Effect of Reactant Gases Velocity Distribution in PEM Fuel Cell for Different Cell Voltages

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***Abstract*— The performance improvement of the PEM fuel cell can be achieved by varying the geometric designs and operating parameters. The water droplet generation and accumulation on the cathode side is drastically reducing the effective penetration of reactant gases from an anode side to the cathode side. In order to improve the performance of PEM fuel cell velocity distribution of reactant gases are taken into account to enhance the effective penetration of the reactant gases between anode and cathode side. In this paper deals with an effect of reactant gases velocity distribution at gas diffusion layer in PEM fuel cell with a single flow channel for different cell voltages. The numerical analysis has carried out to predict the maximum flow velocity distribution for different cell voltages (0.4 0.45, 0.5, 0.55, 0.6, 0.65, 0.70, 0.75, 0.8, 0.85 and 0.9V) respectively. The result shows that the PEM fuel cell with a cell voltage of 0.4V yields the maximum and better reactant gases flow velocity distribution (1.1549 m/s) at gas diffusion layer among the other ten cell voltages.**

Keywords*— PEM fuel cell, single flow channel, gas diffusion layer, reactant gases, velocity distribution.

I. INTRODUCTION

Proton exchange membrane fuel cells (PEMFCs) have recently approved on the scene and are expected to play a major role within the next generation of energy consumption systems as a clean power supply for varied applications [1]. In order to improve the performance of the PEM fuel cell different analysis are performed. One of the techniques which are used to improve the PEM fuel cell performance is to increase the reactants velocity inside the cell. Reactant gases velocity is increased up to 2% in the numerical analysis which is carried out to investigate the effect of flow velocity in parallel flow channel configuration [2]. Baffle blockage in tapered channels provides a better convection and a higher fuel flow velocity and enhances cell performance [3].

Inlet velocity and pressure of the reactants gases were examined through a flow distribution model in a PEM fuel cell stack [4]. The VOF-based modeling has also been conducted to investigate the droplet dynamics at the interface. The droplets on the GDL surface increases reactant transport resistance into the GDL as well as liquid flow inside [5-9]. Neutron imaging on liquid water in PEMFCs was also performed and presented detection of liquid accumulation in flow field and GDL under various operating conditions [10].

II. PROBLEM FORMULATION

Complete three dimensional model of the high temperature single flow channel PEM fuel cell is created using commercial modeling software package. The various design inputs like channel length, channel height, channel width, rib width and membrane thickness etc., are considered to create the isometric model. The three dimensional model is shown in figure.1. Meshing of the above model is done by using the commercial analysis software. The entire model is meshed with fine mesh elements for getting the better numerical results. Complete mesh is shown in figure.2.

III. DESIGN

The entire three dimensional model of the single flow channel is created by using commercial modeling software with different design parameters such as Rib width Plate width Gdl height, channel length, channel height, channel width, membrane thickness, and gas diffusion layer thickness. The complete model is imported into commercial analysis software after the successful completion of the three dimensional model of PEM fuel cell with single flow channel configuration. The entire model is meshed with fine meshing elements to enhance the numerical results. The three dimensional model of PEM fuel cell is shown in figure.1.

