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# Numerical study of the cathode manifold design for enhancing the performance of a 5KW PEM fuel cell

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This numerical study is to simulate the flow field of a 5KW PEM fuel cell (PEMFC) cathode manifold and to optimize the inlet manifold design. In order to achieve a better uniform pressure in every plate of the fuel cell, novel designs are described and compared in this paper. Uniform flow distribution is advantageous in providing (i) superior temperature control, (ii) low pressure losses [1] and (iii) a proper distribution of fuels to avoid starvation. Therefore, direct exposure of the channels in each plate to the high velocity flow entering at the inlet is to be avoided.

Three case studies have been studied in order to find alternatives to an original design, as other have done in the past [2]. Figure 1 shows the 5kW PEMFC air flow model of the present fuel cell. The flow structure at the channels is based on serpentines[3], which can drastically improve the active area of a fuel cell at the cost of a higher pressure drop when compared to other geometries. Figure 1 (a) and (b) also show the locations where several indicators will be calculated in order to quantify performance. The cases are explained as follows:

(i) No baffle design (original design):

Figure 2 shows the flow field simulation result of the original design of the cathode manifold. The fluid stream flows into the manifold with a high speed at the channels nearest to the inlet which must significantly decrease the pressure at the channels. This not only causes a non-uniform flow field, but also a significantly lower pressure at the majority of the channel plates.

(ii) A flat rectangular baffle design:

Figure 1 (a) shows the model for this particular case. It successfully prevents direct high velocity inlet flows to be in contact with the channel plates. The flow field is found to be much more uniform than the original design.

(iii)Two porous baffles with an added baffle design:

The flow result for this design is shown in Figure 3. It can be noticed that a much more uniform flow distribution is achieved at the channel.

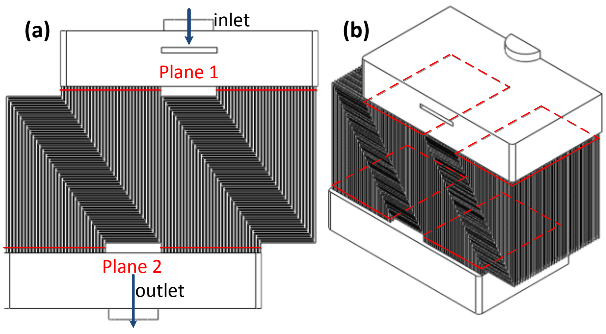

Figure 1 (a) Schematic representation of fuel-cell stacks with inlet and outlet. (b) A flat rectangle baffle at the manifold.

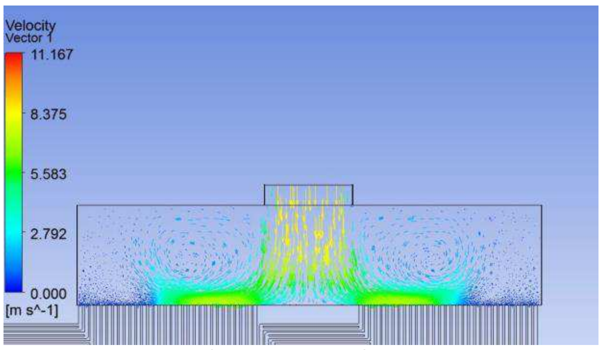

Figure 2 Velocity flow vectors of design (i)

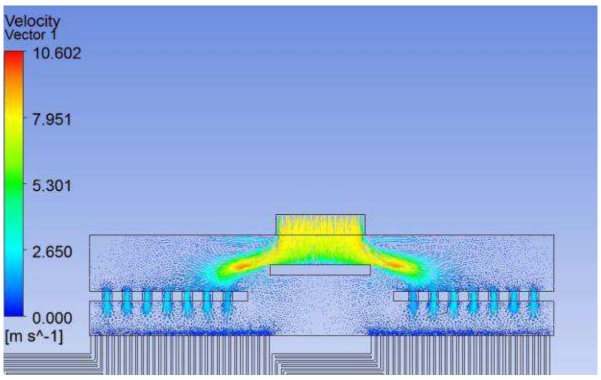

Figure 3 Velocity flow vectors of design (iii)

In order to quantify the effects of the manifold flow fields, two performance indicators are employed, namely, the mesh area average and the mesh area averaged standard deviation of the pressure located at the beginning and end of the serpentine channels; the position of the planes shown in Figure 1. From Figure 4 (a) and (b), it can be seen that design (i) is indeed the worst in flow distribution and channel pressure. Designs (ii) and (iii) have a much better performance. However, design (iii) shows a slightly better pressure uniformity at the channels. More designs which both reduce the manifold geometry and uniformity are still in progress and should give important guidelines for fuel cell designs.

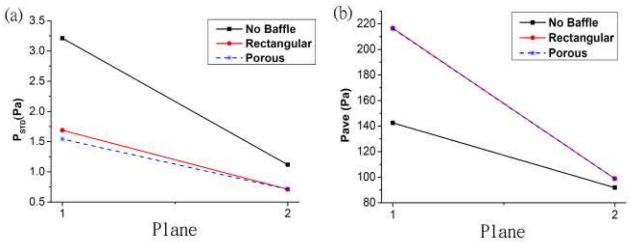

Figure 4 (a) Average pressure and (b) standard deviation (STD subscript) of the selected planes at Planes 1 and 2, respectively, for the three designs.

## REFERENCES

[1] Hong Liu, Peiwen Li*, Jon Van Lew, "CFD study on flow distribution uniformity in fuel distributors having multiple structural bifurcations of flow channels", Int. Journal of Hydrogen Energy 35 ( 2010 ) 9I86-9I98

[2] R. M. Oroviceanu, L. V. Garcia, F. Barreras, M. I. Gil, A. L. Fantoba, *"Study of the Distribution of Air Flow in a Proton Exchange Membrane Fuel Cell Stack"*, Journal of Power Sources 192 (2009)185–189

[3] C. H. Cheng, K. Fei, C. W. Hong, "Computer Simulation of Hydrogen Proton Exchange Membrane and Direct Methanol Fuel Cells", Computers and Chemical Engineering, 31 (2007) 247-257