Project Report

Application No. 2008
Short title Local water content distribution measurements with neutron imaging for CFD model validation of 50 cm2 PEMFCs

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

1. Short term (1-3 months):
    - detailed processing and analysis of the results (more than 60 GB of data were obtained)
    - validation of the CFD model results against the liquid water distribution measurements obtained during the neutron imaging experiments (this is the objective of the project proposal).
    - start preparing journal publications
2. Medium term (<1year):
    - finalize preparing journal publications, presenting results in international conferences.
    - Implement improvements in the fuel cell (MEA type, improving electrical contacts with current collector plate, improving cooling for better heat management, change bipolar plate material/design, relocation of gas inlets for better imaging).
    - Strengthen collaboration with PSI
3. Long term (>1 year):
    - Potential new H2FC proposal with enhanced cell and new objectives aimed at both fundamental knowledge generation and applied research (optimized bipolar plate designs, etc.)
    - Strengthen collaboration with PSI.
    - New research activities followed by further publications and eventually patenting activities.
    - Collaboration with industry.

Brief summary of work carried out:

The first stage was to connect the fuel cell in the test bench and carry out the debugging (some difficulties were encountered, see report section below).
Once the cell was fully operational the set of experiments were performed. The experiments correspond to the initial objectives, and many other experiments were also carried out following common discussions and initiatives with the Technology Expert. This has allowed to generate much more results and information than originally expected (currently being processed). The installation and test bench were excellent, fully automated allowing to carry out experiments also during the night, taking out the most of the access time.
The set of experiments performed were (P=2bar, T=60C):

- exp101: neutron imaging of the cell operating with H2/air, 25A, lambda_a=1.5 RHa=60%, lambda_c=3.5 RHc=60%
- exp102: neutron imaging and cell resistance measurement of the cell operating with H2/air and different RH (20, 35, 60, 90, 110%)
- exp103: neutron imaging of the cell operating with H2/air, 10A, lambda_a=1.5, lambda_c=5.0, RH=35, 60, 90%
- exp104: neutron imaging of the cell operating with H2/air, 25A, lambda_a=1.5, lambda_c=5.0, RH=60, 90%
- exp105: neutron imaging of the cell operating with H2/air, 10A, lambda_a=1.5, lambda_c=3.5. Matrix of 9 points of varying RH values (also different values in anode and cathode). Experiment finalized with a hysteresis study.

- exp106: neutron imaging tests for differentiating water content in anode channels, cathode channels, and GDLs/MEA
- exp107: operation with H2/O2. Neutron imaging tests for identifying local water production rates of the MEA active surface (part I, from dried MEA, 60C)
- exp108: operation with H2/O2. Neutron imaging tests for identifying local water production rates of the MEA active surface (part II, from humidified MEA, 60C)
- exp109: neutron imaging of the cell operating with H2/O2, 10A, lambda_a=2.0 RHa=90%, lambda_c=10.0 RHc=90%
- exp110: neutron imaging of the cell operating with H2/O2, 15A, lambda_a=2.0 RHa=90%, lambda_c=10.0 RHc=90%
- exp111: neutron imaging of the cell operating with H2/O2, 10A, lambda_a=1.5, lambda_c=3.5. Matrix of 9 points of varying RH values (also different values in anode and cathode).

Main achievements intended for publication <250 words

The following results and achievements will be further analysed and are intended for publication after the required processing of the results:

- CFD model validation against local distributions of water content measured with neutron imaging, for a set of different operating conditions. This is the original objective of the project proposal. It was possible to achieve results for air and also for oxygen as oxidant, for different stoichiometries, relative humidities, and current densities. Therefore the set of data and results obtained is comprehensive and after comparison against 3D CFD model results a publication will be prepared.
- Water content patterns found in anode/cathode and their common interaction (pending of verifying literature studies on this interaction already published). Interesting patterns with interconnected influence were identified during the experiments, and will be published after a literature survey.
- Approach for differentiating water content in anode channels, cathode channels, and MEA/GDLs. The procedure is already published in the literature (by GM Fuel Cell research laboratory), but the results obtained and the quantitative validity of the method are prone for publication.
- Effects of RH and oxidant (air/O2) on water content distributions (in steady-state operation and transient effects).

After a detailed analysis and processing of the results (more than 60 GB of neutron imaging data have been obtained in the experiments, that need to be carefully analysed), further findings may be identified and published.

Difficulties encountered <250 words

Three main difficulties were encountered during the experiments:

- Internal leakages in the cell. The cell had been tested by the user in a separate test bench the weeks before starting the experiments, but however an internal leakage was detected during the debugging of the cell operation. This was corrected and the cell was finally full operational.
- The temperature regulation was difficult for some operating conditions (at higher current densities), but it was solved with additional forced cooling of the cell.
- High current densities could not be achieved with the cell, but liquid water was already present in the cell for low and medium current densities, and therefore the results obtained were fully fruitful and valid for the objectives of the test campaign.

Further comments:

- Excellent project, as it allows users/researchers to access unique installations not usually available for external researchers. It also
- allows for the establishment of collaborations between institutions that are enhancing competence and progress in research activities.
- Excellent expertise and competence of the Technology Expert.
- Excellent installation and test bench, fully automated to carry out experiments also during the night, taking out the most of the access time.