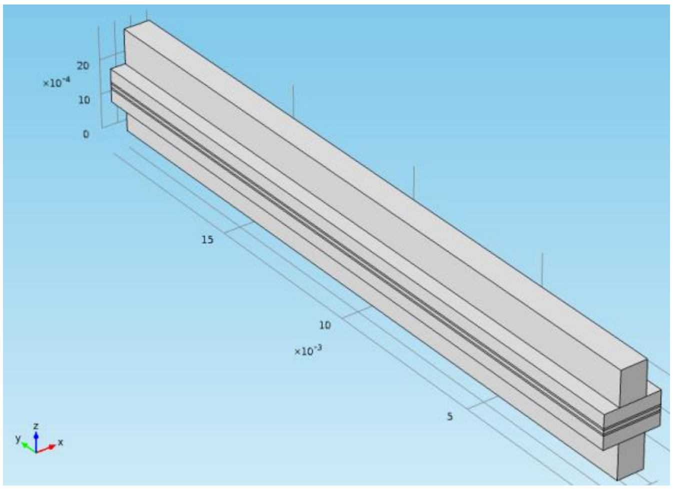

Fig.1. Three dimensional model

IV. ANALYSIS

The mesh model of PEM fuel cell is analysed in commercial analysis software with different operating parameters like cell voltage, open circuit voltage, lumped anode resistance, membrane resistance, cell temperature, oxygen reference concentration, gdl porosity, gdl permeability, inlet H_2O mass fraction (cathode), inlet Oxygen mass fraction (cathode), inlet Hydrogen mass fraction (anode), inlet velocity, outlet velocity, fluid viscosity, nitrogen molar mass, water molar mass, oxygen molar mass, N_2-H_2O binary diffusion coefficient, O_2-N_2 binary diffusion coefficient, O_2-H_2O binary diffusion coefficient, reference pressure, cathodic transfer coefficient are taken into account. The numerical results are obtained in the form of colour plots by clicking the compute domain for the eleven cell voltages.

V. RESULTS & DISCUSSIONS

The following numerical results were obtained in PEM fuel cell with single flow channel configuration for reactant flow gases velocity distribution on gas diffusion layer for eleven cell voltages from commercial analysis software. Fig.2 to Fig.12 shows the numerically analyzed results of the velocity distribution of reactant gases on gas diffusion layer at (0.4 0.45, 0.5, 0.55, 0.6, 0.65, 0.70, 0.75, 0.8, 0.85 and 0.9V) respectively.

