Two-Phase Flow Models for PEM Fuel Cells:
Correlation of Experimental and Model Results

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Abstract

Better understanding of the phenomena occurring in the PEM fuel cells, especially the performance limiting processes, is essential to achieving high performance and efficiency. Of the performance controlling components of the fuel cell, the cathode electrode is most influential. The performance of the cathode is highly dependent on the transport rate of oxygen to the active sites, which in turn is strongly affected by the presence of liquid water in the cathode. The presence of liquid water in the cathode can reduce the oxygen reduction rate in two ways. It can reduce the cross-sectional area for gas transport when it is present in the porous diffusion layer of the cathode and act as an additional barrier for oxygen transport to the active sites when it is present on the catalyst layer.

Our research group at the University of Kansas is developing mathematical models to describe two-phase transport in the porous electrodes of PEM fuel cells and its effects on the performance of these cells. [1-4] Two models, one for the case when a conventional flow field is used and the other for the interdigitated flow field, have been developed to look at the effects of liquid water on the performance of the cathodes of PEM fuel cells. Main conclusions drawn from the model results are:

- The performance of the cathodes at high current densities is limited by the liquid water removal rate from the porous layers in the cathodes.
- Water is removed from the cathodes by a combination of the following five mechanisms: 1) liquid water transport by capillary force, 2) liquid water transport by the shear force of gas flow, 3) evaporation, 4) water vapor transport by diffusion and 5) water vapor transport by convection.
- When the interdigitated flow fields are used water removal involves all five mechanisms but predominantly by mechanisms 2, 3 and 5.
- When the conventional flow fields are used water removal involves mainly mechanisms 1, 3 and 4.
- Since water removal is predominantly by convective transport processes when the interdigitated flow fields are used better performance is obtained.

This paper presents correlation between the model predicted results for the cathode and the experimental results obtained from full cells and half cells (with reference electrodes) for the two flow field cases discussed above.

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References

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