High Performance PEM Fuel Cells - From Electrochemistry and Material Science to Engineering Development of a Multicell Stack

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1. Task 1. Advanced Membrane - Electrode Assembly (MEA) Optimization

Investigators: Serguey Gamburzev and Omourtag A. Velev

Objectives

The objective of this Task is to develop MEAs capable of attaining a current density of 0.7 A/cm^2 at 0.7 V with hydrogen and air as reactants at atmospheric pressure.

1.1 Catalysts and Electrodes

Several 50 cm^2 MEAs were prepared to test the reproducibility of our techniques for electrodes and MEAs manufacture. Results from these tests are presented on Figure 1. At low current densities the performance of the cells is identical. In the range of current densities of practical interest differences of up to 40 mV can be observed.

1.2 Proton Conducting Membranes

We used different thicknesses GORE-SELECT™ and Nafion® 112 membrane.

1.3 Work to be Performed in the Next Month

- Preparation of larger size electrodes (up to 200 cm^2) with the best electrode composition and determination of the effects of scale-up on cell performance.

2. Task 2. Water Management

Investigators: Hari Dhar*, Serguey Gamburzev, Omourtag A. Velev, and Frank Simoneaux

Objectives

The objective of this Task is to eliminate external humidification of the reactant gases for PEMFC stacks operating at the desired current density of 0.7 A/cm^2 for which the goal is a cell potential of 0.7 V.

2.1 Single Cells

No single cell tests were performed this month.

2.2 Cell Stacks

During this month a four cell stack with MEAs provided by BCS Technology was assembled and tested. The MEAs were with electrodes with catalyst loading of 4.5 mg Pt/cm^2, area 50 cm^2, and Nafion® 112 membrane. The uncatalyzed gas diffusion substrate for these MEAs was provided by CESHR. The cell stack was operated with dry reactant gases at atmospheric pressure and at 50 °C continuously for 600 hours at different power levels. The average cell voltage at a current density of 300 mA/cm^2 was 0.61 V.

2.3 Work to be Performed in the Next Month

2.3.1 Single Cells

- Evaluation of thinner membranes such as Nafion 112 and GORE-SELECT™.

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* BCS Technology, Inc. - subcontractor on this project

- Evaluation of self-humidified MEAs with Nafion 112 and GORE-SELECT™ membranes in larger (100 and 150 cm^2) area fuel cells. The objective will be to reproduce the performance of smaller cells.

2.3.2 Cell Stacks

- Investigation of the effect of scale-up and cell stacking on performance in four cell stacks using BCS and CESHR MEAs.

3. Task 3. Lightweight Cell Components

Investigators: Imran J. Kakwan, Frank Simoneaux, and Omourtag A. Velev

Objectives

The objective of this Task is to identify and test cell components to build a lightweight PEMFC stack.

3.1 Compact Lightweight Bipolar Plates

A study on the effect of gas flow field design on fuel cell performance was initiated this month. One MEA prepared with 40 μm thick membrane GORE-SELECT™ and CESHR electrodes was tested in two types of flow fields. One with three serpentine channels in series (series design) and one with three channels in a series/parallel configuration (series/parallel design). Comparison of the cell performance is presented on Figure 2. There is very little difference in cell performance. At high current densities the series/parallel design shows a slight advantage over the series design. We used real time neutron radiography to image liquid water flow patterns during cell operation. This technique provides us with a quick and reliable indicator for the quality of the flow field design. The series design showed no water accumulation and channel plugging during operation at different power levels. We observed that some of the channels in the series/parallel design became plugged with water soon after cell startup and remained full with water during the cell operation. This is probably due to the uneven gas flow distribution for this design.

3.2 Work to be Performed During Next Month

- Flow field design optimization
- Real time neutron radiography experiments

4. Task 4: Performance Demonstration in > 250 W Short Stack

Investigators: James Lee, Imran J. Kakwan, and Omourtag A. Velev.

Status - no work during quarter.

4.1. Work to be Performed in the Next Quarter

- Studies and analysis of designs for bipolar plates, flow-fields, thermal and water management for a short stack configuration will continue.

Summary of Expenditures

The summary of expenditures for this project is presented in Figure 3.

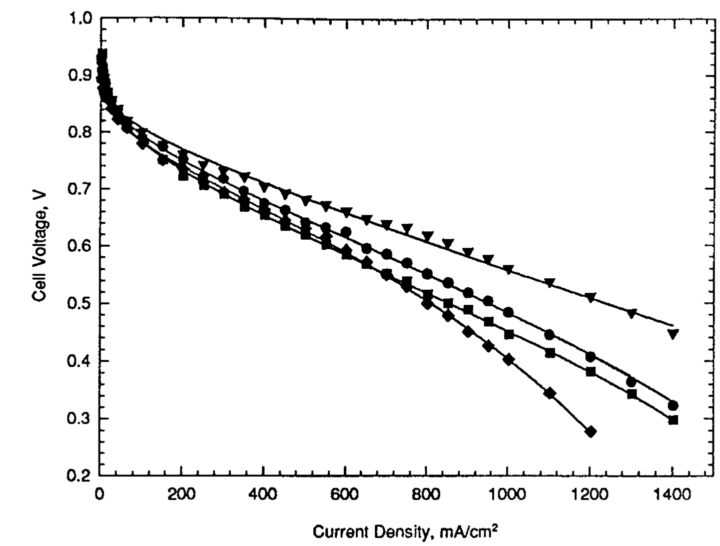

Figure 1 Cell potential vs. current density plots for PEMFCs for identically prepared MEAs, 50 cm^2 cell, anode Pt loading 0.3 mg/cm^2, cathode Pt loading 1.4 mg/cm^2 GORE-SELECT™ 40 μm membrane, temperature 50 °C, atmospheric pressure, reactants humidified.

