The Effects of Flow-Field Configurations on PEMFC Performance

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Introduction

According to the increasing of a number of fossil fuel power sources all areas, the necessity for alternatives to the internal-combustion engine becomes ever more obvious. Proton Exchange Membrane (PEM) fuel cell producing power for stationary and transportation are now widely seen possibility. It chemically produces the electricity from hydrogen and oxygen with less pollution and it can run as long as fuel and oxidant are supplied.

Right now, many researchers including us have studied the problem of water management inside the PEM fuel cell on both steady state and transient operations already discussed in Shimpalee et al.[1] and Lee et al.[2]. However, only few those focus on the effects of flow field pattern on its performance[3]. With different reacting areas and flow patterns of fuel cell, it will give us the idea to optimize size with best possible flow field design of PEM fuel cell. In this work, we extend our previous works[3] by concentrating on other two flow-field patterns as shown in Figure 1, current density distributions, temperature contours, liquid water concentration (if presented), and velocity fields will be discussed and compared with previous work[3].

Numerical Procedure

A control volume technique based on a commercial flow solver, FLUENT, was used to solve in steady state approach with Navier-Stokes equations, the energy equation, phase change aspects, and governing electrochemical equations as taken from Dutta et al.[4, 5], Shimpalee and Dutta[6], and Glandt et al[3]. These equations are solved to obtain flow characteristics along the flow channel and in the gas diffusion media, temperature of the entire control volume, and the local current density on the membrane surface. However, the software requires specification of species source terms and new subroutines were written to calculate the electrochemical and permeability for this simulation. Also FLUENT requires a user-subroutine to account for the flux of protons and water across the membrane.

Results and Discussion

The performance of a PEM fuel cell is also a function of flow channel configurations of both cathode and anode. By changing its pattern from cyclic flow-field pattern to symmetric flow-field pattern as presented in this work or from single pass flow-field pattern to double pass flow-field pattern as shown in Glandt et al.[3], the current density distribution, water concentration distribution, temperature contour, and other electrochemical variables' profiles are varied. These results will lead us to the optimization of the flow-field design in PEMFC with the highest efficiency.

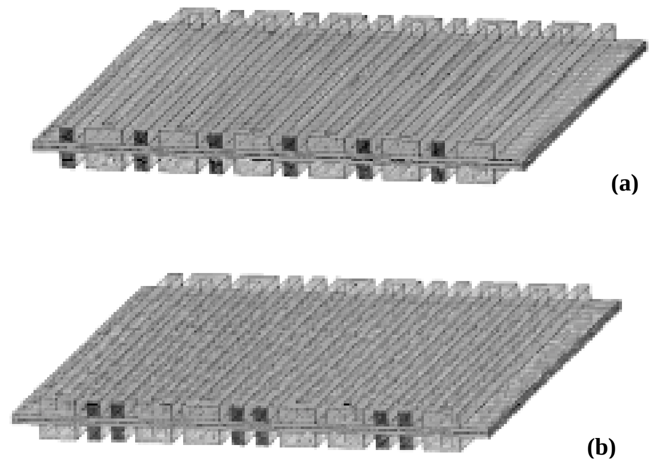

Figure 1. The geometrical models of the complete fuel cell without graphite current collector; a) 10-cm^2 cyclic flow-field pattern and b) 10-cm^2 symmetric flow-field pattern.

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