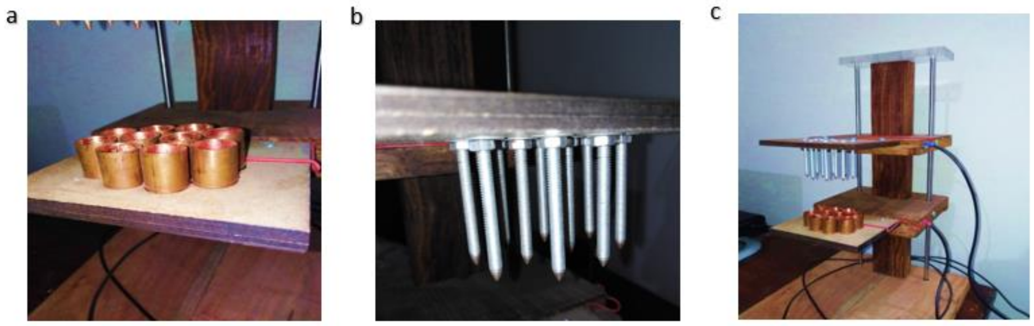

Fig. 1 - (a) Cylinder Electrode; (b) Nail Electrode; (c) Ionic wind Generator

The DC power supply is provided between the electrodes. The multimeter is used to determine the discharge current flowing within the electrodes and a hot wire anemometer is used to measure the ionic wind velocity (U) which is generated during the experiment procession. Applied Voltage (V) and distance (G) between electrodes hold a vital role in the production of ionic wind and it has a direct impact on smooth ionic wind production quantities. Electrodes were tested with a voltage range of 5kV to 10kV and an interelectrode distance of -10mm to 20mm. Negative interelectrode distance means that both electrodes are inserted into each other without any gap left i.e., tips of the nail electrode and bottom of the cylinder electrode. To maintain the equilibrium of the ionic wind flow, a 16 to 19-second period of operation had to be performed shortly after putting on the power supply.

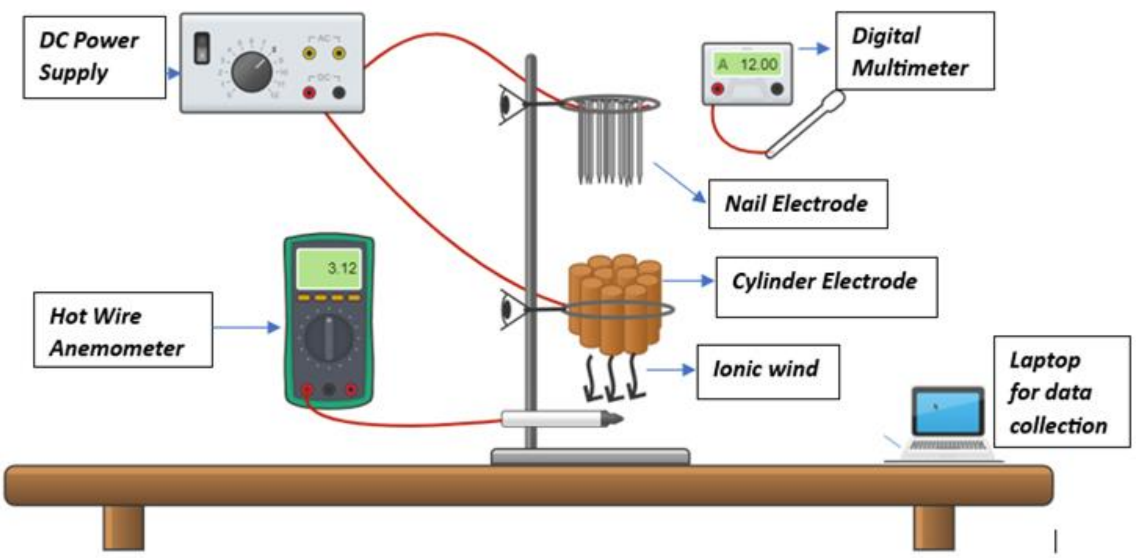

Fig. 2 – Schematic Diagram of Experimental Setup

Table 1 – The following parameters were used in the experiment.