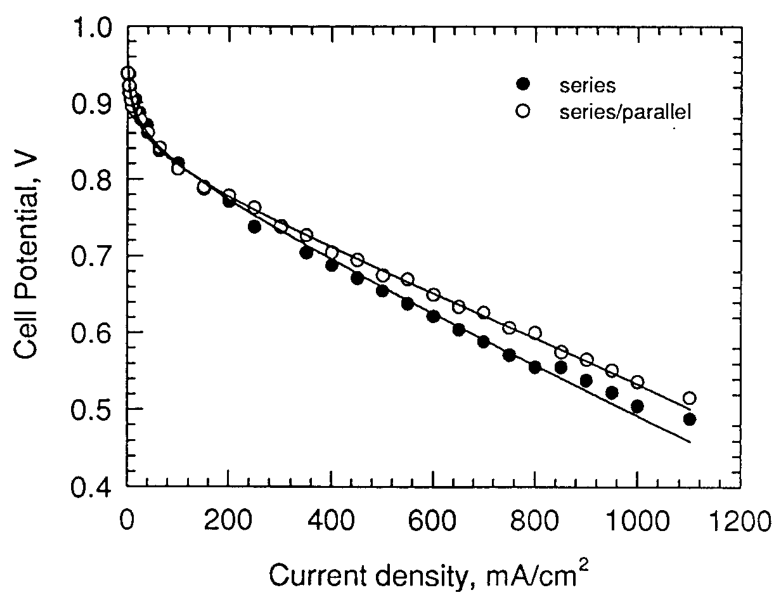

Figure 2 Potential vs. current density plots for an MEA tested in cell fixtures with different gas flow field design. 50 cm^2 cell, anode Pt loading 0.3 mg/cm^2, cathode Pt loading 1.2 mg/cm^2, GORE-SELECT 40 μm membrane, temperature 50 °C, atmospheric pressure, reactants humidified.

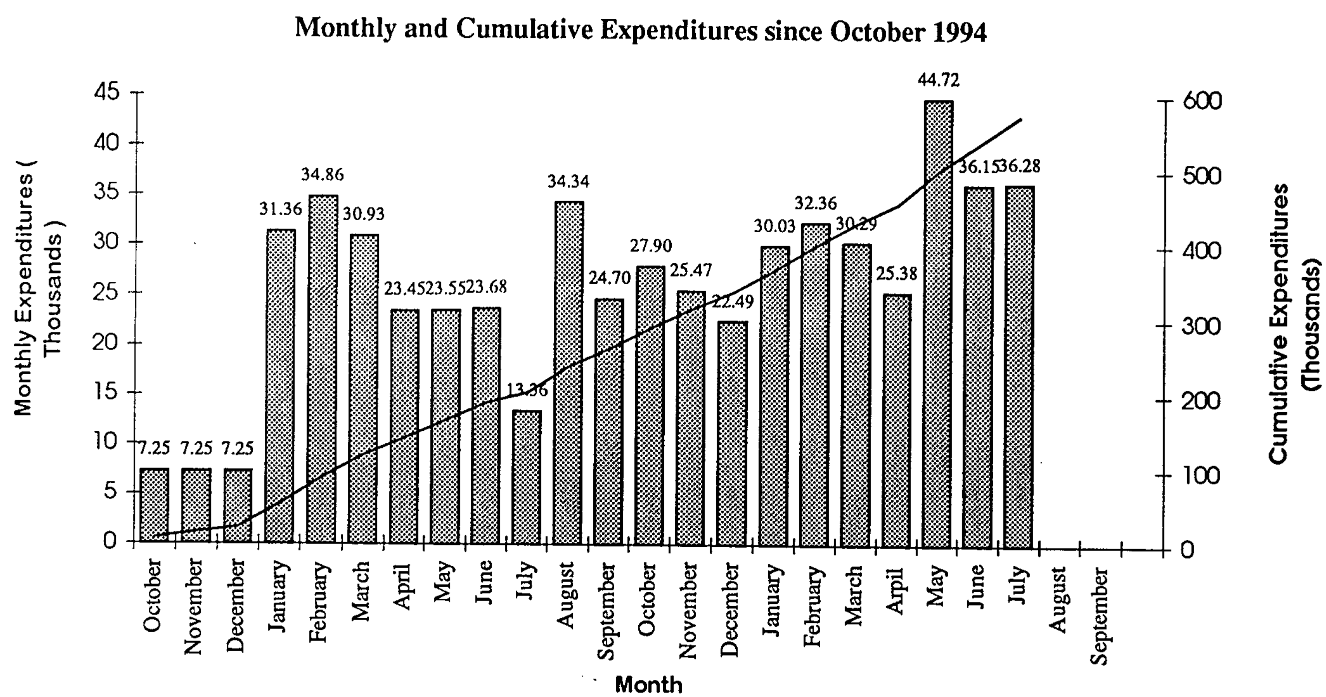

Figure 3 Summary of expenditures - monthly and running totals.

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