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Harnessing Wind Energy for Use in an Automobile

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Background

With the recent commitment of multiple auto manufacturers to develop and mass-produce battery-powered vehicles, there may exist an opportunity to implement a ubiquitous device to extend battery life in future versions of these vehicles. The industry is already implementing new and creative technologies to accomplish improved efficiencies such as solar cells on electric vehicles [1], regenerative braking systems on hybrid vehicles [2]. The device proposed in this project would serve a similar purpose.

Purpose

This project explores the possibility of using wind turbines to generate power for automobiles by converting a portion of the car's drag into usable energy. Specifically, placing the turbines inside the grille of the car was the focus of this project.

Hypothesis

This project hypothesized that when installing a wind turbine inside the grille of a car, the turbine will produce more power than the amount of drag that the turbine will produce. This would mean that a grille-mounted wind turbine would increase a car's efficiency. This is under the assumption that the added mass of the turbine would have a negligible effect on the car's efficiency.

Procedure

This experiment is designed to compare the difference between the drag of 2 foam boxes to the power generated by a wind turbine. Inside a homemade wind tunnel, when a fan is switched on a pane of plexiglass that is attached to four identical springs pushes against and compresses the springs with the force of the fan's wind (figure 1). The spring constant for each spring is calculated using Hooke's law. A Motion Sensor analyzes the position of the pane of plexiglass with respect to time as the wind moves it. The displacement of the pane and the spring constant are used to calculate the total energy absorbed by the springs. The period of time in which the energy was absorbed was used to calculate the power that was exerted to compress the springs. Two foam core boxes with identical dimensions are tested in the wind tunnel: one plain box, and one containing a wind turbine. The difference in the power used to compress the springs for each box yields the amount of drag (in watts) caused by the addition of the wind turbine. The wind turbine's power output is measured using a multimeter. If the wind turbine's power output is greater than the drag it adds, then the results support the hypothesis.

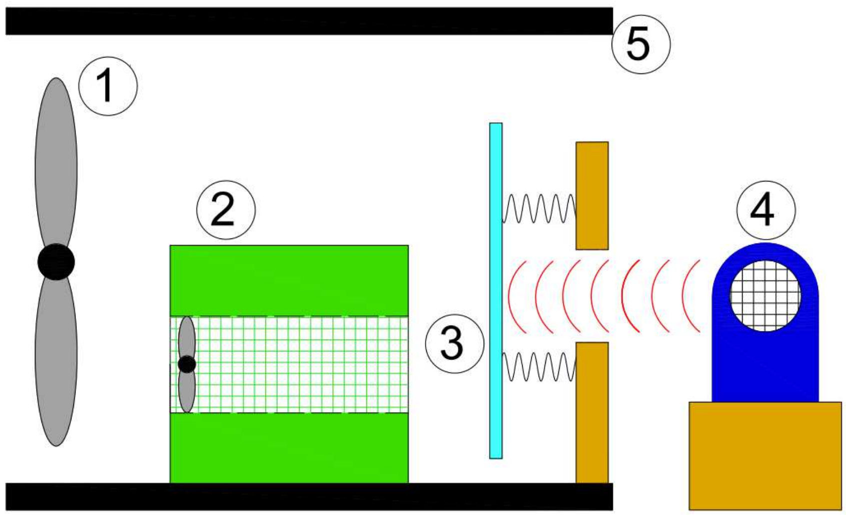

Figure 1: Depicts the experimental setup. 1 represents the fan that generates the wind. 2 represents the foam box; the box containing the turbine is depicted above. 3 represents the pane of plexiglass which compresses the springs when pushed by the wind. 4 represents the motion sensor which measures the position and time of the plexiglass. 5 represents the wind tunnel itself which is made from foam core.

Variables

Two identically-sized foam core boxes were tested: one with a wind turbine installed inside it, and one without a wind turbine. The air resistance of the plain box with no turbine represents the control. The air resistance of the box containing a turbine represents the dependent variable. The power generated by the wind turbine represents the independent variable. distance from fan, dimensions of box, air pressure

Results

The average spring constant of each spring was calculated to be 274 N/m. When testing the plain box the average power used to move the plexiglass was 431 mW. When testing the box containing the wind turbine the average power used to move the pane of plexiglass was 341 mW. The plain box is more aerodynamic than the box containing the turbine which means that more airflow can push on the plexiglass (figure 2). The difference between these values represents the wind turbine's drag which was calculated to be 90.0 mW.

The average voltage output from the wind turbine was 2.04 V and the average current output from the wind turbine was 833 mA. Using these values the motor's average power output was calculated to be 170 mW.

