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CFD Investigation of Microchannel design effect on Al_2O_3 Nano-fluids Thermal Behavior in PEM fuel cell cooling plate

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Abstract

A uniform temperature distribution is important to obtain better control and higher performance of polymer electrolyte membrane fuel cells (PEMFCs). In PEMFCs, more than half of the chemical energy of hydrogen is converted into heat during the electrochemical generation of electricity. If not being properly exhausted, this reaction heat overheats the PEMFCs and thus impairs their performance. In general, large-scale PEMFCs are cooled by Nanofluid that circulates through coolant flow channels in cooling plates. In this study, detailed fluid flow and heat transfer in large scale cooling plates with 140× 180 cm2 was simulated using a commercial computational fluid dynamics (CFD) .Based on the CFD simulations, the performances of three different coolant flow field designs were assessed in terms of the maximum temperature, temperature uniformity, and pressure drop characteristics, and compare it to a straight traditional flow field. The results demonstrated that –S- character flow field designs could significantly improve the uniformity of temperature distribution in a cooling plate compared with other zigzag flow field designs, despite the high Nanofluid (Al2O3-W(60)/EG(40)) pressure drop.

Keywords: *PEMFCs, CFD, Nano-fluid(Al2O3-W(60)/EG(40)), Cooling Plate Flow field Design, Enhancement of heat transfer.*

1. Introduction

The energy crisis has become one of the most important problems the world is currently facing due to the large and continuous increase in energy consumption, which is matched by a specific reserve of traditional energy resources, as well as a significant increase in fuel prices and environmental problems caused by fossil fuels [1], so the researchers deliberately developed resources New and alternative to it, where attention is drawn to the development of renewable energies such as solar thermal energy, photovoltaic cells, wind energy, hydropower, geothermal, biofuel energy, etc., where these renewable sources are inexhaustible and non-polluting to the environment.

Fuel cells are one of the most effective techniques for producing energy in a clean way. These cells use hydrogen as a biofuel, which are devices that convert the chemical reaction energy directly into electrical energy without going through mechanical energy. Where there are several types of fuel cells that can be classified according to the nature of the electrolyte (a material that contains free ions that form a transportable medium) or its operating temperature [2]. These types include proton transport membrane fuel cells (PEMFC).

Since the PEMFC fuel cell is an advanced technology, its development still faces many problems that must be addressed extensively. Many economic, scientific and technological aspects must be accurate and ideal in order to obtain a viable technology, such as reducing the cost, durability and reliability of the cell and the flow of water and heat in it. To overcome these problems, many research activities have been carried out by laboratories, universities and industrial companies during the past three decades [3]. Generally these studies can be classified into two categories: experimental and numerical simulations.

In experimental studies, research usually focuses on improving cell performance, but the combination of temporal and spatial scales by means of experimental methods is still more difficult, because the measure of the length of the basic elements of the cell ranges between micro and macro, and the time scale for some transfers ranges from milliseconds to A few hours [3], as physical models can be very expensive and time consuming. Consequently, fuel cell modeling and simulation has become a useful method for researchers, meaning that it can lead to improvements in design of a less expensive and more efficient fuel cell.

One of the most important factors affecting the performance of a PEMFC fuel cell is the formation of cold plates. Improving the engineering parameters of the coolant flow channels (fluid having the advantage of removing excess heat from the cell) such as the length, width and depth of the channel as well as the shape of the cross section can improve the performance of the fuel cell. The aim of our work is to develop a three-dimensional numerical model of the heat transfer phenomenon, and study the effect of the coolant fluid flow in the channels and the effect of the geometrical shape of the channels themselves on the performance of the proton exchange membrane fuel cell. Al2O3–water ethylene glycol mixture nanofluid Al2O3 was used for carrying out the present numerical simulation.

