"A Direct-Methanol Fuel Cell Model for Automotive System Simulations"

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Direct methanol fuel cells (DMFCs) have been the subject of research for a number of years. Although the cell performance is substantially less than that of the hydrogen-air fuel cell, the ease of storage and high energy density of a liquid fuel (methanol) has provided motivation for continued development of the DMFC.

Current "micro-power" DMFC system development for small, portable electronic applications focus on relatively low temperature cell operation (between 40^0C and 70^0C).

To apply DMFC systems to automotive powertrains, a higher temperature cell operation (100^0C) is necessary to improve fuel cell stack power density (W/L). Unfortunately, very little public literature focuses on this higher temperature stack operation and the related system implications – although several automotive companies have evaluated high temperature DMFC systems. In order to evaluate the automotive system issues, it is necessary to develop a DMFC model that is usable in a dynamic automotive system simulation.

Figure 1 illustrates a schematic of a direct methanol fuel cell. The anode and cathode reactions are shown in the diagram. Methanol is electrochemically oxidized at the anode and the protons are transported across the membrane and react with oxygen in the cathode.

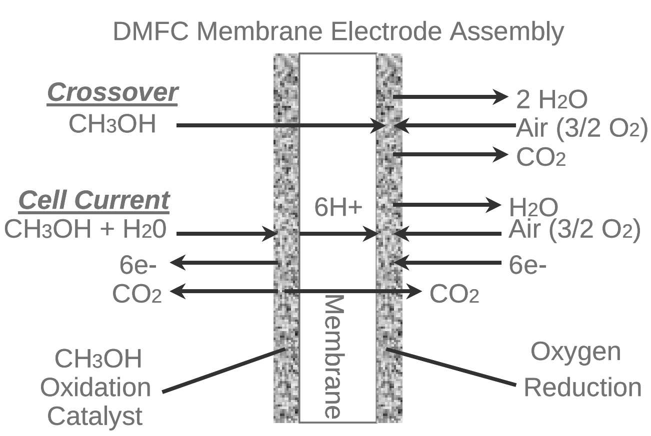

Figure 1: Schematic of a direct methanol fuel cell

The DMFC is inherently different from a direct hydrogen fuel cell because of the methanol crossover, illustrated in Figure 1. This methanol that crosses over from the anode to the cathode is taken into account in the DMFC model by simulating its effect on the cathode performance.

The DMFC model calculates the anode, cathode and membrane losses as a function of the dilute methanol fuel input and air input to the cathode of the cell. The DMFC model also calculates the crossover methanol current (based on the methanol transport in the membrane) and calculates the reduction in cathode performance as a result of this methanol cross over. The DMFC model has been validated by experimental data provided by the Los Alamos National Laboratory.

The output of the DMFC model is the voltage-current (V-I) characteristic of the DMFC as a function of the anode input methanol concentration, flow rate, and pressure and as a function of the cathode input air flow rate and pressure. These input variables are determined from the associated system control simulation and the resulting V-I data is fed into the automotive system simulation.