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SELF-ADJUSTING TRIBOELECTRIC NANOGENERATOR (SA-TENG)

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ABSTRACT
This project presents the design of a Self-Adjusting Triboelectric Nanogenerator (SA-TENG), which autonomously modulates the contact area through centrifugal spring equilibrium. Comparative tests with a conventional triboelectric nanogenerator (N-TENG) show that the SA-TENG has a peak power that is ~35% higher than that of the N-TENG above 9 m/s.

KEYWORD
Triboelectric nanogenerator, Self-adjusting, Wind speed, Cylindrical, Generation area

INTRODUCTION
According to the rising the global energy demand (Figure 1), accelerates the need of demand for sustain-able energy harvesting technologies. The diffusion of the Internet of Things (IoT) has increased demand for self-powered solutions in remote applications. Triboelectric nanogenerators (TENGs) represent an innovative energy harvesting technology that utilises the triboelectric effect. Existing rotational TENGs achieve maximum efficiency from a specific contact area, depending on the wind speed (Figure 2). Therefore, an innovative structural design that enables automatic adjustment of the generation area is essential.

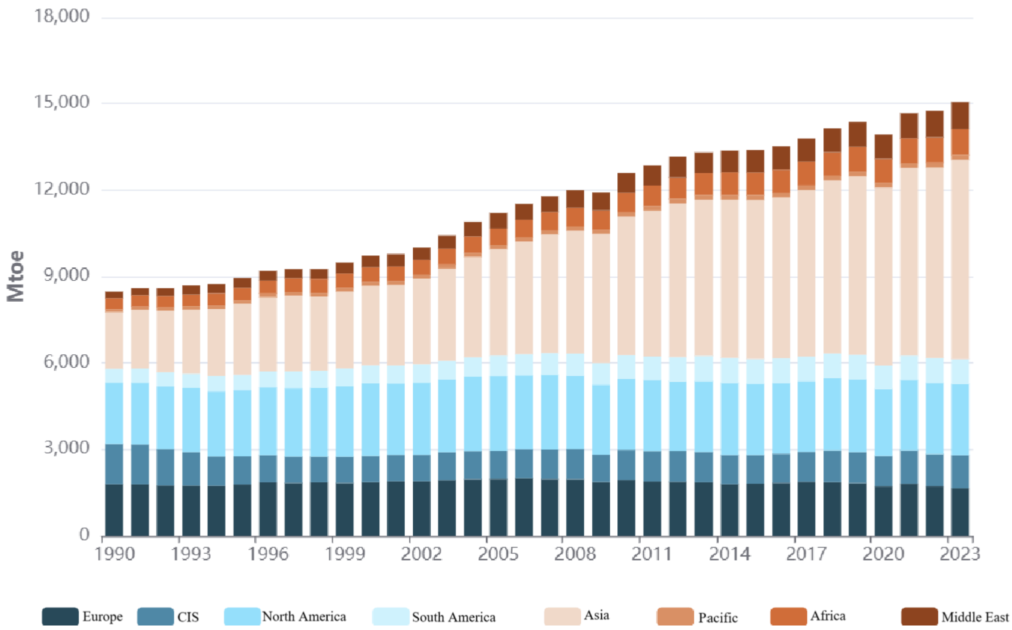

Figure 1: Global energy consumption trend.
(https://yearbook.enerdata.co.kr/total-energy/world-consumption-statistics.html)

