Distributed Current, Species, Temperature, and Resistance in PEFCs for Low Humidity Operating Conditions

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The operation of polymer electrolyte fuel cells (PEFCs) requires a careful consideration of heat and water management. At low humidity, the electrolyte suffers from poor conductivity. On the other hand, excessive liquid water can block the pores of electrode diffusion media (DM), and then prevents the transportation of reactant to the catalyst layer. Heat management has significant effects on water management. In the operation temperature range of PEFCs, the saturation pressure of water increases exponentially with temperature. Therefore, even small variations in temperature can dramatically affect performance. In order to better understand the operation and optimize the performance of PEFCs, there is a need for detailed experimental data including distributed temperature, coupled with other distributed parameters, including current density, species concentrations, and resistance. This paper will present results of a series of new experiments designed to comprehensively examine distributed temperature coupled with current density, species, and high frequency resistance for various operation conditions for low humidity conditions.

The temperature distributions are determined in a newly developed segmented fuel cell with a true isothermal boundary condition, using the embedded micro thermocouple technique developed by Mench et al.[1] Current distributions are measured with the segmented cell and a multi-channel potentiostat with a method described in references 2 and 3. The multi-channel potentiostat is also used to measure distributed high frequency resistance (HFR) data, which indicate the local ionic conductivity (and thus hydration state) of the electrolyte. Species distribution measurements are determined with an Agilent Real-Time Gas Analyzer (RTGA), which has been previously described by Dong *et al.*[4]

Figure 1 is a plot of electrolyte temperature as a function of current density. Figure 2 is a plot of cathode species distribution as a function of fractional distance from the cathode inlet. The combined temperature, species, current, and resistance data represent the most complete set of benchmark data for detailed model validation published to date. Data are also used to solve the energy and mass balance to determine the rate of liquid water accumulation/depletion with time at a given operating point, and the latent heat contribution to the overall energy balance.

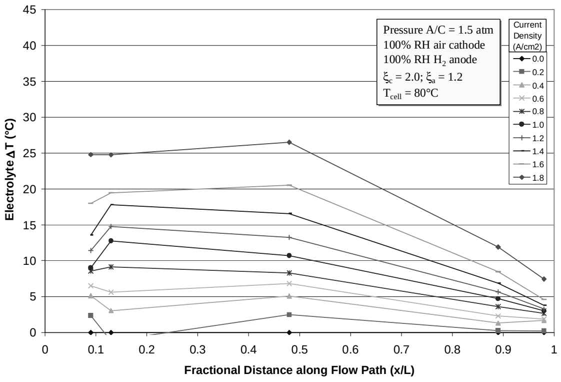

Figure 1. Electrolyte temperature increase (ΔT) over set point of 80^{o}C versus fractional distance along the flow path (x/L) as a function of current density for 100% cathode inlet humidity.

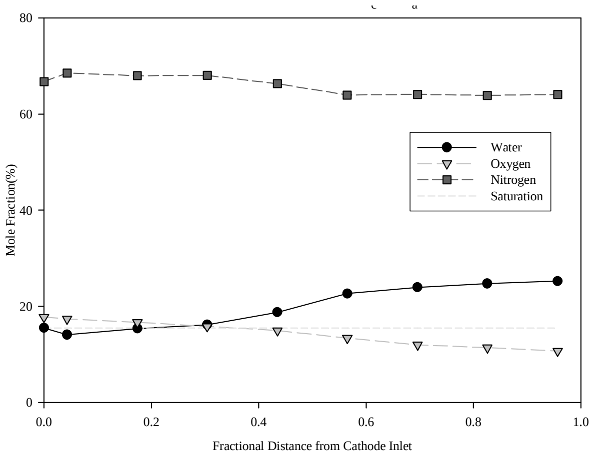

Figure 2. Cathode species distribution as a function of fractional distance from the cathode inlet

1) M. M. Mench, D. J. Burford, and T. W. Davis, IMECE2003-42393, Proceedings of IMECE'03, Washington D.C., 2003
2) M. M. Mench and C. Y. Wang, J. Electrochem. Soc., Vol. 150, ppA79-A85 (2003)
3) M. M. Mench, C. Y. Wang, and M. Ishikawa, J. Electrochem. Soc., Vol. 150, No. 9, pp. A1052-A1059 (2003)
4) Q. Dong, E. C. Kumbur, J. Kull, D. Shields, and M. M. Mench, Abstract 354, Spring Meeting of the Electrochemical Society, San Antonio, Texas (2004).