Modelling of a 5 Cell Intermediate Temperature Polymer Electrolyte Fuel Cell (IT-PEFC) Stack: Analysis of Flow Configuration and Heat Transfer

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Abstract

Introduction

Polymer Electrolyte Fuel Cells (PEFCs) are a key technology in the advancement of society towards a low carbon future. In particular, PEFCs will be important for use within the automotive sector. PEFCs are advantageous due to their low operating temperature (60-80 oC), quick start up times and responsiveness to load change. However, the requirement for expensive platinum, difficulty of water management and heat dissipation means that further improvements are required [1].

One of the ways a PEFCs can be improved is by increasing their operating temperature (>100 oC) [2], commonly known as the Intermediate Temperature PEFC (IT-PEFC) (120 oC). This allows for the generation of high temperature heat, which can be used in a combined heat and power system thus enabling higher system efficiencies, while simplifying water management as water will exist solely in the vapour phase.

Use of COMSOL Multiphysics®

COMSOL Multiphysics® was used to create a three dimensional model of a 5 cell stack (see figure 1) in order to assess the effects of the stack flow configuration on the dissipation of the heat generated by the electrochemical reactions. In particular, the effects of the cell materials were studied to improve the cell design.

Results have shown that the flow configuration within the stack has a large effect on the dissipation of heat generated. The PEFC has an electrical efficiency between 10-60 % and therefore it can be assumed that the remaining energy is generated as heat which must be removed.

It was also found that by replacing some of the conventional cell materials with novel component composite materials, the heat removal from the stack could be increased significantly (see figure 2). This could lead to a reduction in the requirement for the gas flow rates and therefore an increase in the air utilisation which lowers the parasitic loses from the system. The overall

pressure required to force the gas through the stack can be reduced by using a novel integrated diffusion layer/flow channel (see figure 3).

In conclusion, the flow configuration of the stack is important to the removal of heat generated by the stack. The materials used in the cell and therefore the stack can influence the heat transfer properties of the stack and so the cost of novel materials to improve heat transfer must be carefully considered against the lifetime of the stack. Future work will involve the validation of the model with "real life" experiments.

Reference

[1] Chandan A., Hattenberger M. et. al., “High temperature (HT) polymer electrolyte membrane fuel cells (PEMFC) – A review,” Journal of Power Sources, 231, pp. 264–278. (2013)

[2] Shamardina O., Chertovich a., et. al., “A simple model of a high temperature PEM fuel cell,” International Journal of Hydrogen Energy, 35,18, pp. 9954–9962 (2010)

Figures used in the abstract

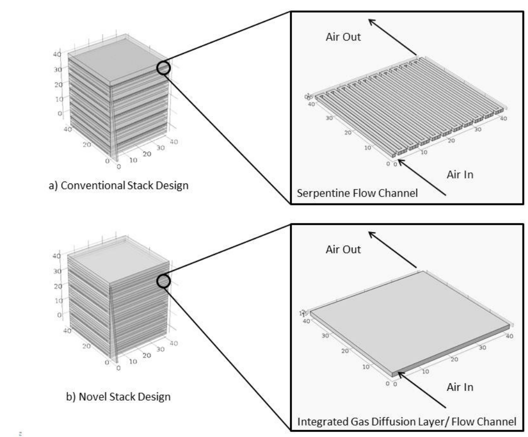

Figure 1: Geometries Used Within The Study

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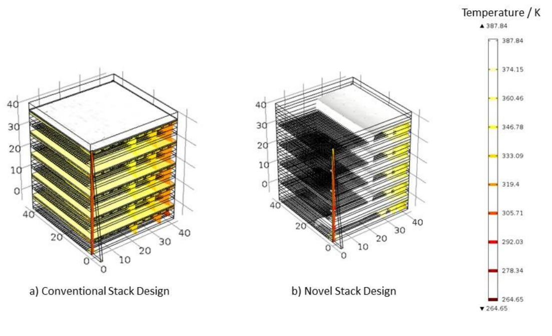

Figure 2: Heat Transfer Within The Stack

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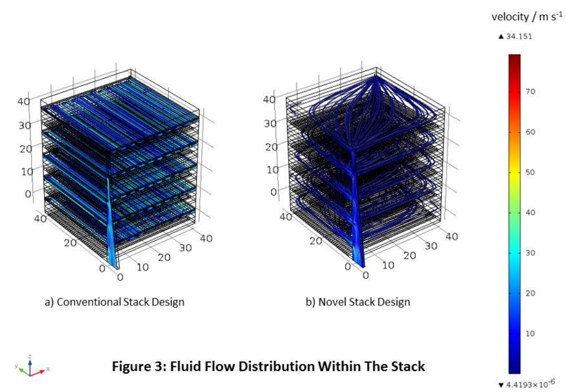

Figure 3: Fluid Flow Distribution Within The Stack

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