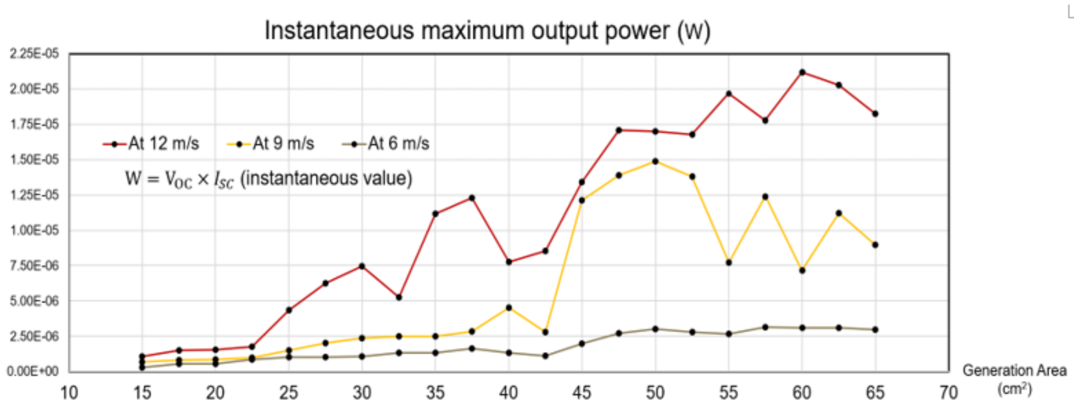

Figure 2: Instantaneous maximum output power for preprocessing.

EXPERIMENT METHODOLOGY

The material selection was based on the physical properties of four materials: aluminium, copper, PTFE, and FEP. Following the experiment (Table 1), the material selected for the role of the conductor was copper, while FEP film was selected for the dielectric. The self-adjusting mechanism utilises a spring and is based on the equilibrium of force between the centrifugal force due to the mass and the restoring force of the spring (Figure 3).

The final design is illustrated in Figure 4. The rotator is equipped with a wind scoop to rotate according to the wind, and a modified dielectric and spring are attached to apply a self-adjusting mechanism depending on the strength of the wind. The stator is equipped with a conductor for the purpose of extracting AC current, and the external design is curved, in contrast to the existing cylindrical TENG. This enables the provision of different contact areas depending on the degree of spring stretching.

The wind speed in the range of 2–14 m/s was varied via a hairdryer (H501 Xiaomi, Beijing, China). The experiments to find out the internal resistance of each cylindrical TENG between 1 and 20 MΩ and the peak-to-peak voltage for deriving the power generation were measured by a source measurement unit (2612B Keithley Instruments, Solon, Ohio, USA). The analysis of the data and the subsequent visualisation of the results were conducted using the software programme Microsoft Excel.

Table 1: Output comparison of material combination.

	Voltage [V]	Current [A]
FEP – Cu	182.95	2.40E-07
FEP – Al	38.20	7.37E-08
PTFE – Cu	70.52	2.49E-08
PTFE - Al	25.77	1.00E-08

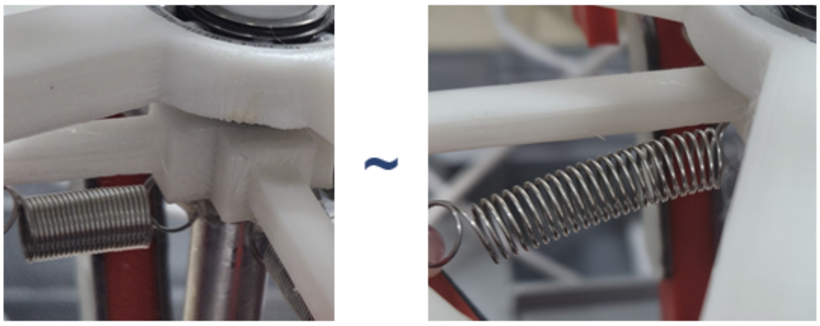

Figure 3: Self-adjusting mechanism.

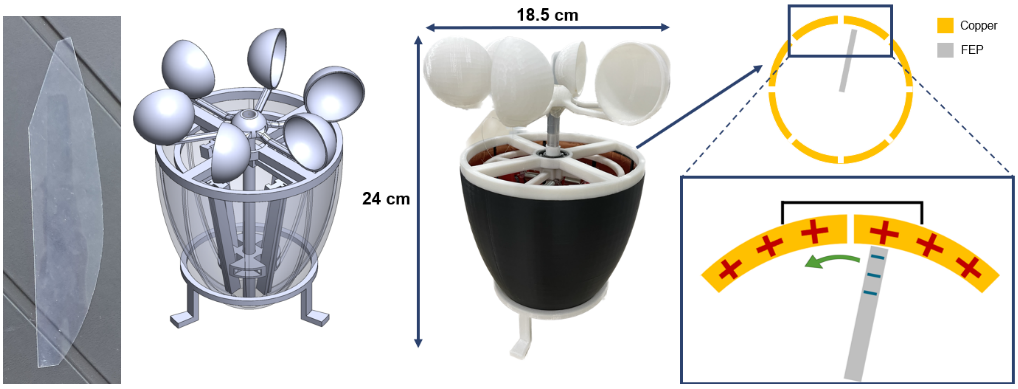

Figure 4: Final model design.

