Name(s)

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Project Number

S1013

Project Title

Energy Generation from Motor Vehicle Drag through Piezoelectric Processes

Abstract

Objectives

As concluded by the U.S. Department of Energy, aerodynamic drag exerted upon motor vehicles dissipates approximately 8-12% of potential energy provided by finished motor gasoline as heat. In proportion to the daily average gasoline consumption, energy provided by ~39.17 million gallons of gasoline is dissipated as heat in contemporary vehicles with an average drag coefficient of 0.30 Cd.

The presence of aerodynamic drag, though the phenomena dissipates usable energy as heat, can potentially generate electricity with the use of polyvinylidene fluoride (PVDF) film, a piezoelectric polymer. If such piezoelectric semi-crystalline material connected to a storage capacitor by a circuit is placed on the frontal body of a vehicle, mechanical stress produced by an accelerating vehicle can induce polarization within the PVDF film as per the piezoelectric direct effect, and electrical energy (Uout) can be harvested.

Methods

An Arduino Uno R3 microcontroller was uploaded with written code using the Arduino IDE platform to read input voltage values at the analog port. The PVDF film was attached to the upper center of a 2002 Toyota Prius (0.29 Cd) registration plate and connected to a 1 M ohm load resistor via a breadboard. Another set of test leads connected the breadboard to the analog port (A0) of the microcontroller, which was connected to a computer. The vehicle was then accelerated, thus inducing changes in stress upon the semi-crystalline film. Voltage was generated and measured by the microcontroller. The voltage values were plotted onto the Arduino IDE serial plotter. 20 trials were conducted with a time duration of 500 ms. and the amount of electrical energy (Uout) generated was calculated.

Results

The total electrical energy (Uout) generated for all trials by the PVDF piezo film was determined to be minimal, ranging within nanojoules. The potential electrical energy that could be harvested if all usable vehicle frontal surface area was covered in PVDF film was also estimated.

Conclusions

With the stated results, this energy harvesting method is deemed possible and is able to produce electrical energy. However, due to current inefficiencies in energy conversion ratios of piezoelectric polymers, this energy harvesting method is of now not entirely possible for compact vehicles. However, this method would be much more suitable for larger vehicles with greater surface area and drag coefficients such as aeroplanes and trucks.

Summary Statement

I produced electricity by converting mechanical energy from vehicle drag using the direct piezoelectric effect of polyvinylidene fluoride (PVDF) film.

Help Received

None. I myself designed my engineering model, constructed the prototype, and gathered/analyzed the experimental data.