Parameters	Units	Test Values
Interelectrode Gap (G)	mm	-10, -5, 0, 5, 10, 15, 20
Applied Voltage (V)	kV	5, 6, 7, 8, 9, 10
Cylinder Electrode Diameter (D)	mm	22
No. of Both Electrodes	-	10

Result and Discussion

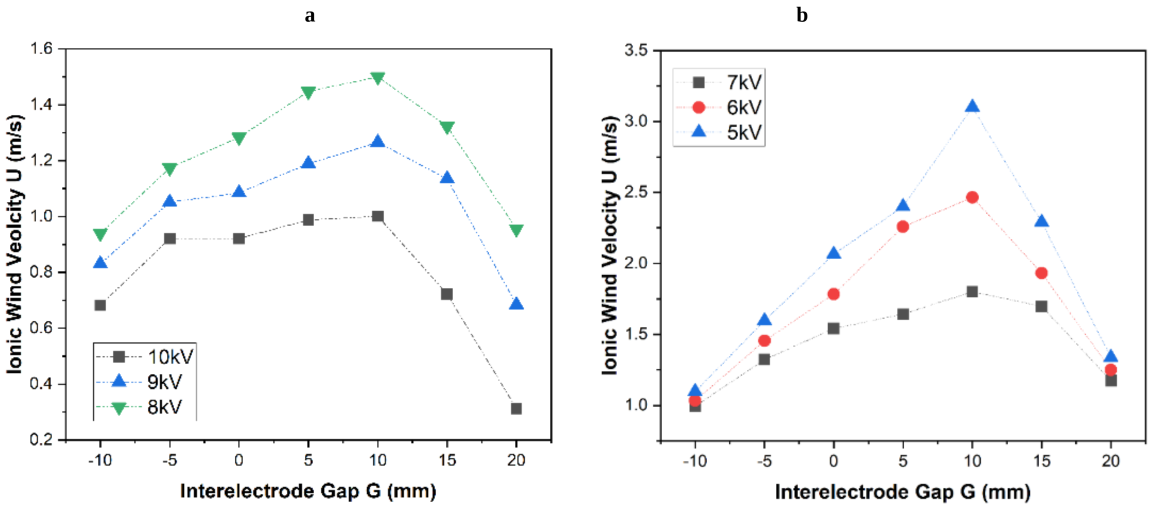

Fig. 3 - Ionic wind velocity U Vs interelectrode gap G at (a) 5, 6, 7kV voltages; (b) 8, 9, 10kV voltages

Figure 3,4 depicts the relationship between ionic wind velocity U, the interelectrode gap G, and applied voltage V