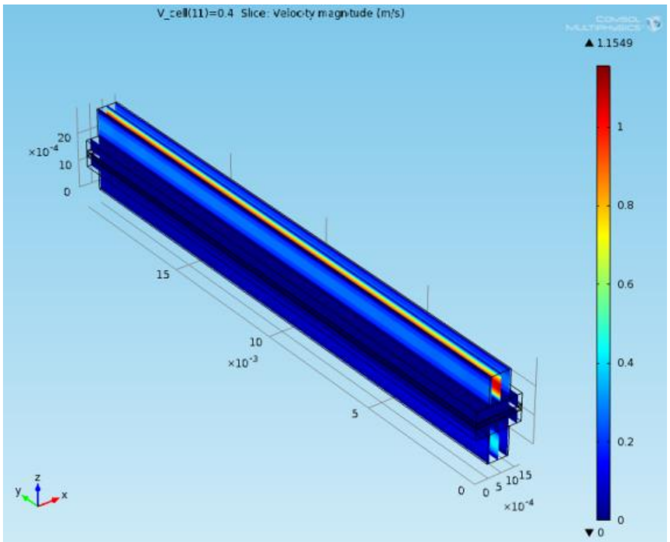

Fig.2. Reactant gases flow velocity at 0.4V

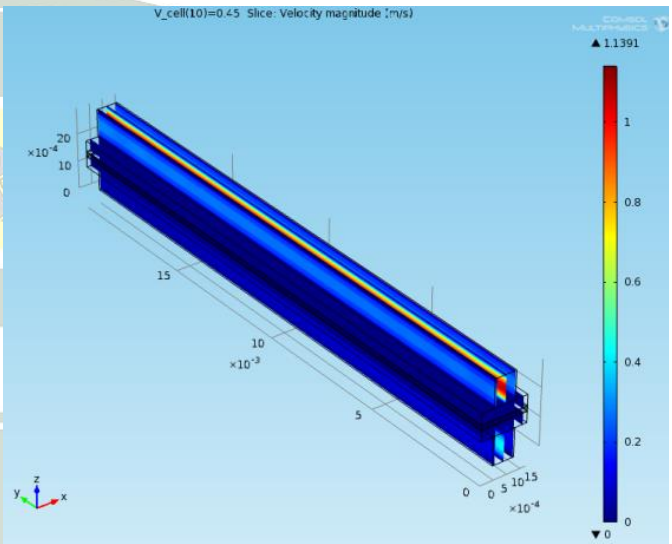

Fig.3. Reactant gases flow velocity at 0.45V

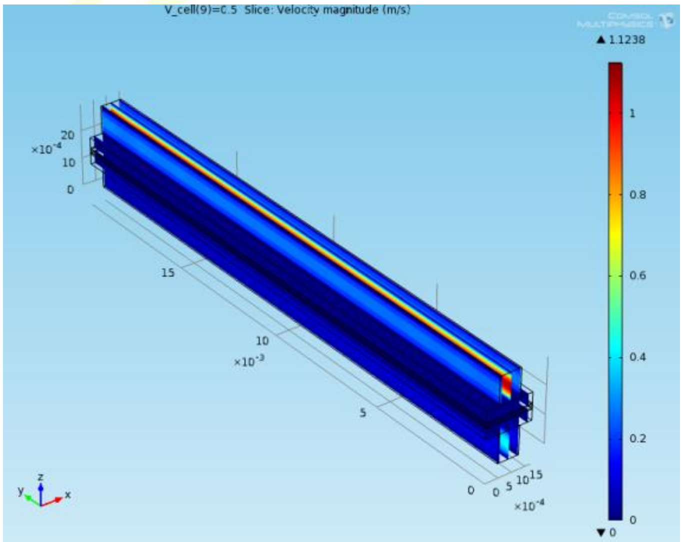

Fig.4. Reactant gases flow velocity at 0.5V

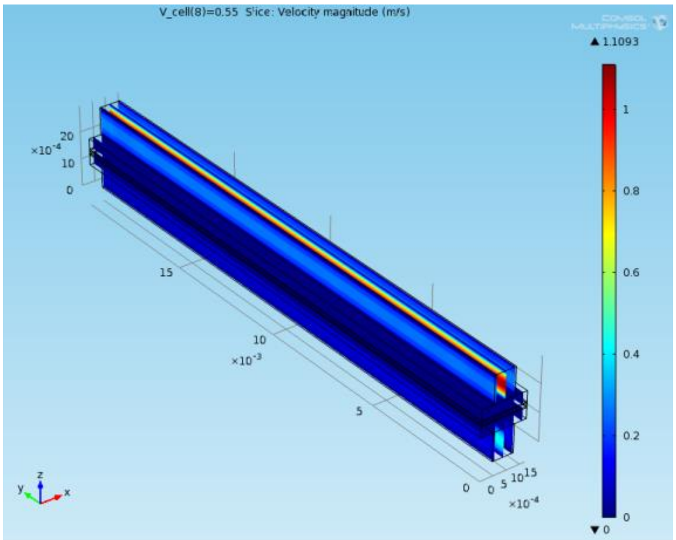

Fig.5. Reactant gases flow velocity at 0.55V

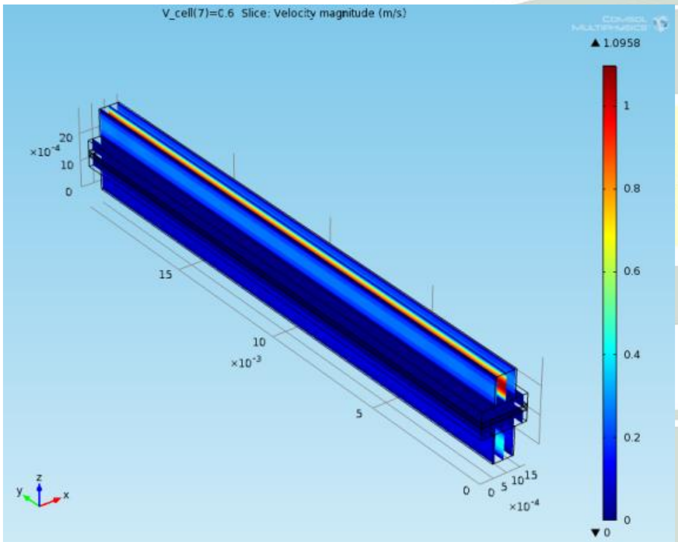

