Sealing of High Temperature PBI Membrane Electrode Assemblies Used in Fuel Cells

by

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Abstract

With the current economic and environmental situation, the development of affordable and clean energy sources is receiving much attention. One leading area of promise is Polymer Electrolyte Membrane (PEM) fuel cells. The main challenges of low temperature Nafion-based PEM technology are (1) low cathode performance due to slow kinetics of the oxygen reduction reaction (2) high material costs (3) considerable system design and operation for water management (4) low tolerance to impurities in fuel stream and (5) low quality heat resulting in low overall system efficiency. Furthermore, Nafion membranes achieve maximum conductivity only when hydrated, limiting their operation to < 100 C. Operating the fuel cell > 100 C is desirable to overcome the aforementioned limitations. Though several high temperature membranes for PEMFC have been developed, acid doped polybenzimidazole (PBI) membranes developed by BASF Fuel cell are currently seeing commercial interest.

The most vital step in Membrane Electrode Assembly (MEA) manufacturing is the sealing of the membrane in between the electrode-substrate assembly. Currently, MEA sealing is done by a thermal seal process. This paper examines the effect of thermal sealing process parameters, namely (1) sealing temperature (2) percent compression (3) sealing time and (4) manufacturer-specified post-processing after sealing on the fuel cell performance. A Design Of Experiments (DOE) was developed with these input process parameters and the polarization behavior during single cell operation, as well as internal cell resistance and catalyst utilization were analyzed as performance parameters. ANOVA analysis revealed the statistically significant input factors for the thermal sealing process, which are essential for the rapid and high-quality manufacturing of membrane electrode assemblies for high temperature fuel cells. Furthermore, a multi-physics model has been developed to allow an engineer to further refine the MEA sealing process.

To further investigate the effects of sealing temperature on MEA performance in hopes of reducing manufacturing costs, an additional DOE was performed in which MEAs were manufactured with the tooling at room temperature. A typical sealing process requires heated tooling to press electrode-subgasket assemblies into a sol-gel PBI membrane. MEAs designed for transportation purposes have a large active area that requires expensive heated tooling, which in turn requires many kilowatts of power to operate. MEAs were manufactured using three

different thickness membranes with these input process parameters. This data is compared to MEAs made with traditional heated tooling. The analysis reveals the insignificance of sealing temperature on the initial performance of the MEA.