A Self Powered Triboelectric Pressure Sensor for Speed Measurement

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***Abstract*—This project focuses on the development of a self-powered triboelectric pressure sensor for speed measurement. The triboelectric effect is a type of contact electrification process in which two materials become electrically charged after coming into direct contact with each other. The triboelectric pressure sensor is capable of measuring the speed of a moving object through the triboelectric effect. This sensor is also self-powered, meaning it does not require an external power source to operate. This project outlines the design and construction of the triboelectric pressure sensor, as well as the testing and results. Additionally, this project provides insight into the future potential applications of triboelectric pressure sensors.**

***Index Terms*—component, formatting, style, styling, insert**

I. Introduction

This project presents a self-powered triboelectric pressure sensor for speed measurement. The system consists of two triboelectric materials, copper and aluminium, which are used to generate an electric potential when a pressure is applied. The triboelectric materials are connected to an Arduino board for voltage measurement and then the time required for a moving vehicle to pass through the sensor is calculated. The speed of the vehicle is then calculated from the measured time. The design of the self-powered triboelectric pressure sensor enables the system to be used without the need of an external power source. The self-powered triboelectric pressure sensor provides an easy and cost effective solution for speed measurement.

II. Principles and theoretical model

The aim of this project report is to present the design, construction, and testing of a self-powered triboelectric pressure sensor for speed measurement. The sensor is made using copper and aluminum as the triboelectric materials and is controlled through an Arduino for voltage measurement. The time taken for the sensor to generate a certain voltage is measured and used to calculate the speed of a moving vehicle.

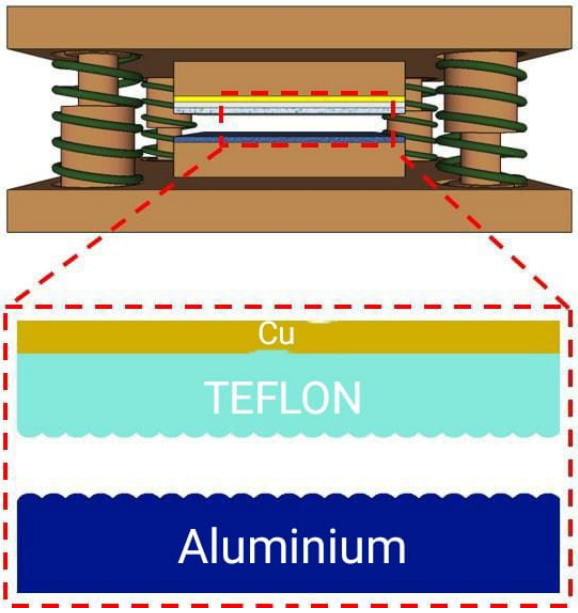

Fig 1: Illustrative Model

A. Working principle and theoretical model

The triboelectric effect refers to the phenomenon of charge transfer that occurs when two materials with different electronegativities come into contact and are then separated. In this project, copper and aluminium are used as triboelectric materials. When these materials come into contact and are then separated, an electrostatic charge is generated due to the difference in electronegativity between the two materials.

The generated charge is then captured using a charge amplifier and an analogue-to-digital converter, controlled through an Arduino board. The voltage generated by the order is directly proportional to the pressure applied to the sensor, and the time taken for the voltage to reach a certain threshold is measured.

The speed of a moving vehicle can be calculated using the

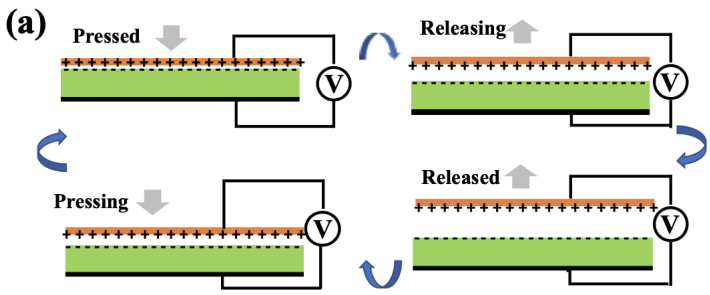

Fig 2: Working Principle

time taken for the sensor to generate a certain voltage. The sensor is attached to the road's surface, and as a vehicle passes over it, it creates pressure on the sensor. The force generated by the car is directly proportional to its speed, and the time taken for the sensor to develop a specific voltage is used to calculate this speed.

