Project Report 2044

Freezing behavior of PEFC in the outer perimeter of the active cell area

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Objectives: short, medium and long term

In this work cold-start of PEM fuel cells is investigated by means of neutron radiography. The focus of the experiments laid on the outer perimeter of a cell, located between flowfield and sealing gasket. Water can be accumulated there and depending on the cell design it can hardly be removed. It was the objective to examine if residual water located in this edge region can have a negative influence on the cold-start capability of a cell. The obtained data is subjected to be revised in the next few months and will be published soon in a peer reviewed journal. On a long-term scale the results will be considered in the development of new cell generations and sealing solutions with respect to a good cold-start capability. Also procedures for shutting down cells with an effective water removal will be derived from the results.

Brief summary of work carried out

In this work liquid cooled test cells with an active area of 50cm² were deployed in three different cell setups. Whereas two of the cells were designed in a way that residual water remains in the edge region of the cell even after drying the cell for a few minutes. From the third cell liquid water can be removed simply by purging with dry gases. Neutron imaging was performed with the operating cells whereby the neutron beam was led through the cell perpendicular to the cell plane. The images show the in-plane water distribution in the cell. A dual spectrum method is applied, in order to facilitate the differentiation of water and ice, as described in [1]. Thereby images are taken at two different neutron energy levels, induced by introducing a beryllium filter into the beam periodically. The comparison of the two images over the time domain gives an information about relative phase transitions. Isothermal cold-starts were performed at different temperatures, varying from -12,5 to -2,5°C, whereby the cells were sub-cooled to -15°C before the start to ensure freezing of the residual water in the whole cell. After reheating the cell to the start temperature an electrical load is applied until the cell voltage breaks down. High frequency resistance of the cell is measured during all experiments. In another experiment, cold-starts were performed with a defined amount of water remaining in the cell, in order to investigate the influence of the present water mass on cell breakdown time. Therefore a defined amount of water is produced by closed-end operation at anode and cathode side in H2/O2 mode for a short period of time. [1] J. Biesdorf, P. Oberholzer, F. Bernauer et. al, Dual Spectrum Neutron Radiography: Identification of Phase Transitions between Frozen and Liquid Water, Phys. Rev. Lett. 112 (2014) 248301

Main achievements intended for publication

In a subsequent publication, the influence of residual water mass and distribution on cold start capabilities of a fuel cell will be discussed. Also the influences of the cell preconditioning and the operation conditions during the start on the breakdown time should be exposed. The spatial distribution and development processes of ice in the cell during the cell breakdown during isothermal cold-starts will be intended to be explained as far as the present measurement data allows a detailed analysis.

Difficulties encountered

Caused by the cyclic introduction of a filter into the neutron beam, the overall energy density was low, so that image resolution was relatively low. In contrast the time resolution was quite high with around 3 seconds per image. As the taken images show the in-plane water distribution in the cell, anode and cathode sided water can hardly be distinguished. And as purging is not a viable solution to remove the water on one side, the imaged water and ice related processes cannot be assigned to anode or cathode side.

Further comments

The great support by the team at Paul Scherrer Institute, Pierre Boillat (Electrochemistry Laboratory and Neutron Imaging and Activation Group) and Johannes Biesdorf (Electrochemistry Laboratory) is highly appreciated here. Their support round-the-clock during the measurements was energetically and exceedingly beneficial. Furthermore the H2FC Project is recommend to any other user in the fuel cell sector for a simple and fast access to highly interesting user facilities.