Modeling of Liquid Water Distribution at Cathode Gas Flow Channels in Proton Exchange Membrane Fuel Cell-PEMFC

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Introduction: Fuel cells are electrochemical systems that transform the chemical energy of a fuel directly into electricity and heat, possessing, however, a continuous operation, . Its properties are remarkable high efficiency in energy conversion and zero emissions. The objective of this study is to determine the locations where liquid water accumulates at cathode gas flow channels, and the corresponding operating conditions for mitigate slug flow responsible for channel blockage and hindering the diffusion of reactants to the catalytic sites and consequently performance drop of PEM fuel cell.

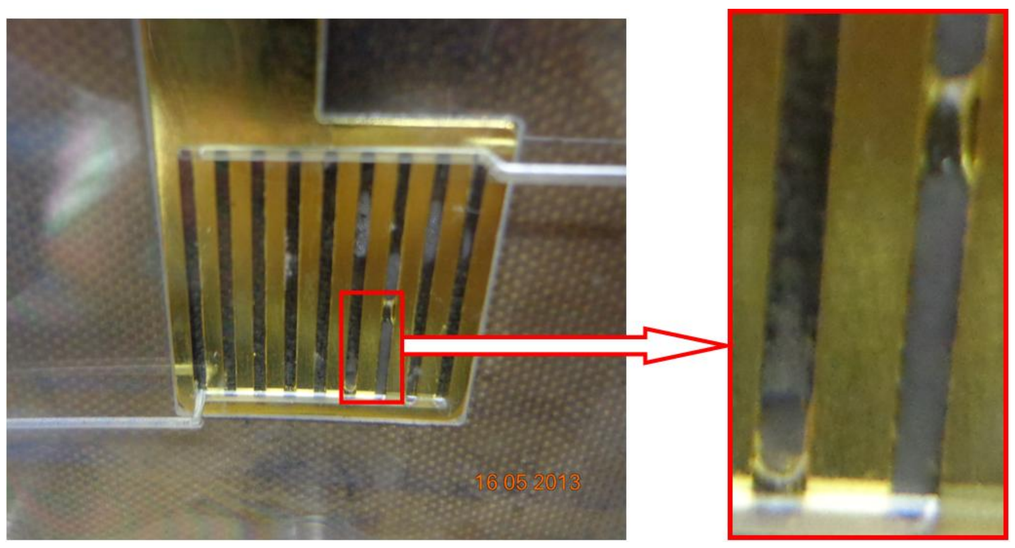

Figure 1. Water droplet build-up and slug flow at cathode gas flow channels

Computational Methods: Electrochemical reactions and charge transport were modeled using the Secondary Current Distribution interface. Free and Porous Media Flow interface was used for modeling momentum transport. Diffusion of reactants and products was modeled with the Transport of Concentrated Species interface. Most of the mesh consisted of hexahedral elements and only the membrane was meshed with tetrahedral elements. A switch function was implemented to analyze water condensation. The function returns one when vapor content is 98% of saturation or higher, and zero in other cases.

$$\gamma_{LV} = 1 - 0.5\left[1 + \tanh\left(61\frac{\rho_{WV}^{g}}{\rho_{SAT}^{g}} - 59\right)\right]$$

Equation (1) . Switch function

Results: Polarization curves for experimental and numerical data were plotted and validated model. The switch function was useful for analyzing in which regions condensation occurs. Plots with this function demonstrated that high temperatures may mitigate condensation.

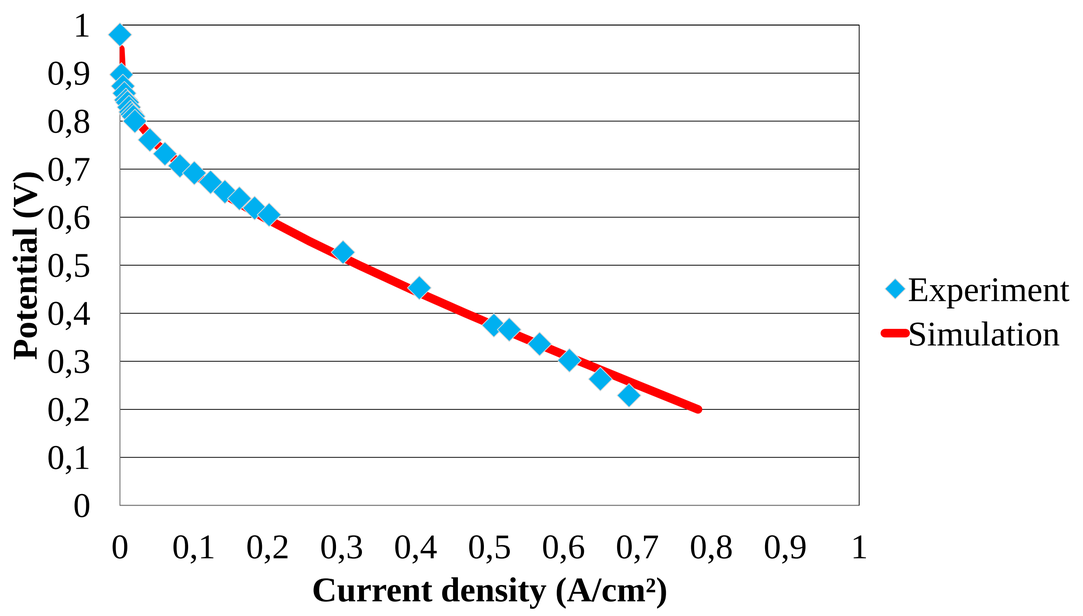

Figure 2. Polarization curves for experimental and numerical data.

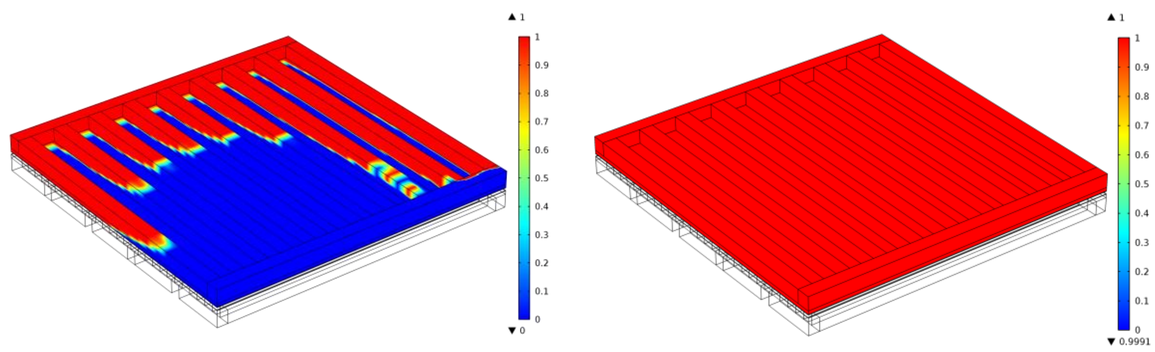

Figure 3. Switch function values at 308K (left) and 328K (right)

Conclusions: The implementation of the switch function with the evaporation/condensation mass transfer coefficient, improved the model allowing the visualization of the saturated and vapor water at the channels.

References:

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