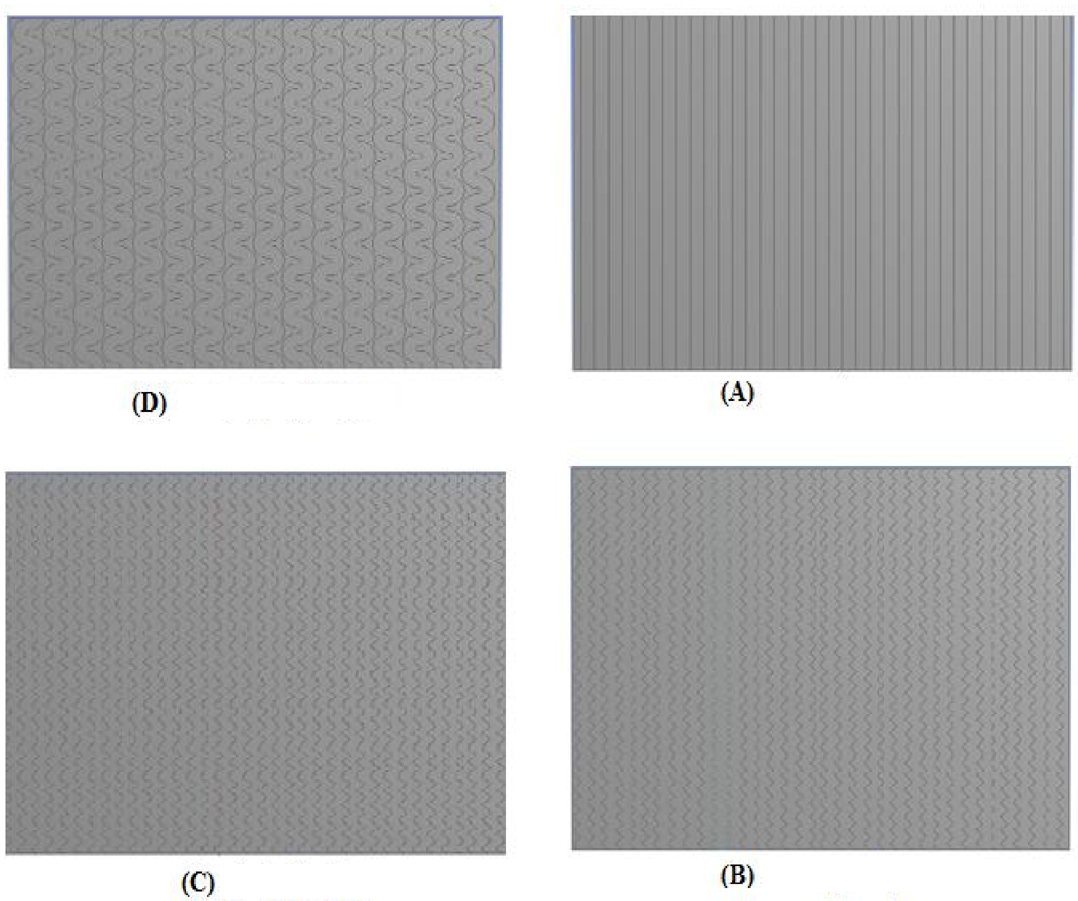
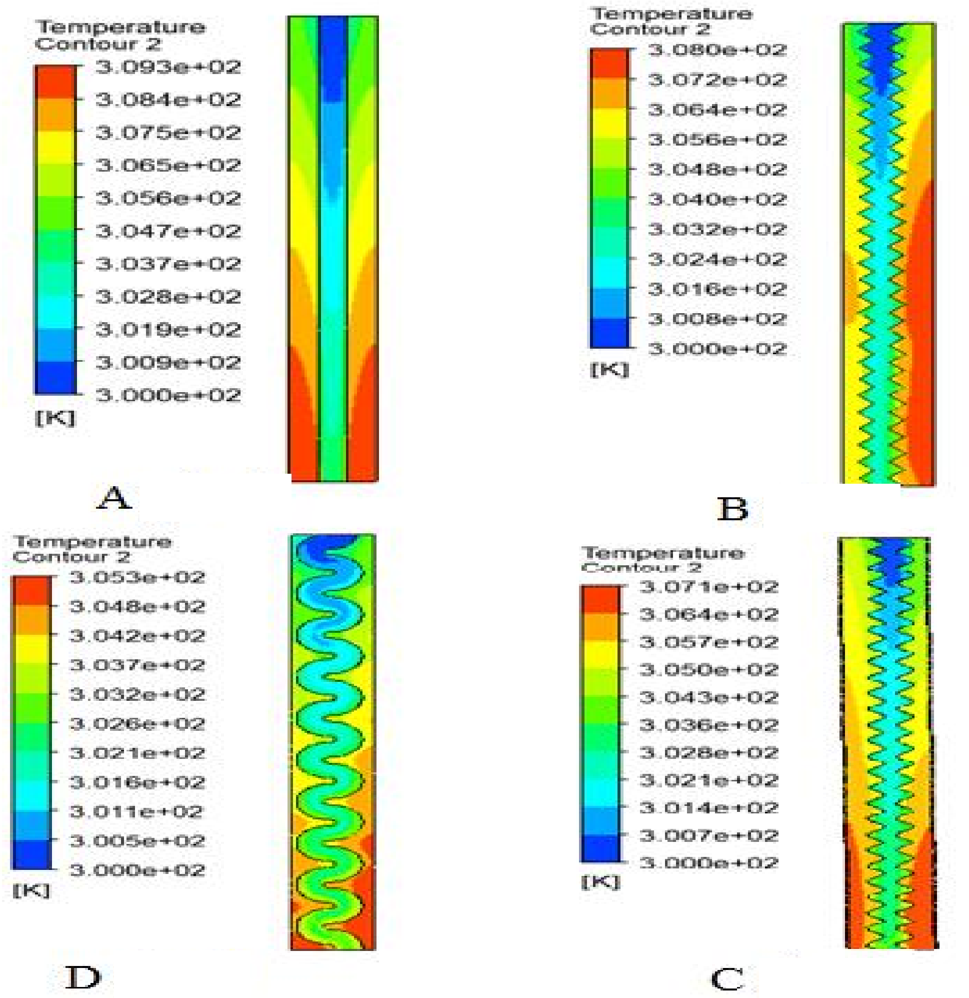


Fig1. Fluid flow channels form



2. Conclusion

Through our numerical study using CFD using ANSYS FLUENT 19.0 by selecting three models with new non-straight (curved) designs and comparing them with the traditional straight, parallel design of the nanofluid flow channels (mixture Al2O3-W (60) / EG (40)) Drilled in PEMFC fuel cell cooler panels in terms of improved heat transfer, thermal performance and pressure drop controlling pumping power and interest rate. We found that enhanced heat transfer for curved, refracted and S-shaped models in terms of the heat transfer coefficient and the number of Nu nesalt appears in Reynolds numbers 60 and above despite the high pressure drop that generates significant pumping power.

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