Energy Conservation and Transformation

Goals

- Understand how energy can change
- Observe the transformation of energy
- Compare the efficiencies of processes

Background

We can't create or destroy energy, only transform it from one form to another. But why do we talk about energy being used up, wasted, or lost? When energy transforms into a form that we can't use effectively, it can be said to be wasted. Our goal then is to minimize the amount of energy that is wasted in any energy transformation by trying to get as much of the energy as possible to convert into the form we want.

Gasoline-powered cars face this problem every day. The ideal energy transformation is from the chemical potential energy within the fuel to kinetic energy of motion, which causes the car to move. However, most internal combustion engines, which release the stored energy of the fuel by burning it, have terrible efficiency, averaging around 20%.

Efficiency is just the ratio of the output (or useful) energy of a process to its input energy. Efficiency is always a dimensionless number from 0 to 1.0, and is usually written as a percentage from 0% to 100%.

Internal combustion engines, which run on gasoline, have an upper limit of around 40% efficiency. So a majority of the energy transformation of an internal combustion engine does not go into its primary use: motion. Instead, the potential energy of the gasoline is turned into sound, vibration, and a large amount of heat.

Fuel cells, in comparison, regularly achieve 60% efficiency in stacks, and have upper limits approaching 85%. With no moving parts, there's much less energy loss to heat and friction.

How well does a miniature fuel cell approach the efficiencies of its larger cousins? We will run a series of experiments to find out.

Procedure

1. Insert the cylinders into the frame of the car. Fill them with about 40 mL of distilled water.
2. Uncap the tube on the O2 side of the fuel cell.
3. Fill the syringe with distilled water and fill the fuel cell using the syringe.
4. Replace the cap on the O2 tube.
5. Insert the fuel cell into the frame of the car in front of the cylinders. Attach the H2 and O2 sides of the fuel cell to the H2 and O2 cylinders with the longer tubes, which will prevent the hydrogen and oxygen gases from escaping.
6. Connect the battery pack to the fuel cell using the red and black plugs, then turn on the battery pack. You should see the fuel cell start to generate hydrogen and oxygen gas.
7. Once you see bubbles start to escape the H2 cylinder, turn off and disconnect the battery pack.
8. Connect the red and black wires to the car chassis to start the car.

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Observations

Experimentation

1. You've produced hydrogen and oxygen from water. Now, connect the fuel cell to the motor. What happens?

2. What could you change about your car that might make the car run faster? Design an experiment to try to make the car run faster. Describe it and record your results below.

3. What if you wanted to make your car run for a longer time? How would you alter your car to achieve that? Design an experiment you could run and describe it below.

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Measurement

For this section, you will need a multimeter or the Horizon Renewable Energy Monitor. For an introduction to using a multimeter, click here.

1. Measure the current in Amps and the voltage in Volts while generating hydrogen and oxygen. Record your answers below:

Current: ____________ A

Voltage: __________ V

2. Voltage is equal to the current multiplied by the resistance (V = IR), so according to your data what is the resistance of the fuel cell?

Resistance: ___________ Ω

3. Lift the front wheels to keep the car in one place and measure the current in Amps and the voltage in Volts while the car is running. Record your answers below:

Current: ____________ A

Voltage: __________ V

4. P = I • V, where P is power, I is current, and V is voltage. Calculate the power required to split water and the power to run the car and record your answers below:

Power (generating): ____________ W

Power (running): ____________ W

5. How do you explain the results you just calculated in terms of the efficiency of the fuel cell?

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Analysis

1. Make a scientific claim about what you observed while running the fuel cell car.

2. What evidence do you have to back up your scientific claim?

3. What reasoning did you use to support your claim?

4. Use your observations to design an experiment you could run to try to increase the energy efficiency of the fuel cell. Describe your experiment below.

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Conclusions

1. Would it ever be possible to use 100% of the electric energy produced by the fuel cell to move the car? Why or why not?

2. Do you think your fuel cell achieved the levels of efficiency of the fuel cell stacks described in the Background section? Why or why not?

3. Why is it important for machines to have high efficiency?

4. Based on your results, do you think fuel cells are a good energy source for cars?