

THE OPTIMIZATION OF VARIOUS CROSS SECTION FLOW IN NUMERICAL ANALYSIS OF PEM FUEL CELLS BY USING CFD

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Abstract— The objective of the project is to optimize various cross section of PEM fuel cell. Proton Exchange Membrane (PEM) Fuel Cell model numerically to understand the performance of the Fuel Cell model in various design and operating pressure and temperature and flows. Which is difficult to analyze through the experiment? The numerical analysis was performed on single channel fuel cell cross section for semicircular and triangular flow which has to be INTERDIGIT flow path. After completing the modeling to analysis by using comsol software for various cross sections. Similar procedure was followed for the analysis of various INTERDIGIT models with semicircular and triangular cross section and the performance of the models. The results show that the performance of the PEM Fuel Cell model is improved by decreasing the temperature and by increasing the operating pressure and by using semicircular and triangular flow channels. Compared triangular flow channel and semi circle flow channel is give better performance for **triangular flow channel**.

Key word: Fuel cell, Pem, Cross section, Interdigit, Comsol.

1. INTRODUCTION

A fuel cell is most interesting new power source because it solves not only the environment problem but also natural resource exhaustion problem. CFD modeling and simulation for heat and mass transport in PEM fuel cells are being used extensively in researches and industrial applications to gain better understanding of the fundamental processes and to optimize fuel cell designs before building a prototype for engineering application [1]. Proton exchange membrane fuel cells have many distinctive features that made it an attractive alternative clean energy source, including low start-up, high power density, high efficiency, portability and remote applications [2]. This system in a proton exchange membrane (PEM) fuel cell for the objective of reducing ohmic loss, thereby achieving higher power density. Specifically, the dimensions of current collection ribs as well as the rib distribution were optimized to get a maximized power density in a fuel cell [3]. When assembling a fuel cell stack, the assembly pressure generated can decrease the interfacial contact resistance (ICR) between the bipolar plate (BPP), gas diffusion layer (GDL) and catalyst layer, and also, the reduction in mass transfer that happens during the

electrochemical reaction in the catalyst layer through the GDL must be considered. Recent research on the numerical analysis of fuel cells does not take into account the aforementioned importance of the GDL compression deformation, claiming the restrictions of numerical analysis, and uses a simple model to analyze the mass transfer of the fuel cells using CFD analysis [4]. CFD modeling and simulation for heat and mass transport in micro PEM fuel cells are being used extensively in researches and industrial applications to gain better understanding of the fundamental processes and to optimize the micro fuel cell designs before building a prototype for engineering application [5].

2. PROBLEM IDENTIFICATION FROM LITERATURE

With serpentine and interdigitated flow fields, it can generally achieve more uniform reactants distribution. Fuel cell with interdigitated flow field can perform similarly to another cell with parallel channels geometry, but with a lower fuel consumption.

Flow field with interdigitated type channels yielded a better performance compared to serpentine flow channel, although a lower pressure drop was found at a fixed active area of the MEA. So in this project, a PEMFC with interdigitated flow channel is taken for analysis.

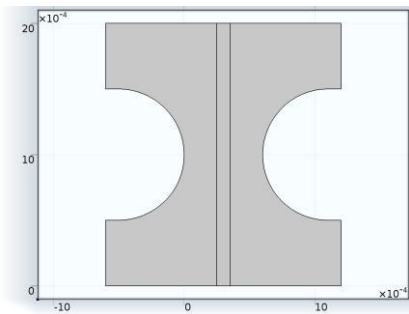
3. DATA COLLECTION

Before going for computational modeling the data required for the interdigit rectangular cross-section PEM model is collected from PSG Institute of Advanced Studies where the experimental analysis of PEM models were done. At first we are doing numerical analysis of PEM models being used in PSG IAS for experiments. The data's collected include,

DESCRIPTION	UNITS	VALUES
Width of flow path	mm	0.5
Depth of flow path	mm	0.5
Width of rib	mm	1
Depth of rib	mm	1

