Use of computational fluid dynamic to compare the pressure loss between a parallel flow field plate and a parallel-baffle flow field plate in a direct ethanol proton exchange membrane fuel cell

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ABSTRACT

Fuel cells are considered to be the green power sources for the 21st century, and may make the "hydrogen economy" a reality [1]. The fuel cell e discovered around two centuries ago by William Grove and Friedrich Schönbein and has yet to see widespread commercialization, despite the advantages of the technology and its wide range of potential applications. The reason for the delay in commercialization of the technology can be ascribed to several present characteristics of the fuel cell: for example, cost and complexity, immaturity, and its role as replacement technology [2]. Improvements in cell design and manufacturing have further increased power, while reducing manufacturing costs, which is essential if the fuel cell is to compete with the internal combustion engine [3].

According to Li et al. [3], bipolar plates comprise about 60% of the weight and 30% of the total cost in a fuel cell stack. The channels design and its pattern considerably affect the effectiveness of mass transport as well as electrochemical reactions inside the cell. More recently, there was a trend to apply CFD methods to fuel cells modeling [4]

Computational fluid dynamics (CFD) modeling is the most common approach to creating simulations of ethanol alcohol within a direct ethanol proton exchange membrane fuel cell (DE-PEMFC) [5]. The pressure loss in the DE-PEMFC flow field plates decrease the power density and the fuel cell performance. Within parallel flow channels the reactant gas speed is low relative to serpentine flow fields which may lead to local flooding, particularly under the lands, where the pressure gradient is a minimum [6].

The basic idea of interdigitated flow fields is to force the total mass flow through the land area to improve the local cell performance [7]. However, here the excessive pressure drop from the gas inlet to the gas outlet of the flow field requires additional parasitic power [8].

The aim of this research was project a new flow field design, with PFFP and IFFP characteristics, a parallel-baffle flow field plate (PBFFP). The new flow field plate design were created and was employed the SOLIDWORKS software 2013 with flow simulation tool in a computer model Alienware Aurora Desktop – BRH3171 (3.2 GHz, 8 MB L3 cache; 24GB DDR3 1333MHz memory (6x4GB)) with an high-performance liquid cooling (Alienware®), equipped with a Intel® Core™ i7-960. In the simulations both flow plates (the classic PFFP and the new PBFFP) received a volume flow of 1 L/min (hydrogen) in the inlet with an environment pressure in the outlet.

The result showed that in the PFFP all channels suffered with pressure loss but in the PBFFP, the interdigitated channels pressure loss stabilized and it was concentrated only in the channel connected to the outlet (lower pressure), improving the fuel cell performance.

REFERENCES

[1] X. CHENG, Z. SHI, N. GLASS, L. J. ZHANG,NG, D. SONG, Z-S. LIU, H. WANG, J. A. SHEN, "Review of PEM hydrogen fuel cell contamination: Impacts, mechanisms, and mitigation", J. P. Sources, 165, 739-756 (2007).

[2] H. L. HELLMAN, R. Van Den HOED, "Characterizing fuel cell technology: challenges of the commercialization process", Int. J. Hyd. Energy, 32, 305-315 (2007).

[3] X. LI, I. SABIR, "Review of bipolar plates in PEM fuel cells: flow field designs" Int. J. Hyd. Energy, 30, 359-371 (2005).

[4] Z. H. WANG, C. Y. WANG, K. S. CHEN, "Two-phase flow and transport in the air cathode of proton exchange membrane fuel cells", J. P Sources, 94, 40-50 (2001).

[5] A. ARVAY, J. FRENCH, J-C. WANG, X-H. PENG, A. M. KANNAN, "Nature inspired flow field designs for proton exchange membrane fuel cell", Int. J. Hyd. Energy, 38, 3717-3726 (2013).

[6] J. BACHMAN, M. CHARVET, A. SANTAMARIA, H-Y. TANG, J. W. PARK, R. WALKER, "Experimental investigation of the effect of channel length on performance and water accumulation in a PEMFC parallel flow field". Int. J. Hyd. Energy, 37, 17172-17179 (2012).

[7] T. V. NGUYEN, "A Gas Distributor Design for Proton-Exchange-Membrane Fuel Cells". Electrochem Soc, 143, L103-L105 (1996).

[8] P. J. HAMILTON, B. G. POLLET, "Polymer electrolyte membrane fuel cell (PEMFC) flow field plate: design, materials and characterization", Fuel Cells, 10, 489–509 (2010).