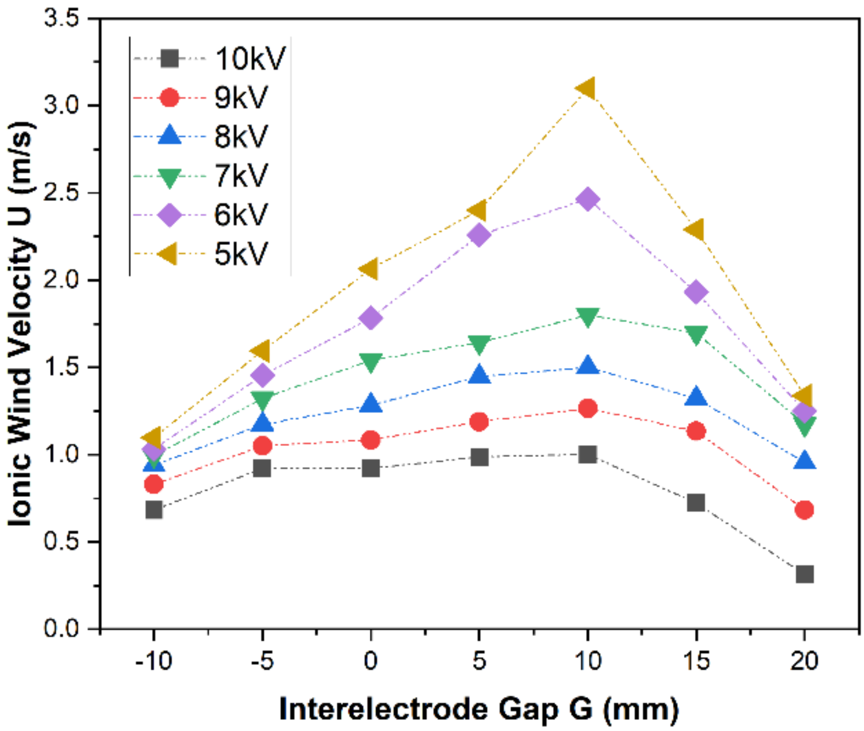

Fig. 4 – the overall relationship of interelectrode gap G and Ionic wind Velocity U at different applied voltage V

As voltage is applied between the electrodes, an electric field is generated between electrodes, and because of this ionic wind is formed. A hot wire anemometer is used for the measurement of ionic wind velocity. Ionic wind production is directly dependent on interelectrode G and applied voltage V. As Figure 4 depicts, a maximum value of ionic wind(U) is achieved at the interelectrode gap of 10mm and applied voltage of 5kV.

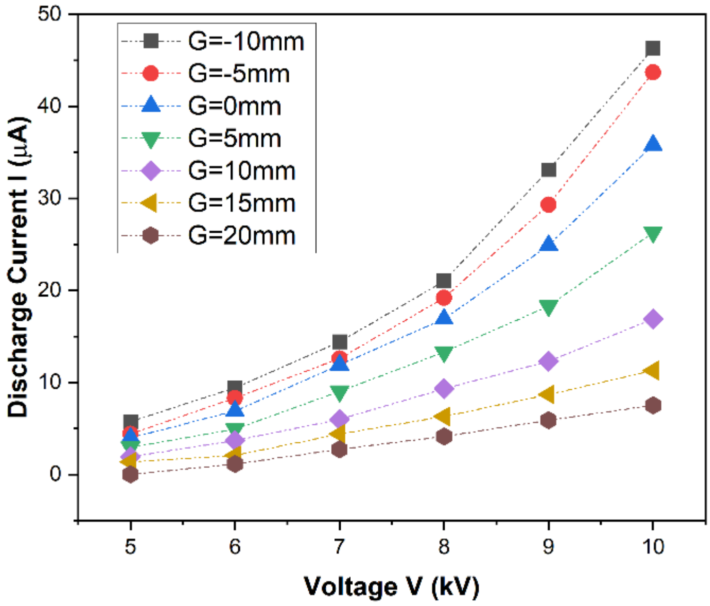

Fig. 5 - The ionic wind generator's discharge current-voltage attributes.

Figure 5 displays the current-voltage relationship for an ionic wind generator. No association was found in the research studies between the discharge current and other factors such as electrode length L, Diameter D, or ionic wind velocity U. The discharge current(I) emerged as the applied voltage value got higher. The current reached its highest when the applied voltage value reached 10 kV. These findings were achieved at different gaps (G) between the electrodes i.e., Nail-to-Cylinder and a cylinder diameter of 22 mm.

Conclusion

After conducting the experiment, we conclude:

Firstly, when the electrode spacing is large, the corona discharge of the nail-to-cylinder electrode could be maintained at a greater voltage, resulting in an increase in maximum wind velocity. When the electrode spacing is 10mm, the maximal velocity is 3.1 m/s, which is more than when electrode spacing is 5,15, and 20mm approximately. Furthermore, Increasing the number of nails enhances the ionic wind production value drastically. The ionic wind velocity of the ten nails to cylinders electrode reaches 3.1 meters/second in this experiment. However, when the applied voltage amplitude raises, the rate of development of ionic wind slows, and energy efficiency decreases when the voltage is high. It was feasible to accomplish the maximum ionic wind velocity U(m/s) when the voltage was 5kV and the gap between electrodes was 10mm, and the cylinder diameter was 22mm.

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