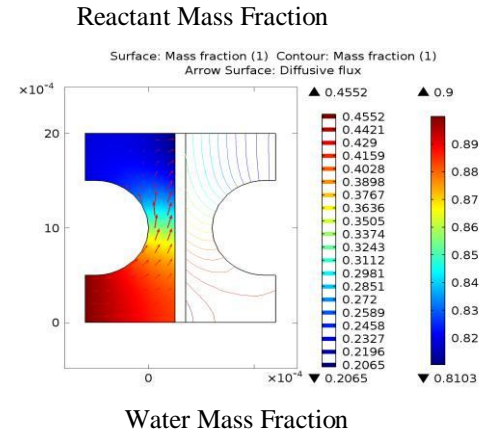
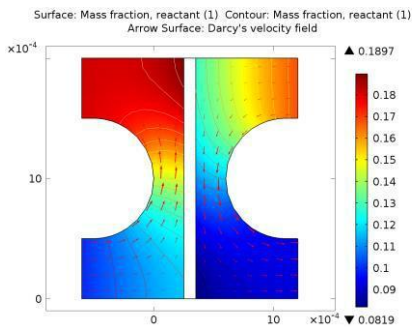
Size of flow channel	mm	50x50
GDL thickness	mm	0.3
Catalyst layer thickness	mm	0.08
Membrane layer thickness	mm	0.127
Porosity of GDL layer		0.5
Operating pressure	bar	1.5
Operating temperature	°C	50
Hydrogen mass flow rate	lpm	0.6
Oxygen mass flow rate	lpm	0.3

4. MODELING OF SEMI CIRCLE FLOW CHANNEL MATERIALS USED



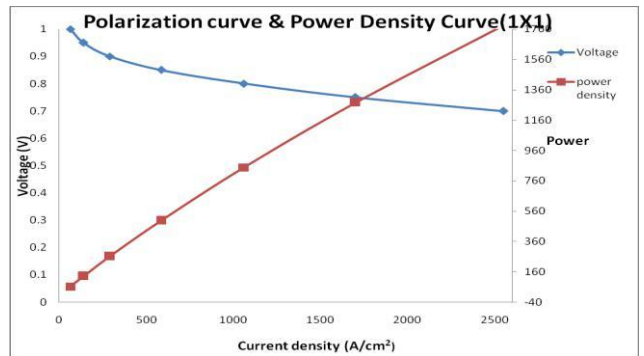
Modeling parameters of PEM fuel cell with single flow channel semi circular cross section 1*1

5. ANALYSIS OF SEMI CIRCLE SINGLE FLOW CHANNEL.



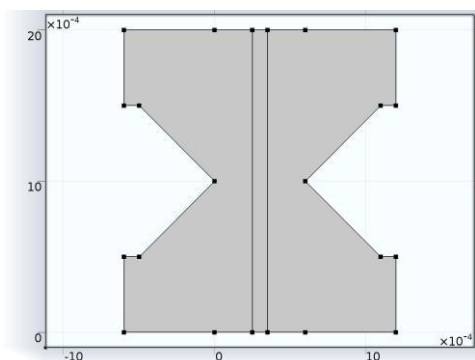
6. RESULTS AND DISCUSSION FOR NUMERICAL VALUES SEMI CIRCLE SINGLE FLOW CHANNEL

SL.NO	CURRENT DENSITY W/M ²	VOLTAGE	POWER DENSITY W/M ²
1	2550	0.7	1785
2	1700	0.75	1275
3	1060	0.8	848
4	585	0.85	497.25
5	290	0.9	261
6	139	0.95	132.05
7	63.5	1	63.5

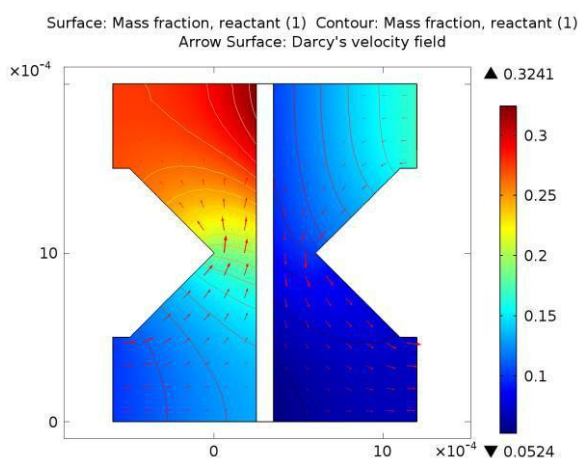


The above curve shows that the increasing current density of PEM fuel cell and also increase power density of PEM fuel cell.

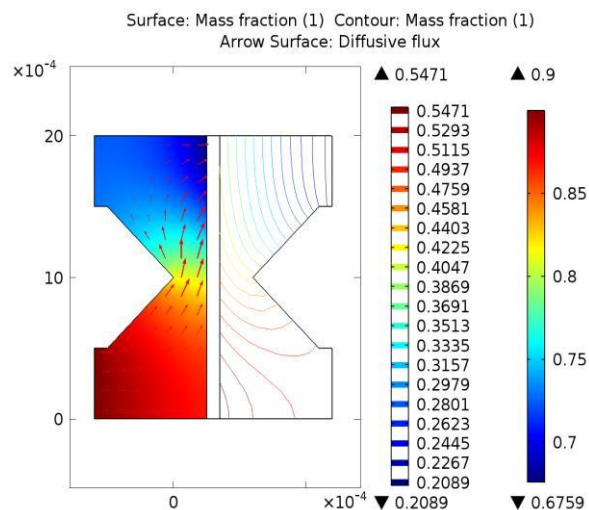
7. ANALYSIS OF SEMI CIRCLE SINGLE FLOW CHANNEL.



