CONVECTIVE HEAT TRANSFER ANALYSIS AND DEVELOPMENT OF COOLING SYSTEM FOR FUEL CELLS

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Introduction:

A fuel cell is an electrochemical device that uses hydrogen as fuel and oxygen as reactant to produce electricity with steam as a by-product to produce electric current.

For a fuel cell to run efficiently and consistently for a long period of time, proper heat management is necessary. Increase in temperature, increases performance, efficiency, power production and voltage and leakage current but decreases mass crossover and durability. But at higher temperatures, the membrane becomes dehydrated resulting in a smaller number of protons passing from anode to cathode will reduce electron flow and hence reducing current density and efficiency.

In this project, an efficient cooling channel design is fabricated after performing heat transfer analysis. Water (coolant) is supplied at the top end of the channel. Since the fuel cell is oriented in a vertical position, gravity will cause the coolant to flow through the channels. Additional pumps can be used to increase the mass flow rate.

Objectives:

1. To design and model different cooling channels for an existing 50*50 mm single stack fuel cell.
2. To perform convective heat transfer analysis between the bipolar plate and the coolant and identify the best design configuration.
3. To perform a CNC milling operation on the bipolar plate to facilitate coolant flow.

Methodology:

1. Design different channel designs based on the serpentine channel configuration using SolidWorks.
2. Perform CFD and convective heat transfer analysis on the designed channels using Ansys.

3. Study results based on pressure drop, overall heat transfer in the bipolar plate.
4. Fabricating the channels on the bipolar plate using the CNC milling process.

Conclusion:

1. A detail study of fuel cell heat management was carried out and a cooling system has been developed for a single plate fuel cell.
2. Three channel designs are studied for cooling, namely straight channel, serpentine single channel, and serpentine double channel.
3. Serpentine double channels design has a higher heat transfer of 225.67 W and 229.81 W as compared to serpentine single channel design, lower coolant outlet temperature for 1.5 and 2 mm channel width respectively.
4. With consideration to thermal performance factors and ease of practical use, it has been found that the serpentine double channels design is the best among the three designs.
5. The serpentine double channel design is fabricated.

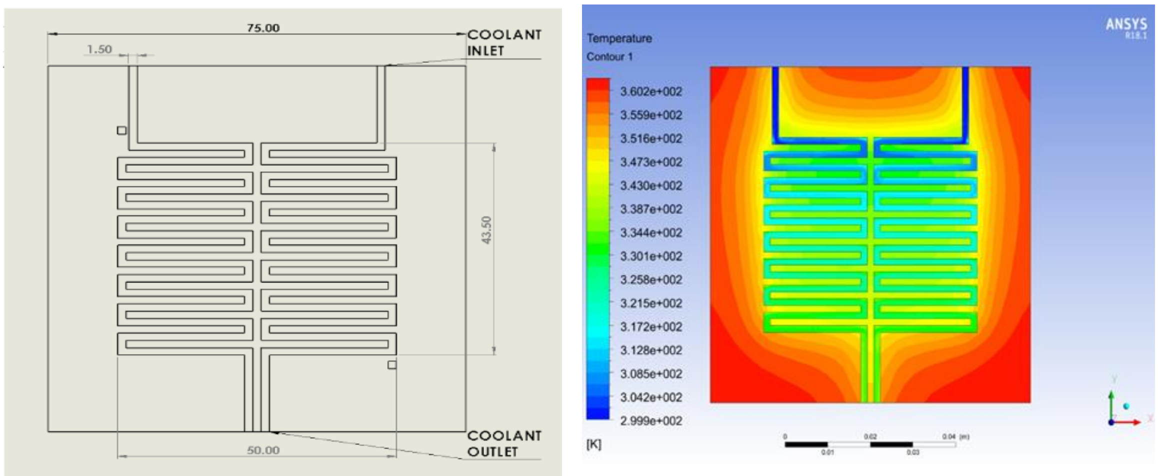

Fig: Serpentine double channel design (left) and temperature distribution (right)

Scope for future work:

1. The designs can be used create a thermal management system such that the coolant cools the fuel cell and then the coolant is cooled through external means like radiators.
2. The coolant can be circulated whenever the fuel cell temperature increases over the optimal temperature region.
3. This setup would require several flow-control valves, thermostats, a pump, a radiator and a reservoir.