CALIFORNIA STATE SCIENCE FAIR
2005 PROJECT SUMMARY

Name(s)
Christopher F. Weyant

Project Number
S0716

Project Title
Improving the Performance of Proton Exchange Membrane (PEM) Fuel Cells through Design Modifications

Abstract

Objectives/Goals
My objective is to improve the performance of Proton Exchange Membrane (PEM) Fuel Cells. The ideal thermodynamic voltage limit on PEM fuel cell performance is approximately 1.23 Volts. Activation, ohmic, and mass transport losses in fuel cells lead to reductions in voltage as loads are attached to the electrodes and current is drawn.

Methods/Materials
I modified the flow plate/anode of a fuel cell from a kit by changing the size of the holes in the anode flow plate. I also added flow channels with various other geometries (e.g., parallel or inter-digitated patterns with various channel depths and widths). I varied the load on the cell by adding resistors with a range of resistances to the external electrical circuit, and measured the resulting voltages and currents. I drew I-V and Tafel plots for each design. I also used a 2-D fluid mechanics approximation of flow in a channel to model concentration losses along the flow channels.

Results
The linearity of the Tafel plots based on the Butler-Volmer equation shows that the initial voltage losses resulting from current increases are largely activation losses. My results for the different flow plate hole sizes show that the greater the total hole perimeters there is in a flow plate, the lower the activation losses and the better the fuel cell performance (less reduction in voltage for any level of current). Although experiments with alternative flow channel designs are continuing, initial results suggest that smaller flow channels reduce both activation and mass transport losses.

Conclusions/Discussion
I used electro-chemistry and fluid mechanics laws governing fuel cell performance to try to predict the performance of the fuel cell kit as I modified it. I also used existing theoretical and experimental results in picking my designs. Through this process I was able to substantially improve the measured performance of a PEM fuel cell kit by making design modifications.

Summary Statement
I improved the performance of a PEM fuel cell through design modifications.

Help Received
Mr. Tim Holme, a graduate student at Stanford University, provided me with feedback and references.