Modeling parameters of PEM fuel cell with single flow channel semi circular cross section 1*1



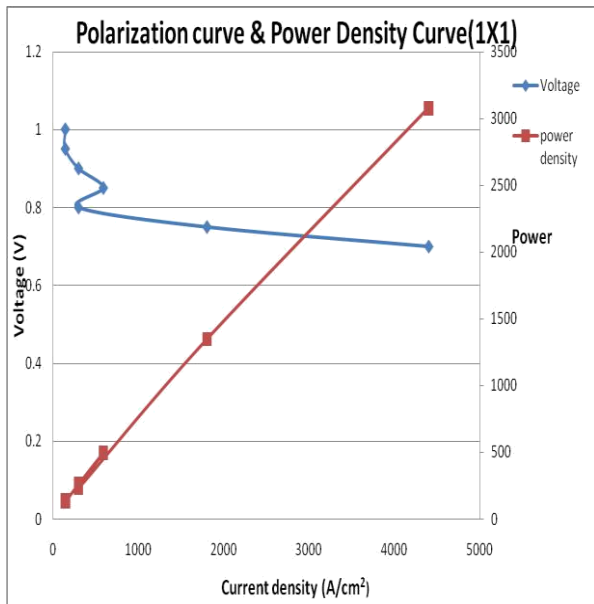
DESCRIPTION	UNITS	VALUES
Width of flow path	mm	H/3
Depth of flow path	mm	H/3
Width of rib	mm	1
Depth of rib	mm	1
Size of flow channel	mm	50x50
GDL thickness	mm	0.3
Catalyst layer thickness	mm	0.08
Membrane layer thickness	mm	0.127
Porosity of GDL layer		0.5
Operating pressure	bar	1.5
Operating temperature	°C	50
Hydrogen mass flow rate	lpm	0.6
Oxygen mass flow rate	lpm	0.3



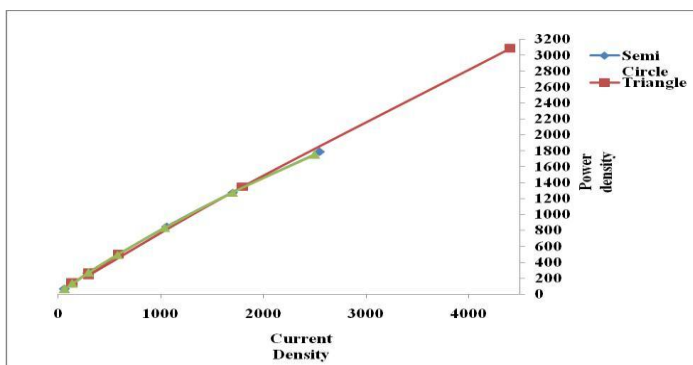
8. RESULTS AND DISCUSSION FOR NUMERICAL VALUES TRIANGULAR SINGLE FLOW CHANNEL.

SL.NO	CURRENT DENSITY A/M ²	VOLTAGE	POWER DENSITY W/M ²
1	4400	0.7	3080
2	1800	0.75	1350
3	294	0.8	235.2
4	585	0.85	497.25
5	294	0.9	264.6
6	139	0.95	132.05
7	139	1	139

The above cure shows that the increasing current density of PEM fuel cell and also increase power density of PEM fuel cell.



Comparison graph of rectangular semi circle triangular of single flow channel.



The above cure shows that the increasing current density of triangular PEM fuel cell and also increase power density of PEM fuel cell.

9. CONCLUSION

The various flow channel shape and size were considered for the analysis of single straight channel PEM fuel cell. Various cross section and direction of flow of reactant gases were same for all flow channels.

In serpentine and interdigitated flow channel, the two different shapes of flow channel were considered for the analysis of PEM fuel cell. In interdigit give better performance compare to serpentine.

From the above numerical and experimental values we have conclude that power density of interdigit PEM fuel cell where compared with each other almost same.

The results show that the performance of the PEM Fuel Cell model is improved by decreasing the temperature and by increasing the operating pressure and by using semicircular and triangular flow channels compared with rectangular channel. Compared rectangular flow channel and semi circle flow channel is give better performance for triangular flow channel.

For 0.7V

Current density = 4400 A/M^2
 Power density = 3080 W/M^2

10. REFERENCES

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 Journal homepage: www.IJEE.IEEFoundation.org.