Numerical Modeling of Alkaline Fuel Cell

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Abstract

A fuel cell is an efficient and clean alternative power source of energy. Alkaline anion exchange membrane (AAEM) fuel cells are one in which conduction of oH- (hydroxyl ion) take place. The advantages of using alkaline fuel cells over proton exchange membrane fuel cells is that electrochemical kinetics is fast and alkaline environment is friendly for catalysts.
Experiments performed at various temperatures and pressure can give information only about cell performance but simulations can provide information about velocity profile, pressure profile and mass fraction profile inside the fuel cell with different parameter variations. The main reason to do simulation is that obtained model can predict behavior of system for given any parameters but practically it might not be possible to change certain parameters.
In this study, a three-dimensional (3D) transient model is developed to study the dynamic characteristics of AAEM fuel cell and simulation is done using COMSOL Multiphysics® software. All the parameters of fuel cell are taken of the fuel cell which was used for the experiment purpose at ARCI-Center for fuel cell technology, IITM research park.
In the model fluid flow is described by 'Free and Porous Media Flow interface. It uses the Navier-Stokes equations for describing the flow in open regions, and the Brinkman equations for the flow in porous regions.
Similarly, mass transfer in the model is defined by Maxwell-Stefan equations which account for all pair-wise interactions of the species at anode and cathode both. Current and potential distribution in cell model is described under the assumption that electrolyte concentration doesn't vary. The electrode kinetics for the charge transfer reactions are described by Butler-Volmer equation and current is defined as integral of the current density at anode.
The electrical potential at one of the electrode was grounded and potential at other electrode is varied using parametric sweep feature in COMSOL Multiphysics®.The obtained characteristic curves (power density vs. current density) has reasonable agreement with experimentally obtained characteristic curve.
Therefore, simulated model provides valuable information about spatial concentration variation at anode and cathode, velocity and pressure profile in alkaline fuel cell in 3D which are not available from experimental measurements. The dynamic behaviors observed in this study are of significant importance to the future development of AAEM fuel cells for portable and automotive applications.

Figures used in the abstract

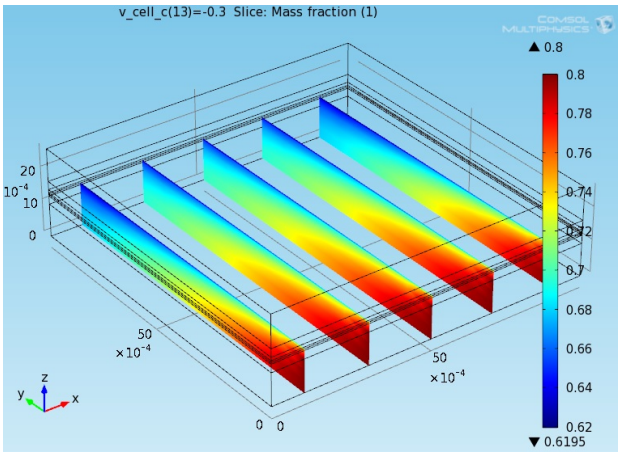

Figure 1: mass fraction of hydrogen.

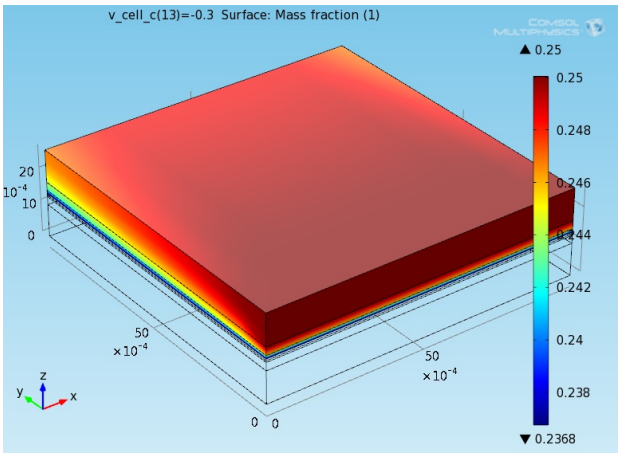

Figure 2: mass fraction of oxygen.

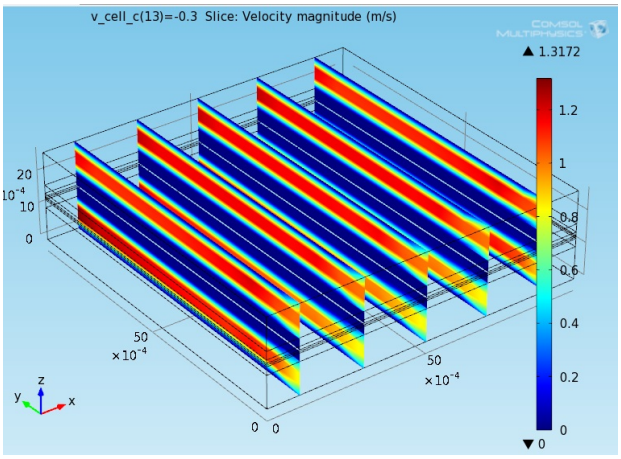

Figure 3: Velocity profile.

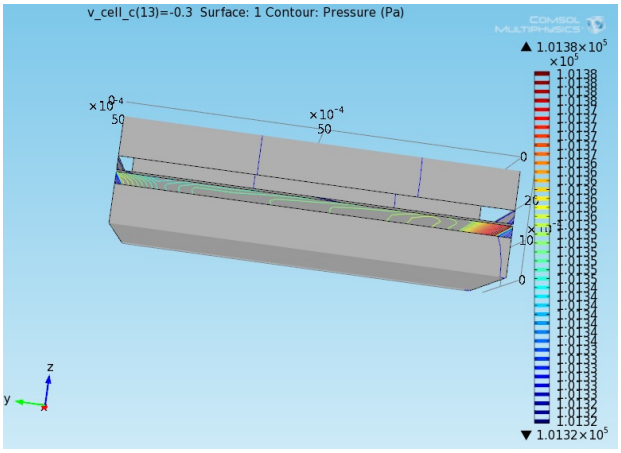

Figure 4: Pressure profile.