RESULT AND DISCUSSION

The internal resistance can be observed by examining the x-axis of the peak value in Figure 5. The values for N-TENG and SA-TENG were found to be 9 MΩ and 11 MΩ, respectively. It has been determined through analysis that the internal resistance of SA-TENG is greater than that of other models due to the intricate nature of its rotator design.

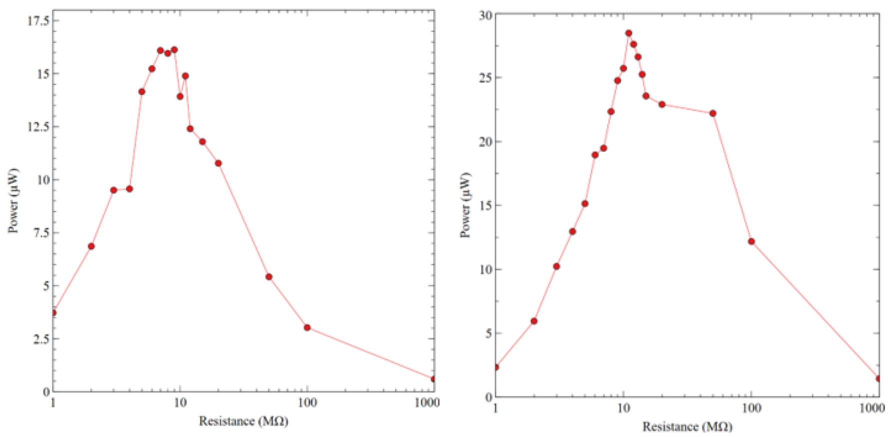

Figure 5: Resistance-power graph of N-TENG (left) and SA-TENG (right).

In conditions of relatively low wind speed (≤6 m/s), the outputs of the two devices are comparable. However, when wind speeds exceed 9 m/s, the contact area of SA-TENG increases, leading to an average increase in maximum output of 35%. The output slope is steep, confirming its excellent energy harvesting potential in a variable wind speed environment (Figure 6).

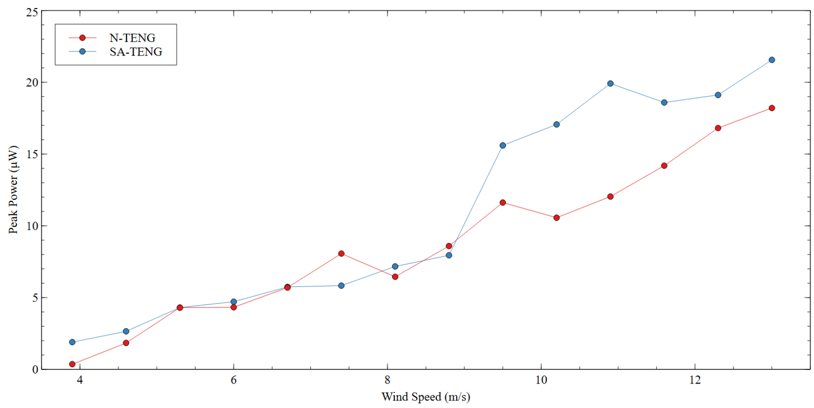

Figure 6: Wind-peak power graph of N-TENG and SA-TENG.

CONCLUSION

The SA-TENG has been demonstrated to deliver enhanced output across a broad wind-speed range, thus widening the applicability of TENG as a renewable micro-power source. Subsequent endeavours will entail the refinement of materials and the integration of charge-management circuitry, with the objective of enhancing power density and facilitating system integration.

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