A Computational Study Of Stoichiometry Sensitivity Of A PEM Fuel Cell With Multi-Parallel Flow Channels

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Abstract

Flow channel design in a PEM fuel cell plays a critical role for uniformly distributing reactants to the reaction sites and effectively removing product water to prevent flooding. Simplistic design and uniform reactant distribution make parallel channels a potential candidate for development. However, due to its low-pressure differential, the parallel channel is also known to be susceptible to liquid water accumulation and blockage inside the channels, which is a severe drawback to this particular design. Increasing flow rate is often suggested in the literature as a feasible solution to overcome this problem. Thus, understanding the Stoichiometry sensitivity in parallel flow field design is a vital step to improving its performance. In this study, the effect of stoichiometry on water accumulation and fuel cell performance will be analyzed using a simulation model. A 3-D steady state, non-isothermal, single phase numerical study of the complete cell geometry, including intake and outlet manifold, has been carried out using commercial package COMSOL Multiphysics. Fuel cell and CAD import modules have been used for this study. The electrochemistry equations are solved using the Secondary current distribution interface and the reactant flow and mass transport equations are solved using the reacting flow in porous media interface. In addition, electric ground and potential boundary condition are applied to anode GDM and cathode GDM, respectively, to solve HOR and ORR kinetics equations using linear and Tafel approximation of the Butler-Volmer equation. Moreover, (i) inlet mass fraction boundary condition is used to solve the Maxwell-Stefan diffusion equations and (ii) laminar inflow for inlet boundary condition and atmospheric outlet boundary condition are used to solve the Brinkman equation. A structured user-defined rectangular mapped mesh is created in the in-plane direction and then swept in the through-plane direction to complete the whole computational domain. A free triangular mesh is created in parallel flow channels and free tetrahedral elements are used in the intake manifold. Solution convergence is found to be very sensitive to the structure and size of the mesh. Our results show that concentration loss is evident and the pressure differential is very small when the stoichiometric flow is less than 2.5 on both anode and cathode sides. The presence of high amount of saturated water in the flow channels is observed in cathode channels. In contrast, the presence of saturated water is found to be less prominent and the performance is improved when the stoichiometric flow is greater than 8.0. We will present more detail finding of water accumulation and fuel cell performance under various stoichiometric conditions in the conference.

Figures used in the abstract

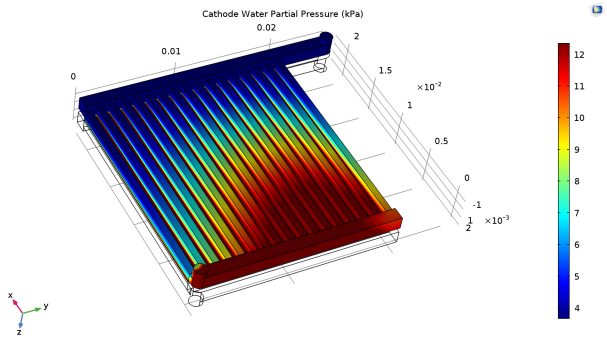

Figure 1 : Cathode water partial pressure at stoichiometric flow rate of 8.0