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

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Cold-start capabilities of PEM fuel cells are essential for their usability and their market access in mobile applications. Component degradation

processes, caused by freezing, can be crucial for the lifetime of fuel cells and much effort is done in mitigating the influence of freezing on

durability.

When shutting down a cell, the flowfields and the gas diffusion layers (GDL) are usually dried out by specific procedures, for example by purging

both, the anode and the cathode compartment with dry gas. However, water can remain in the cell, which may lead to a mechanically destruction

of the cell components, the membrane and catalyst layers as well as the GDLs, when freezing [1,2].

The sealing gaskets of a PEMFC are situated around the active area and the flowfield. Manufacturing and assembling tolerances require a gap (in

the following called edge channel) between sealing and flowfield. Depending on the size of the edge channel and its fluidic connection to the

flowfield, the edge region can be prone to retain water even when the cell is purged with dry gas [3].

Apart from forcing mechanical deterioration during the freezing, remaining water in edge channels can pose a nucleus for the propagation of ice

across the cell during the startup phase while the cell temperature is below 0°C. Thus the structure in the cell edge region and the sealing concept

can have a significant impact on the cold-start capability of a PEMFC.

In order to understand these processes, neutron imaging technique should be applied on a set of technical cell setups under isothermal freezing

conditions (as described in [4]) to investigate the influence of accumulated water in the edge channels on freezing behavior of the whole cell.

Design parameters will be varied in a technically suitable range. Different strategies should be evaluated, for efficiently removing water from the

edge channels.

With conventional imaging methods at a constant neutron energy level water and ice can hardly be distinguished [5]. The change in density

between both aggregate states cannot be taken into account for quantification, because freezing water changes its shape and volume in all three

dimensions. Even though, water and ice cannot been distinguished with classical neutron radiography (NR), Oberholzer et al. [4] successfully

showed in their work, that the formation of ice could be detected by observing changes in the water transport. Also different purge strategies

with dry gases could help to distinguish the solid from the liquid phase.

Furthermore, a recently developed method (dual spectrum neutron radiography), should be applied in order to detect phase transitions between

water and ice [6]. It is based on the differing cross sections between both aggregate states in a lower neutron energy level (<5.25meV) [7]. A filter

is periodically introduced into the beam, to take images at two different energy stages over a small period of time. Assuming constant water/ice

thickness over the measurement time for both energy levels, the comparison of cross sections delivers an information about the aggregate state.

The measurements are expected to require about 5 days of beam time:

- Day 1+2: Cell setup 1, classical NR and dual spectrum NR
- Day 3+4: Cell setup 2, classical NR and dual spectrum NR
- Day 5: Cell setup 5, dual spectrum NR

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