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

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Abstract

The objective of this study is to determine the locations where liquid water accumulates at cathode gas flow channels, and the corresponding operating conditions. In such way it is possible to mitigate slug flow, responsible for channel blockage and hindering the diffusion of reactants to the catalytic sites. The electrochemical reactions responsible by the performance of PEM fuel cell can be optimized by controlling the operating conditions. The model presented here is a comprehensive PEMFC 3D model, which includes liquid water phase detection along the flow direction, and transport of gaseous species, protons and energy. Computational models of fuel cells have been an important optimization tool to fuel cell development. The experimental data from a transparent-cathode-channels-fuel cell set up (Figure 1) were used to validate the computational model. The investigated parameters were: temperature (25-75oC); flow rates (hydrogen: 200-300 ml/min and oxygen: 100-150 ml/min); and potential (0.1-1.0 V). The software used was COMSOL Multiphysics® and the admitted conditions were: agglomerate model in catalytic region; oxygen as the cathode reactant; steady state; parametric sweep study; direct segregated solver. Modeling results are showed in Figure 2 (experimental) and Figure 3 and 4 (numerical) to illustrate the importance of water detection and management. The idea is to avoid the water accumulation in the cathode layers, which lead to an improvement of PEM fuel cell, since there is not liquid water transport overpotential.

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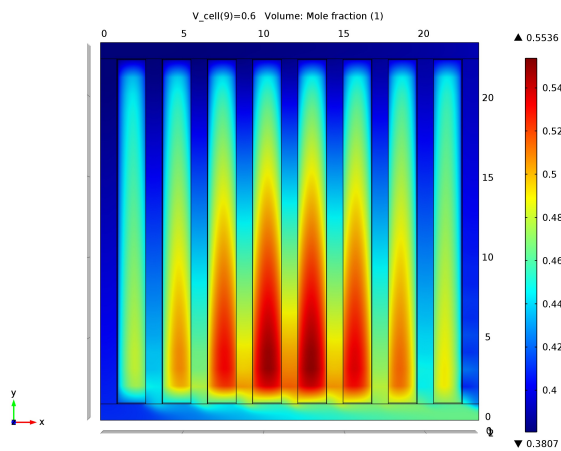12.S.V.Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corp., New York (1980)
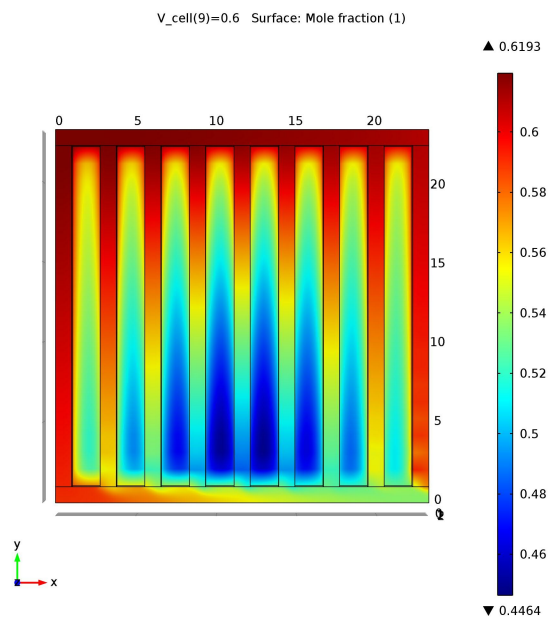
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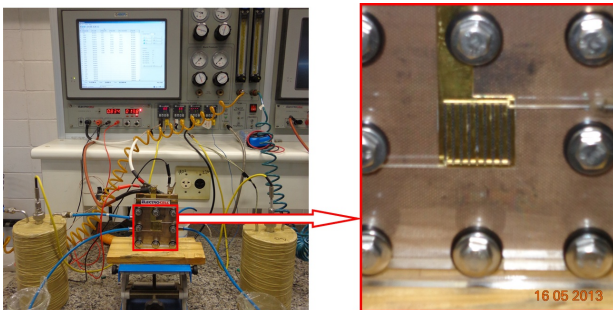
Figure 1: Figure 1: Transparent-cathode-channels-fuel cell set up; inset: channels view.
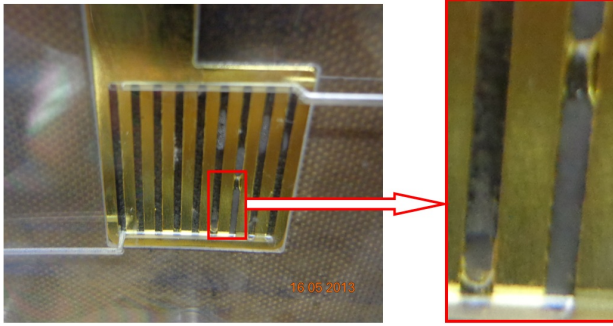
Figure 2: Figure 2: Experimental results; inset: slug formation along the cathode channels, 338K, 0.6V.

Figure 3: Figure 3. Numerical results: water mole fraction distribution, 338K, 0.6V.

Figure 4: Numerical results: oxygen mole fraction distribution, 338K, 0.6V.