Project Report

Application No. 2014
Short title Imaging Water Profile in Alkaline Exchange Membrane Fuel Cells

Objectives: short, medium and long term (<250 words)

In the short term, our primary goal was to generate the first neutron images of water distribution within an operational Alkaline Exchange Membrane Fuel Cell (AEMFC). This allowed elucidation of mechanisms facilitating water management in AEMFCs; and identification of gaps in existing knowledge and understanding of AEMFC operations and barriers to performance. These objectives were achieved to a level beyond what was anticipated prior to the campaign, with imaging an operating fuel cell in 'through-plane' configuration whilst employing a flow field design that allowed distinction between and resolution of water observed on anode and cathode side of the cell. In the medium term we aim to leverage our acquired understanding towards improved hardware design and operational parameters for more effective water management in AEMFCs. Additionally, by solidifying our understanding of current known bottlenecks to AEMFC performance through direct visualization, we wish to identify new directions for further improvement in AEMFCs as well as undertaking further imaging experiments for next-generation advances. This is intended to advance our long term goal of securing AEMFC as a disruptive technology in automotive applications, by competing directly with proton exchange membrane fuel cells in performance while greatly reducing costs due to the key advantages of AEMFCs, namely non-precious catalysts and less expensive hardware materials. Key to this challenge will be alleviating complication in water management that were presumed and now, for the first time, demonstrated in AEMFCs.

Brief summary of work carried out:

Through-plane neutron images of three different hardware configurations of single, large active area (250cm2) alkaline exchange membrane fuel cells were carried out. The cells were operated under conditions similar to the nominal operation of a fuel cell stack designed for 2kW power delivery. Imaging covered cell activation, normal operation, flooding and drying events, variations in reactant (Air,H2) stoichiometric flow and shutdown. Selective water removal techniques were employed to achieve a snapshot of water distributions under various conditions of anode and cathode flow fields and GDLs allowing resolution of different water concentration regimes as a function of location in the active area relative to the gas flow paths.

Main achievements intended for publication <250 words

The first ever internal images of an operational AEMFC showing water distribution will be presented. Further we demonstrate a methodology for addressing one of the major challenges associated with AEMFC water management, namely the generation of water on the fuel (H2) side of the cell and the need to remove that water in excess without a drastic increase in H2 consumption. Mapping of water distribution is carried out, identifying problem areas in a large-active-area fuel cell arising from the x-y distributions of humidity, gas velocity in flow fields, water stagnation etc, providing design concepts that can alleviate these performance-limiting phenomena.

Difficulties encountered <250 words

No significant difficulties were encountered experimentally, other than the inability to measure in the in-plane direction, which was expected due to the size of the cells. This issue was anticipated and we expect to make in-plane measurements in a subsequent campaign with specialized cell hardware.

Further comments: