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Experimental Study on Heat and Mass Transfer of Humidifier for Fuel Cell

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Abstract : Major contributions of this study are threefold: designing a new model of planar-membrane humidifier for Proton Exchange Membrane Fuel Cell (PEMFC), an index to measure the Effectiveness (εT) of that humidifier, and an air compressor system to replicate related planar-membrane humidifier experiments. PEMFC as a kind of renewable energy has become more and more important in recent years due to its reliability and durability. To maintain the efficiency of the fuel cell, the membrane of PEMFC need to be controlled in a good hydration condition. How to maintain proper membrane humidity is one of the key issues to optimize PEMFC. We developed new humidifier to recycle water vapor from cathode air outlet so as to keep the moisture content of cathode air inlet in a PEMFC. By measuring parameters such as dry side air outlet dew point temperature, dry side air inlet temperature and humidity, wet side air inlet temperature and humidity, and differential pressure between dry side and wet side, we calculated indices obtained by dew point approach temperature (DPAT), water flux (J), water recovery ratio (WRR), effectiveness (εT), and differential pressure (ΔP). We discussed six topics including sealing effect, flow rate effect, flow direction effect, channel effect, temperature effect, and humidity effect by using these indices. Gas cylinders are used as sources of air supply in many studies of humidifiers. Gas cylinder depletes quickly during experiment at 1kW air flow rate, and it causes replication difficult. In order to ensure high stable air quality and better replication of experimental data, this study designs an air supply system to overcome this difficulty. The experimental result shows that the best rate of pressure loss of humidifier is 0.133×10^3 Pa(g)/min at the torque of 25 (N.m). The best humidifier performance ranges from 30-40 (LPM) of air flow rates. The counter flow configured humidifies moisturizes the dry side inlet air more effectively than the parallel flow humidifier. From the performance measurements of the channel plates various rib widths studied in this study, it is found that the narrower the rib width is, the more the performance of humidifier improves. Raising channel width in same hydraulic diameter (Dh) will obtain higher εT and lower ΔP. Moreover, increasing the dry side air inlet temperature or humidity will lead to lower εT. In addition, when the dry side air inlet temperature exceeds 50°C, the effect becomes even more obvious.

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