Dependence of the Current Density Distribution with Flow Channel Geometry in a Half-Cell Model

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Abstract

A half-cell model has been used to simulate the cathodic stationary state of a 50cm² proton exchange membrane fuel cell operating with humidified hydrogen and oxygen gases, under the assumption that the anodic processes are not limiting. The model geometry, seen in Figure 1, comprises the membrane, catalyst and gas diffusion layers, and the flow channels, these being modeled for 4 different geometries. The simulations were run using COMSOL Multiphysics® software in a stationary, fully coupled, configuration, including the following physics interfaces: Free and Porous Media Flow, Transport of Concentrated Species, Heat Transfer in Porous Media and Secundary Current Distribution, noticing that the species transport and fluid flow were not defined for the membrane domain. To account for the anodic reaction, an electrolyte-electrode boundary condition was used at the upper surface of the membrane domain. The remaining conditions used for the simulations are obtained from elsewhere [1], and it minimizes the possibility of two-phase flow, hence justifying the neglect of such process. The results reproduce qualitatively the ones observed in the experimental work [1], mainly the current density distribution measurements, as seen in Figure 2, for an average drawn current density of 0.1 A/cm². It is observed that the main effects influencing the current density distribution seems to be different according to the chosen geometry. This can be inferred from the flow field and pressure surfaces in Figures 3 and 4, respectively. These results suggests that the strategies to optimize the working conditions are dependent on the choice of the flow channel geometry.

Reference

1. Justo Lobato et. al., Study of flow channel geometry using curent distribution measurement in a high temperature polymer electrolyte membrane fuel cell, J. Power Sources, 196, 4209-4217 (2011).

Figures used in the abstract

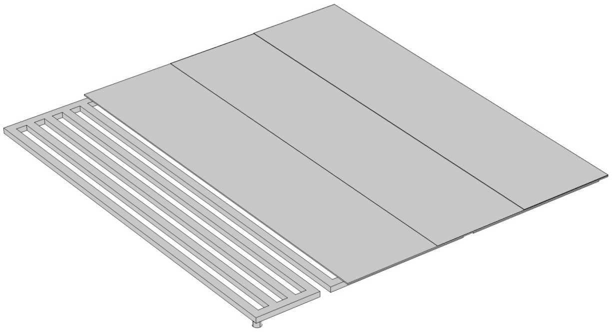

Figure 1: Schematics of the geometry used. From top to bottom: Membrane, catalyst layer, gas diffusion layer and one of the flow channel geometries modeled. The outlet is shown, while the inlet is diagonally opposed to it.

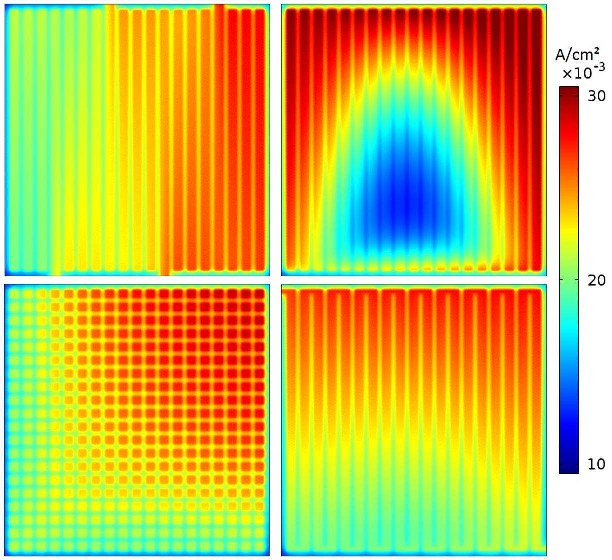

Figure 2: Current density surface, for i = 0.1 A/cm², for each flow channel geometry simulated.

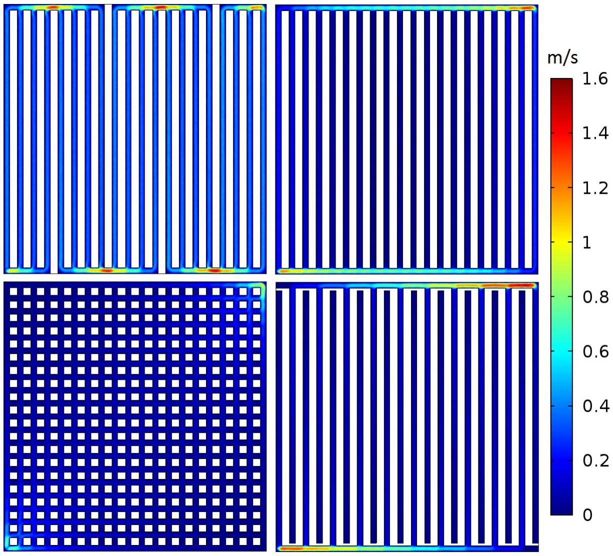

Figure 3: Flow field surface for each flow channel geometry simulated.

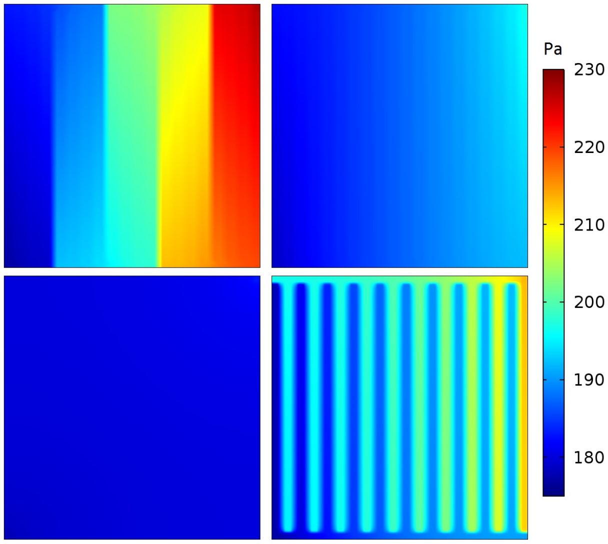

Figure 4: Pressure surface for each flow channel geometry simulated.