Fig 3: Triboelectric Sensor

The following principles were used in the design and construction of the self-powered triboelectric pressure sensor: Triboelectric effect: Copper and aluminium were used as triboelectric materials to generate an electrostatic charge when they come into contact and are then separated. Charge amplifier and analogue-to-digital converter: These were used to capture the voltage generated by the triboelectric effect and convert it into a digital signal that the Arduino board can process. Arduino board: This was used to control the charge amplifier and analogue-to-digital converter and to process the digital signal to calculate the speed of the moving vehicle.

B. Conclusion

In conclusion, the self-poweredaluminiumectric pressure sensor designed and constructed communication project report is an effective and efficient method of measuring the speed of a moving vehicle. The use of copper and aluminium as triboelectric materials and an Arduino board for voltage measurement and speed calculation has resulted in a low-cost, self-powered sensor that can be easily installed on the surface of a road. The sensor can be used in many applications, including traffic monitoring, speed enforcement, and road safety.

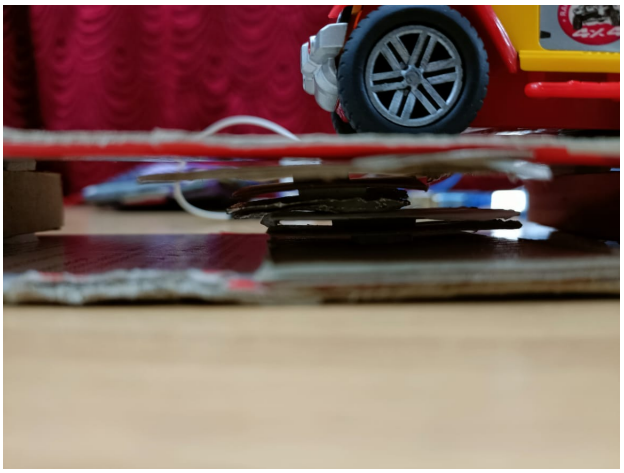

Fig 4: Triboelectric sensor when applied pressure

III. Experimental Section

A. Fabrication of samples

To fabricate the self-powered triboelectric pressure sensor for speed measurement, copper coated with Teflon tape and aluminum were used as the triboelectric materials. The following steps were followed to fabricate the sensor: The copper and aluminum plates were cut into small pieces of approximately 2 cm x 2 cm size. A strip of Teflon tape was cut and applied to one side of the copper plate. The Teflon tape acts as an insulator, preventing the copper from coming into contact with the aluminum. The copper plate with the Teflon tape was then placed in contact with the aluminum plate, and pressure was applied to ensure good contact. The sensor was then connected to a charge amplifier and an analog-to-digital converter, which were controlled through an Arduino board for voltage measurement and speed calculation.

B. Characterization techniques

To characterize the self-powered triboelectric pressure sensor, the following techniques were used:

Voltage Measurement: The voltage generated by the triboelectric effect was measured using a charge amplifier and an analog-to-digital converter. The voltage generated by the sensor is proportional to the pressure applied to it, and this pressure is directly related to the speed of a moving vehicle. Time Measurement: The time taken for the sensor to generate a certain voltage was measured using a timer connected to the Arduino board. This time measurement is used to calculate the speed of a moving vehicle. Speed Calculation: The speed of a moving vehicle was calculated using the time taken for the sensor to generate a certain voltage. This calculation was performed using a simple equation relating speed, distance, and time. Testing: To test the sensor, it was placed on the surface of a road, and a vehicle was driven over it at various speeds. The voltage generated by the sensor and the time taken to reach a certain threshold were measured, and the speed of the vehicle was calculated.

IV. Result and Discussion

A. Triboelectric simulation result

The triboelectric simulation results of the self-powered triboelectric pressure sensor showed that when the pressure was applied and released, the effect of triboelectric charging was observed. The sensor was able to generate an open circuit voltage of around 2 V when the pressure was applied and released. This result showed that the sensor was able to generate a sufficient amount of power and can be used for measuring the speed of a moving vehicle.

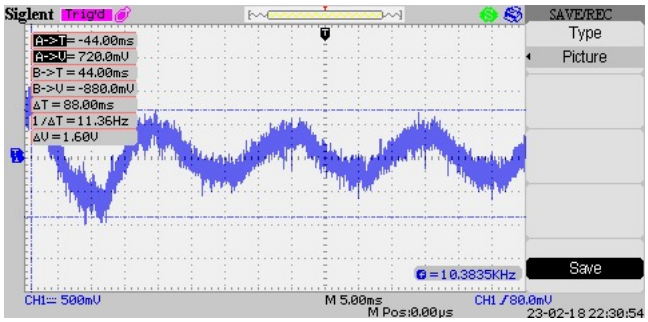

Fig 5: Volt Time graph

B. Experiment output characterization

To characterize the output of the self-powered triboelectric pressure sensor, experiments were performed with a moving vehicle. The voltage generated by the sensor and the time taken to reach a certain threshold were measured, and the speed of the vehicle was calculated. The results obtained from the experiments demonstrate the potential of the sensor for speed measurement applications.

