Pressure Drop as a Diagnostic Tool for PEM Fuel Cells

A. Husar, F. Barbir, and R. Venkataraman
Energy Partners
West Palm Beach, FL 33407

Proton exchange membrane (PEM) fuel cells are being considered for stationary and portable power generation applications. They can deliver high power densities and have high energy conversion efficiencies. They also have low start up times because of their low temperature of operation. However, due to the low operating temperature in PEM fuel cells, issues such as stack cooling and water management become critical for the stable operation of a fuel cell. The performance of the fuel is determined by the extent of hydration of the proton exchange membrane [1,2]. Without adequate amounts of water, the proton conductivity in the membrane and the catalyst are reduced resulting in large losses in the activity. Excess water or humidification on the other hand results in the formation of liquid water in the flow channels and cause reduced mass transfer in the electrodes.

Inadequate cooling of the stack can cause changes in relative humidity in different parts of the stack. This again has an effect similar to that seen with water management. Commonly monitored fuel cell (stack) variables that indicate the state of a fuel cell are the cell voltage(s), the ionic resistance of the membrane, and the pressure drops across the anode and cathode. The ionic resistance, although a useful tool in understanding the fuel cell behavior, is not always monitored in an operating fuel cell.

The cathode and anode pressure drops provide significant information regarding the humidification and gas distribution in a fuel cell [3]. Here, we report investigations on the influence of humidification on single fuel cells and fuel cell stacks. The results indicated that the change in anode and cathode pressure drop could be correlated to the extent of hydration of the MEA. Conditions such as drying and flooding can be determined from the change in pressure drops from the normal values in a single cell. In a cell that is drying, the pressure drop was observed to decrease from its normal value, accompanied by drop in cell voltage and an increase in the ionic resistance of the membrane. On the other hand, excess humidification was found to results in larger pressure drops and also causes decay in the cell voltage. Since the cathode activity is critical to the cell performance, the cathode pressure drop correlates well with the cell voltage.

In a multi-cell stack, water management is important and could lead to flooding or drying of cells in the stack. Unlike a single cell, the pressure drop alone was not sufficient to determine the extent of hydration in the different cells in a stack. However, the pressure drop correlates well with the overall change in humidification in the stack. When combined with information from the change in other variables in the stack, the pressure drop was found to be a useful diagnostic tool in identifying flooding or drying conditions in certain parts of the stack.

References

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