Effect of GDL Material on Thermal Gradients along the Reactant Flow Channels in PEMFCs

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Proton Exchange Membrane Fuel Cells (PEMFCs) are a strong area of interest for the transportation sector. However, water and thermal management techniques remain as key roadblocks to widespread commercial implementation. Zhang and Kandlikar (1) reviewed various cooling techniques and identified the importance of the resulting temperature gradient along the flow channels. Typically, within PEMFCs a temperature gradient is seen between the inlet and the outlet of the flow channels. This can be induced by several causes including uneven reaction and poor cooling. The thermal properties and morphological structure of the gas diffusion layer (GDL) are believed to play an important role in the temperature variation. Additionally, these thermal gradients can result in condensation within the GDL consequently affecting the cell performance (2).

In this work, a visualization PEM fuel cell was designed with an insulative transparent material (Lexan®). The overall fuel cell design was matched to automotive hardware as suggested by Owejan et al. (3). The flow fields were 400 µm thick gold-plated copper plates which were cut via wire EDM (electrical discharge machining). These plates form the two channel walls within the visualization cell, while the GDL forms the third wall. The fourth wall is created by an optically transparent sheet of Lexan® which provides mechanical support. The thin foil thermocouples were used to measure the temperature just above the membrane near the inlet and outlet locations. Four commercially available GDLs (Toray TGP-H-060, MRC-105, SGL 25BC, and Freudenberg H2315) were tested in order to investigate their role in liquid water transport. All samples had an MPL coating, nominally 5 wt. % PTFE treatment, and approximate thickness of ~210 µm. Despite their similar material properties, there are significant differences in the structure of each GDL. The GDL morphology was analyzed using confocal laser scanning microscopy.

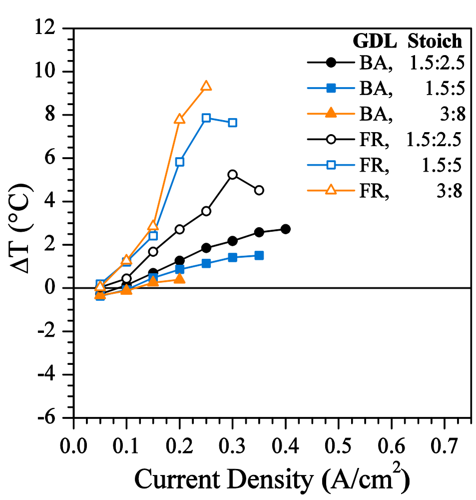

Figure 1 - Thermal gradient along the flow direction of Cathode with dry inlet gases.

Thermal gradients were measured for all four GDLs at various conditions. Figure 1 shows the change in temperature for the cathode side with MRC-105 (BA) and Freudenberg (FR) GDLs with a dry inlet gas stream. With the baseline GDL, the temperature gradient was observed to decrease with stoichiometry. However with the Freudenberg GDL, the temperature gradient increased significantly with stoichiometry. A temperature difference of up to 10 °C between the inlet and outlet was observed with the Freudenberg GDL, over 4 times higher than that for the MRC-105 GDL.

On the anode side with a dry inlet, a similar trend was noted, as shown in Figure 2. With the MRC-105 GDL, the temperature gradient was observed to increase with stoichiometry, however the overheating was not observed. The temperature gradient decreased with stoichiometry with the Freudenberg GDL on the anode side of the membrane. A temperature difference of 11 °C was noted with the MRC-105 GDL, over 3 times higher than the Freudenberg GDL.

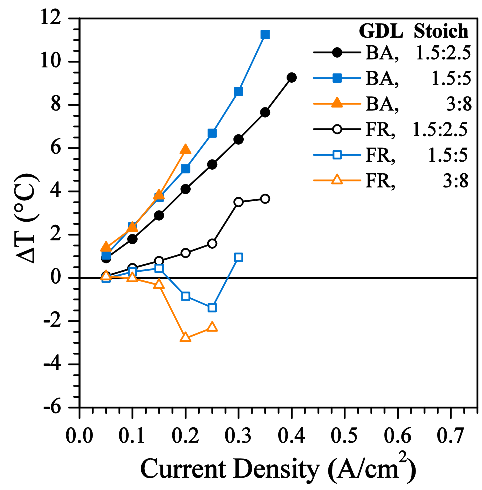

Figure 2 - Thermal gradient along the flow direction of Anode with dry inlet gases.

The change in temperature along the flow direction was observed to vary based on GDL structure, specifically due to a change in its in-plane thermal conductivity. This difference in temperature profile was seen to affect the overall cell performance. Under conditions at which membrane dehydration was likely, the change of in-plane thermal conductivity of the GDL allowed improved performance. It is seen that the GDL material properties, in particular the in-plane thermal conductivity, plays an important role in the overall cell performance due to changes temperature profile and water distribution in the flow channels.

Acknowledgements

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References

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