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Experimental Study on Performance of a Planar Membrane Humidifier for a Proton Exchange Membrane Fuel Cell Stack

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Abstract : The proton exchange membrane fuel cell (PEMFC) becomes more important as an alternative energy source recently. Maintaining proper water content in the membrane is one of the key requirements for optimizing the PEMFC performance. The planar membrane humidifier has the advantages of simple structure, low cost, low-pressure drop, light weight, reliable performance and good gas separability. Thus, it is a common external humidifier for PEMFCs. In this work, a planar membrane humidifier for kW-scale PEMFCs is developed successfully. The heat and mass transfer of humidifier is discussed, and its performance is analyzed in term of dew point approach temperature (DPAT), water vapor transfer rate (WVTR) and water recovery ratio (WRR). The DPAT of the humidifier with the counter flow approach reaches about 6°C under inlet dry air of 50°C and 60% RH and inlet humid air of 70°C and 100% RH. The rate of pressure loss of the humidifier is 5.0×10^{2} Pa/min at the torque of 7 N-m, which reaches the standard of commercial planar membrane humidifiers. From the tests, it is found that increasing the air flow rate increases the WVTR. However, the DPAT and the WRR are not improved by increasing the WVTR as the air flow rate is higher than the optimal value. In addition, increasing the inlet temperature or the humidity of dry air decreases the WVTR and the WRR. Nevertheless, the DPAT is improved at elevated inlet temperatures or humidities of dry air. Furthermore, the performance of the humidifier with the counter flow approach is better than that with the parallel flow approach. The DPAT difference between the two flow approaches reaches up to 8 °C.

Keywords : heat and mass transfer, humidifier performance, PEM fuel cell, planar membrane humidifier
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