Prediction of Transient Response for a 25-cm^2 PEM Fuel Cell

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Introduction

Proton Exchange Membrane (PEM) fuel cells produce power for electric drive motors with less pollution. A full-scale three-dimensional solution to the time dependent Navier-Stokes equations for the flow channel and diffusion layers has been developed by including water phase change model[1, 2] to improve the investigation of transient behavior of the fuel cell and its performance[3], which can be changed to meet the requirements of the amplitude and frequency of the load changes.

Some of our steady state works of PEM fuel cell simulation in water management study[4], mass-exchange study between anode and cathode[5], and temperature effect[1,2] have been achieved. In this study, the three-dimensional model of PEMFC with 25-cm^2 reacting area as shown in Figure 1 is developed with the inclusion of time dependent analysis. This is the first three-dimensional full-scale PEM fuel cell with 25-cm^2 reactive area that includes water phase change model with time dependent examination (shown in Figure 1). Different rates of voltage change are chosen to study their effects on the PEM fuel cell performance at each time interval. Moreover, the detail of local current density, water distribution (liquid and vapor), and reacting gas concentration are investigated and compared with previous work[3].

Numerical Procedure

Figure 2 shows model geometry that created from Figure 1. It has triple pass channel with 11 serpentine fashions. A control volume technique based on a commercial flow solver, FLUENT, is used to solve the coupled governing equations with time dependence. In this model, we include the effects of water phase change and liquid water film on PEMFC performance that already discussed in one of our previous works done by Glandt et al.[6]. 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

By changing the reacting area of PEMFC, the transient response of its performance is also changed. The overshoot and undershoot behaviors when the cell voltages are decreasing and increasing, respectively, are significantly diminished when compared with previous work of 10-cm^2 reacting area[3]. Moreover, the flow-field configuration is also another factor that could control the transient performance when the amplitude and frequency of the load are varied.

Acknowledgement

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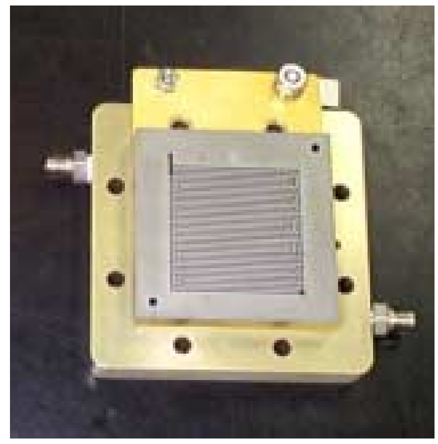

Figure 1. The picture shows actual flow-field plate with gas channel of 25-cm^2 PEMFC. There are thirty straight channels connected in a triple pass serpentine fashion. Anode side and cathode side flow channels are symmetric and placed property aligned (non-staggered) on top of each other.

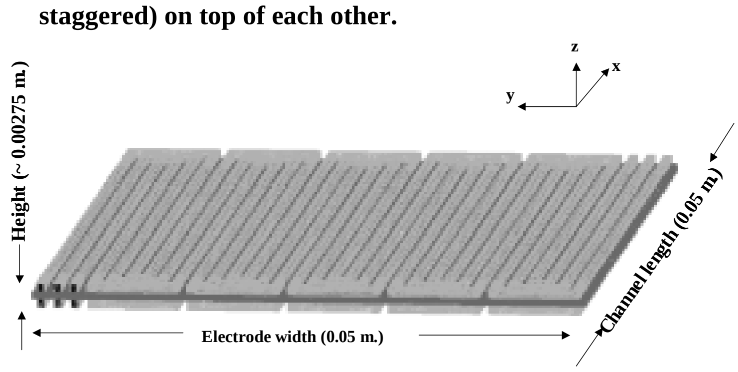

Figure 2. The geometrical model of the complete 25-cm^2 fuel cell without graphite current collector. There are 33 straight channels connected in a triple pass serpentine fashion shown in Figure 1.

References

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