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Quarterly Progress Report

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

Project Title: Hydrogen PEMFC Water Transport, B&R # EB4209, EEW112798.

Project Period: July 1, 2007 to September 30, 2007
Date of Report: October 18, 2007

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Other Key National Lab Researchers:

Sub-Contractors Funded through AOP Task:

Industrial Partners: none

DOE Managers: Nancy Garland

Project Objective: To develop analytical and multi-dimensional models for simulating (1) water transport and removal in a PEM (proton exchange membrane or polymer electrolyte membrane) fuel cell under normal operation conditions, (2) ice formation after the shut down of a PEM fuel cell under freezing conditions, and (3) thawing during start-up from frozen conditions in a PEM fuel cell.

Background: Particularly during peak power conditions, water generated in the oxygen reduction reaction and transported from anode to cathode via electro-osmotic drag must be removed efficiently in order to achieve and maintain high PEM (proton exchange membrane or polymer electrolyte membrane) fuel cell performance. Under freezing conditions, residual water within a PEM fuel cell after its shut-down can freeze. The formation of ice within MEA (membrane electrode assembly) can hinder reactant transport, cause mechanical stresses to develop, and degrade cell voltage. Ice formed after the shutdown of a PEM fuel cell must be thawed during its start-up for given frozen conditions.

In this sub-project, we propose to develop analytical and multi-dimensional models for simulating 1) water transport and removal under normal operation conditions; 2) ice formation after the shut down of a PEM fuel cell under freezing conditions; and 3) thawing during start-up from frozen conditions in a PEM fuel cell. Specifically, we propose to develop sub-models for liquid water removal via droplet detachment and evaporation. Furthermore, we propose to develop multi-dimensional models for simulating water transport and removal under normal operating conditions, ice formation under freezing conditions, and thawing during start-up from frozen conditions.

Status: An analytical model for predicting the critical air-flow velocity at the onset of water-droplet detachment from the GDL/channel interfaces in PEM fuel cells was developed. Model predictions were compared with experimental data available from the literature in order to assess validity of the model. Model utilization was demonstrated in case studies. We've also started to develop a two-phase sub-model for analyzing flow mal-distribution among PEMFC flow channels.

Plans for Next Quarter and Key Issues: Complete development of a two-phase sub-model for assessing flow mal-distribution among PEMFC channels. We also plan to initiate the development of a sub-model for analyzing liquid-water removal via evaporation.

Patents: none.

Publications / Presentations:

1. Ken S. Chen, "Predicting water-droplet detachment from GDL/channel interfaces in PEM fuel cells", *ECS Transactions*, Vol. 11, No. 1, p. 715 – 724 (2007).

2. Ken S. Chen, "Predicting water-droplet detachment from GDL/channel interfaces in PEM fuel cells", presentation at the *212th Electrochemical Society Meeting*, Washington Hilton, Washington DC, October 7 – 12, 2007.