Characterisation of two-phase flow within channels of PEM water electrolysis cells

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Polymer electrolyte membrane water electrolysis (PEMWE) is a favored technology for hydrogen production in presence of high and fluctuating electrical currents [1]. Performance of PEMWE cells is highly dependent on two-phase flow processes [2]. Water and oxygen move in counter current direction within a porous cell component and in the same direction within a channel (Fig. 1). Oxygen, the only waste product of water electrolysis, reduces the reaction potential for further electrolysis or can even block electrodes completely. For porous flow, Darcy scale, two-phase two-component models are usually employed in order to optimize oxygen removal. According to such modeling results to be presented, oxygen transport through the porous material is highly dependent on the gas saturation at the boundary between channel and porous layer. This dependency might be particularly crucial when, for economic reasons, large cells are assembled or a comparatively little amount feed water is pumped. However, it is questionable if free flow states and saturation distributions in the channel can be accurately predicted with Darcy scale models.

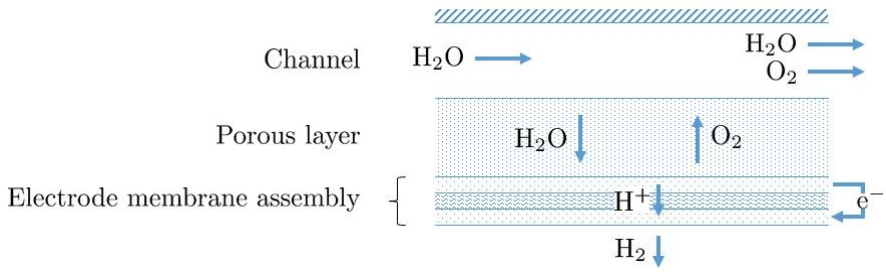

Figure 1: PEMWE cell setup and main component (water H_2O, oxygen O_2, proton H^+, electron e^- and hydrogen H_2) transport directions

For this reason, the two-phase flow within a short channel segment is investigated in this study. The Navier-Stokes and interfacial balance equations are solved adopting a mesh-free, Lagrangian method implemented the Institute of Applied Mechanics in Stuttgart [3]. The spatial scale is chosen according realistic bubble sizes. Interfacial saturation and other channel flow properties influencing oxygen removal are found to be highly sensitive to feed water flux (Reynolds number), global gas saturation and

bubble distribution. We derive limitations for the applicability of a Darcy scale model for channel flow and provide parametrizations for the cases when a Darcy scale model is appropriate.

References

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