

Project Summary

Name of the Applicant: Rochester Institute of Technology

Project Director / Principle Investigator(s): Satish G. Kandlikar, Rochester Institute of Technology, (Project Director and Principle Investigator); Thomas A. Trabold, General Motors (Co-PI); and Jeffery S. Allen, Michigan Technological University (Co-PI)

Project Title: *Visualization of Fuel Cell Water Transport and Performance Characterization*

Objectives: In the proposed program, Rochester Institute of Technology (RIT), General Motors (GM) and Michigan Technological University (MTU) will focus on exploratory studies that address water transport, accumulation and mitigation processes in the gas diffusion layer (GDL) and flow field channels of the bipolar plate (BPP), covering Topic 2A in the current solicitation. The overall objective of the proposed program is to deliver an optimized combination of GDL material, BPP design and surface treatment, and anode/cathode flow conditions that minimize fuel cell water accumulation and the attendant freeze damage while suppressing regions of dehumidification that also degrade performance and material durability. The program will combine material, design and operation parameters to improve fuel cell performance through control of liquid water on both anode and cathode sides, with particular emphasis on freeze operation and consideration of cost constraints for implementation in automotive fuel cell systems.

Description: Program objectives will be accomplished by a systematic experimental and modeling program that begins at the component level, synthesizes this fundamental learning into combinatorial ex-situ experiments with nearly full visual access, and then progresses to increasingly more complex in-situ experiments that utilize fuel cells with full visual access at RIT and advanced diagnostic methods such as current and high-frequency resistance (HFR) distribution and neutron radiography. The program will involve an iterative process for development of diffusion media and BPP design concepts at the component level with Go/No-Go decision points to pass prior to proceeding onto the subsequent task phase involving more complex experimentation. GM will also conduct baseline freeze-thaw testing utilizing neutron radiography, which provides full two-dimensional liquid water distributions in an operating fuel cell, through an existing partnership with the National Institute of Standards and Technology (NIST). The baseline GDL samples from these initial freeze-thaw tests will be sent to MTU for post-mortem analysis of the bulk structure and surface integrity. The experimental activities will lead to development of a two-phase multi-channel flow model. The final system optimization may involve spatial variation of the GDL and/or bipolar plate properties, using material development expertise existing at GM.

Potential Impact: Successfully satisfying the objectives of the proposed project will provide a framework for combining component-level technology into workable fuel cell stack concepts that control the anode and cathode water distributions. The work will directly address a number of water management issues and will potentially affect the development of GDL materials, bipolar plate design and surface properties to yield satisfactory performance over the entire automotive drive cycle, including freeze-start conditions.

Major Participants: The proposal will involve participants from RIT, GM and MTU. Leading the overall project and RIT research activities is Professor Satish G. Kandlikar who brings a great deal of research experience in the areas of microscale flow boiling and visualization. Also contributing from RIT will be Professor N. Rao, a faculty member in the Imaging Science department who will help with the image processing portion of the testing. Key personnel at GM include Dr. Thomas A. Trabold, Mr. Jon P. Owejan and Dr. Mark F. Mathias, who all have extensive experience in various aspects of fuel cell research and development, especially in the areas of material development and water management. Professor Jeffrey S. Allen of MTU, well known in the areas of capillary and two-phase microchannel flows, will be contributing to the project in two-phase modeling and investigation of water transport in component-level studies of GDL and channels. There will also be a significant level of student involvement at both RIT and MTU in the form of co-op, M.S. and Ph.D. students.