GrilleFlowPiezoGen: Design and Development of a Prototype Vehicle Grille for Piezoelectric Power Generation from Airflow

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Abstract

Renewable energy plays a crucial role in mitigating environmental pollution and addressing potential energy crises. One promising approach is harvesting ambient kinetic energy and converting it into electrical energy using piezoelectric materials. This project utilizes the airflow-induced vibration generated during vehicle motion as an alternative energy source. The primary objective was to design, fabricate, and evaluate a prototype vehicle grille integrated with piezoelectric elements to harvest electrical energy from incoming airflow.

Initially, aerodynamic simulations were conducted using SolidWorks to determine the optimal grille geometry for piezoelectric installation. The simulation results revealed that a rounded-edge grille design with a maximized cross-sectional area achieved the highest Reynolds number (34,291.20), indicating a robust turbulent flow ideal for energy harvesting. Based on these insights, a full-scale grille prototype was fabricated using 3D printing. Piezoelectric elements were integrated with an electrical circuit, and impact plates were installed to mechanically transfer the airflow-induced vibrations. Preliminary testing demonstrated that the prototype successfully generated an electrical output of approximately 0.2 mV per impact. These findings validate the feasibility of capturing lost kinetic energy from moving vehicles and provide a foundation for developing energy-harvesting automotive components.

Keywords: renewable energy, vehicle grille, piezoelectricity, 3D printing