Project Report 2058

Investigation of the water distribution, coupled with current density and temperature mapping

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Objectives: short, medium and long term

On the short terms, the objective of the neutron campaigns are to capture the water content in the active and cooling channels of the air cooled, open cathode fuel cells, and to validate and / or infirm the assumptions built up in previous studies. Simultaneously, the current and temperature profiles will be captured at the same time. On the medium term, it will enable to correlate the water profile with the current and temperature maps and understand the gradients, and provide possible explanations on the source of the formation of such behaviour. Finally, the long terms objective are to use the results to change the designs of the fuel cell to improve the water management, and to support and validate CFD simulations of PEFC performances.

Brief summary of work carried out

The experimental campaign was composed of three different experiments. Firstly, in through-flow mode, the cell was operated at a range of flow rates and current density. The changes of voltage, water content, temperature and current density gradients were monitored, using the novel methodology. Secondly, the cell was operated in dead ended at different current densities, in order to understand the processes leading to a coverable voltage drop after extensive dead ended anode operations. Finally, the fans orientation was altered, in order to vary the temperature and water gradients from the air inlet to the air exhaust.

Main achievements intended for publication

The main achievement was the hydro-electro-thermal profile, built using the average water content, temperature, current density and cooling flow to build a map at 42 different combinations of cooling flow rates and current densities. This map correlates temperature and water content, highlighting that the cell dehydration causes the voltage. Different points on this maps are scrutinised, for the variations of localised water content, current density and flow rate. Also, the cooling flow rate was abruptly reduced by half while the cell was operated at 0.67 A cm-2, which created cycles of hydration and dehydrations, and simultaneously affected the temperature, water content and current density gradients. It revealed the hydration and dehydration time constants, as well as the correlations between temperature and water gradients in well-hydrated and and dehydrated environments.

Altogether, these results are novel, and will be presented together for publication purposes.

Difficulties encountered

Firstly, single cells and 2-cell stack do not have a behavior as repeatable to large stacks (5 cells), because of compression issues. This created challenges for dead ended anode operations, probably uneven compressions creating leakage not causing the expected behavior. Therefore, through flow diagnosis were preferred in these conditions. Some of the hardware (USB hubs) also encountered repeated failure, and perhaps didn't behave properly in radiation environments.

Further comments