

Mass Transport Enhancement in Proton Exchange Membrane Fuel Cell

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Fuel cell technology presents huge economical and environment potential for the next-generation power systems because it can offer great advantages over the conventional power-generating systems in terms of both the energy efficiency and the emission reduction. One of these fuel cells is the Proton Exchange Membrane Fuel Cell (PEMFC), which is a low temperature fuel cell. It is highly versatile as it can be used for portable devices, vehicles, as well as stationary power plants.

The transport phenomena of chemical species in PEMFC are difficult to observe and measure by experiments. Therefore, computational modeling is a good alternative approach in analyzing the fuel cell performance relating to the transport processes and electrochemical relations. In this project, we used the Computational Fuel Cell Dynamics (CFCD) methods to solve conservation equations in single domain formulation (without interface boundary conditions between various components of Current Collector, Gas Channel, Gas Diffusion Layer, Catalyst Layers for both anode and cathode, as well as the membrane in PEMFC) for fuel cell modeling. Besides solving for the basic conservation equations (mass, momentum, energy, species concentration, proton and electron transport), the model also include also made reasonable assumptions for the constitutive equations such as Darcy equations for fluid flow in conduits and porous media, Fourier's Law for heat conduction, Fick's Law for diffusion, Faraday's Law for relationship between electrical current and consumption of reactants in an electrochemical reaction, Ohm's Law of electrical current conduction, Stefan-Maxwell equation for multi-species diffusion and Butler Volmer equation for relationship between electrical current and potential. The numerical computer calculations will be carried out using various commercial CFD software such as FLUENT 6.2, COMSOL 3.2 and CFX 10..

The objective of this project is to explore some new design concepts for enhancing the mass transport process in a PEMFC and hence further extend the fuel cell performance at high current density. Some proposed flow distributors design will include the wavy wall, tapered (full or partial), staircase, hybrid serpentine and interdigitated, spiral and impinging jet (single and multiple). At this juncture, some promising results had been obtained by comparisons between parallel channel and double serpentine.

Additionally, the works also aims to develop a new comprehensive three dimensional computational model of an entire PEMFC, especially including multi phase liquid and water vapor transport, as the presence of liquid water plays a crucial rule in the performance of PEMFC. Lastly, it is proposed to setup an experimental rig for PEMFC to carry out an experimental study investigating the parameters that govern fuel cell performance, and also to validate simulation results with corresponding experimental data. The model will be validated against literature data as well.

Publication:

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