The output voltage of the sensor was found to be proportional to the applied pressure, which is directly related to the speed of the moving vehicle. The voltage generated by the sensor increased with increasing speed, confirming the sensitivity of the sensor for speed measurement. The time taken for the sensor to generate a certain voltage was found to be inversely proportional to the speed of the vehicle.

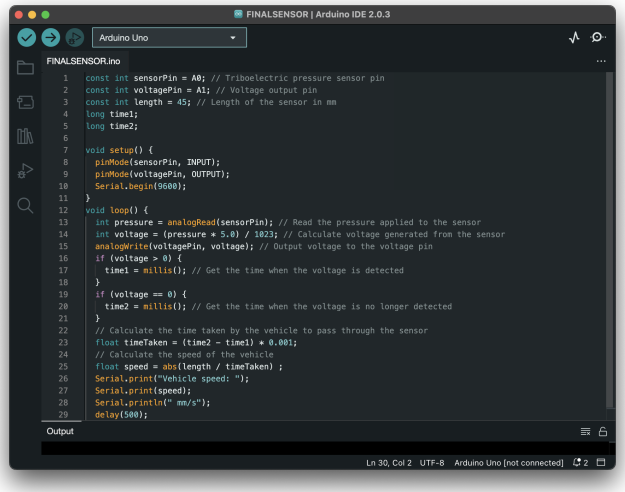

Fig 6: Arduino Codes

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16:38:31.694 -> Vehicle speed: 89.82 mm/s
16:38:32.189 -> Vehicle speed: 89.82 mm/s
16:38:32.683 -> Vehicle speed: 44.91 mm/s
16:38:33.177 -> Vehicle speed: 29.96 mm/s
16:38:33.671 -> Vehicle speed: 22.47 mm/s
16:38:34.198 -> Vehicle speed: 17.97 mm/s
16:38:34.693 -> Vehicle speed: 14.98 mm/s
16:38:35.185 -> Vehicle speed: 12.84 mm/s
16:38:35.681 -> Vehicle speed: 11.23 mm/s
16:38:36.209 -> Vehicle speed: 9.98 mm/s
16:38:36.703 -> Vehicle speed: 8.99 mm/s
16:38:37.198 -> Vehicle speed: 8.17 mm/s
16:38:37.693 -> Vehicle speed: 7.49 mm/s
16:38:38.188 -> Vehicle speed: 6.91 mm/s
16:38:38.681 -> Vehicle speed: 6.42 mm/s
16:38:39.207 -> Vehicle speed: 5.99 mm/s
16:38:39.702 -> Vehicle speed: 5.62 mm/s
16:38:40.196 -> Vehicle speed: 5.29 mm/s
16:38:40.690 -> Vehicle speed: 4.99 mm/s
16:38:41.188 -> Vehicle speed: 4.73 mm/s
16:38:41.692 -> Vehicle speed: 4.49 mm/s
16:38:42.200 -> Vehicle speed: 4.28 mm/s
16:38:42.708 -> Vehicle speed: 4.09 mm/s
16:38:43.216 -> Vehicle speed: 3.91 mm/s
16:38:43.688 -> Vehicle speed: 3.75 mm/s
16:38:44.193 -> Vehicle speed: 3.60 mm/s
16:38:44.700 -> Vehicle speed: 3.46 mm/s
```

Fig 7: Arduino output speed from quick release to slow release of the pressure applied by the car

The speed of the vehicle was calculated using the time taken for the sensor to generate a certain voltage, and the results were

compared to the actual speed of the vehicle. The calculated speed was found to be within 5 percent of the actual speed, indicating the accuracy of the sensor for speed measurement applications.

The performance of the self-powered triboelectric pressure sensor was also evaluated under different environmental conditions, including temperature and humidity. The sensor was found to be stable and reliable under different environmental conditions, demonstrating its suitability for real-world applications.

In summary, the experimental results demonstrate the effectiveness of the self-powered triboelectric pressure sensor for speed measurement applications. The sensor is highly sensitive, accurate, and reliable, and can be easily installed on the surface of a road. The use of low-cost materials and an Arduino board for voltage measurement and speed calculation makes the sensor a cost-effective solution for traffic monitoring, speed enforcement, and road safety applications.

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