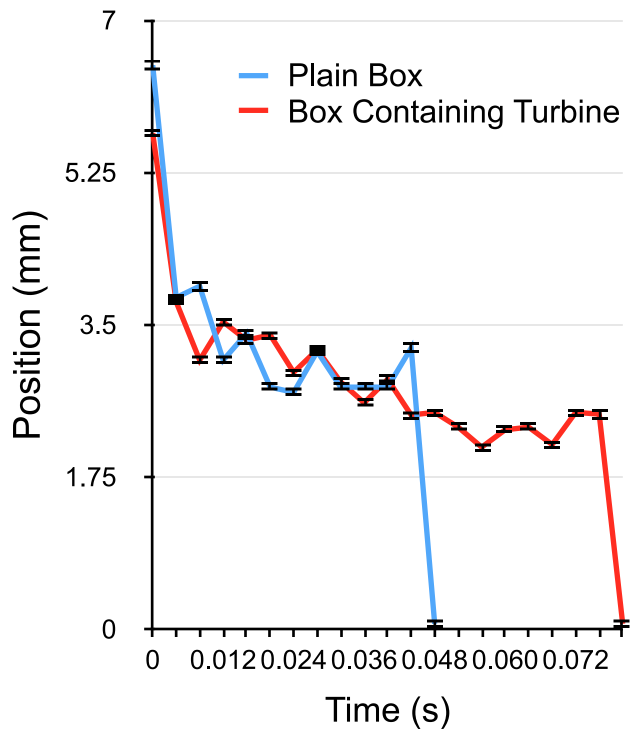

Figure 2: Graph displays the position/time of the plexiglass. Each line is representative of 5 independent experiments. The plain box has less drag because it creates a greater displacement of the plexiglass over a shorter period of time.

The turbine produced 80 mW more power than the amount drag it added. In other words 53% of the turbine's power is neglected by its own air resistance while 47% of the turbine's power is not neglected by the air resistance of the turbine.

Conclusions

The results showed that 53% of the turbine’s power is neglected by its own drag while 47% of the turbine’s power is not neglected by the drag of the turbine. This supports the hypothesis and demonstrates that if a turbine is installed inside the grille of a car, the power produced by the turbine will be greater than the drag it adds. The results from this project demonstrate that installing wind turbines inside the grille of a car is a viable option to explore in future automotive designs.

Future experiments could explore the following: how varying the wind speed will affect efficiency, how adding a second wind turbine behind the first will affect efficiency, how changing the shape of the wind turbine’s enclosure will affect efficiency and what the optimal shape of the wind turbine blades would be.

Applications:

For all cars: Air-tight shutters could be installed in front the wind turbines which only allow airflow when the car is braking. The wind turbines would generate power as the car slows down. This is another form of regenerative braking.

For traditional gasoline powered cars: The wind turbines could replace or assist the alternator by using the extra power generated to charge the car’s battery. Since the alternator places a load on the engine, by assisting the alternator at high speeds, the car would become more fuel efficient.

For Hybrid or Electric Cars: The wind turbines could use the power they generate to recharge the car’s main battery pack which would extend the range of the car.

For High Performance Electric/Hybrid Cars: The wind turbines could route the power directly to the car's electric motor to provide a boost in horsepower to the car. The faster the car travels, the more power the turbines could divert to the motor. Therefore, the faster the car travels, the larger the boost that the motor will receive.

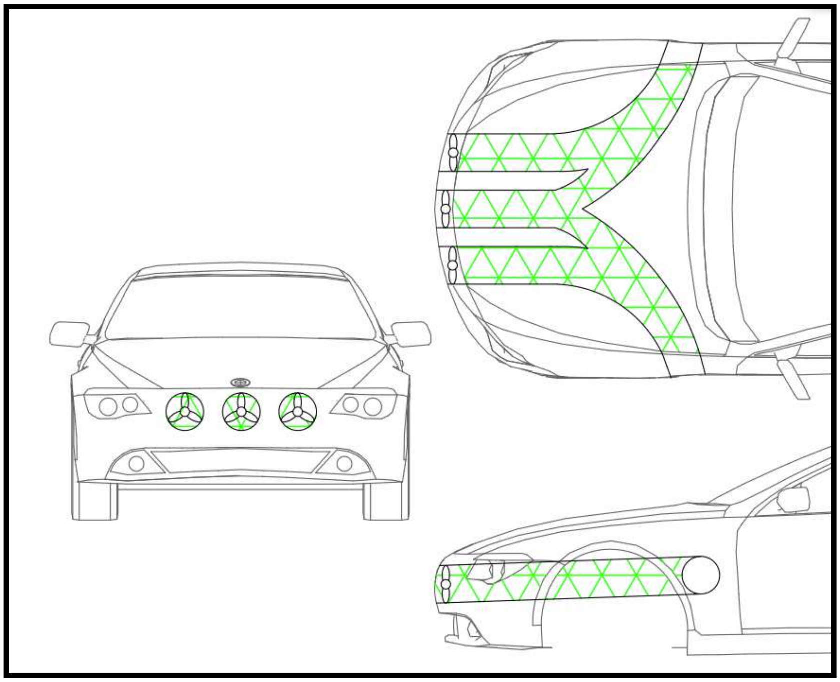

Figure 3: Depicts a possible patent application. Three wind turbines are placed in the grille of an electric car. The air enters inlets through the grille, spins the turbines, then exits via the tunnel exits on either side of the car. The turbines are connected in series. This is novel because neither of the existing patents make any claim to mounting the turbines in a car's grille.

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