Fig.6. Reactant gases flow velocity at 0.6V

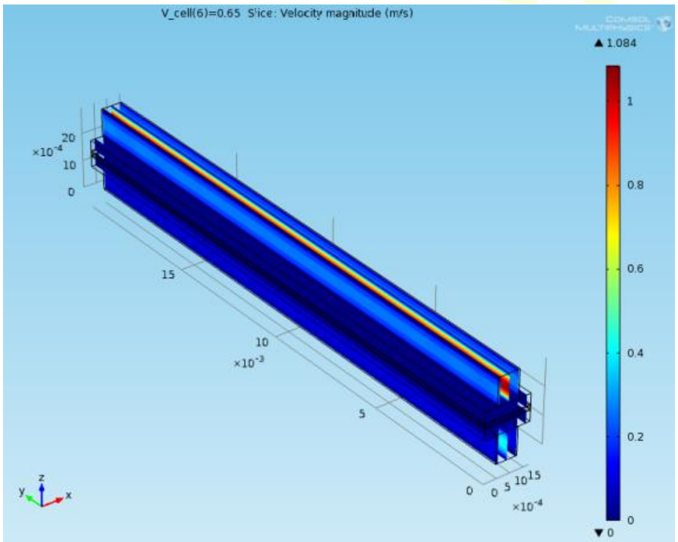

Fig.7. Reactant gases flow velocity at 0.65V

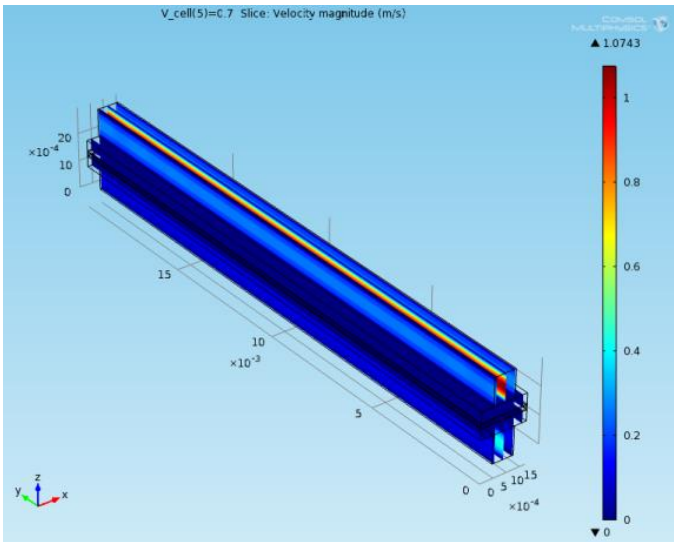

Fig.8. Reactant gases flow velocity at 0.7V

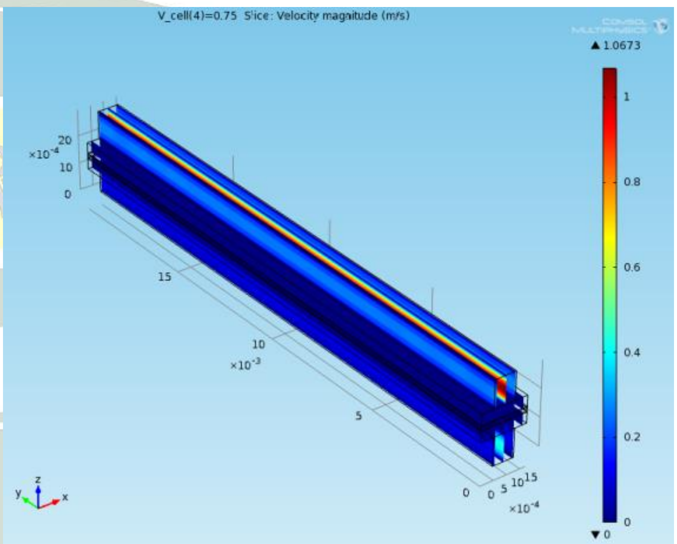

Fig.9. Reactant gases flow velocity at 0.75V

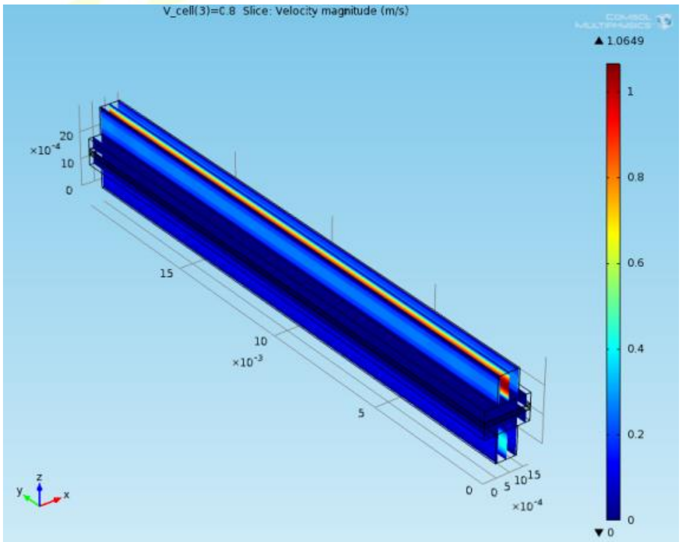

Fig.10. Reactant gases flow velocity at 0.8V

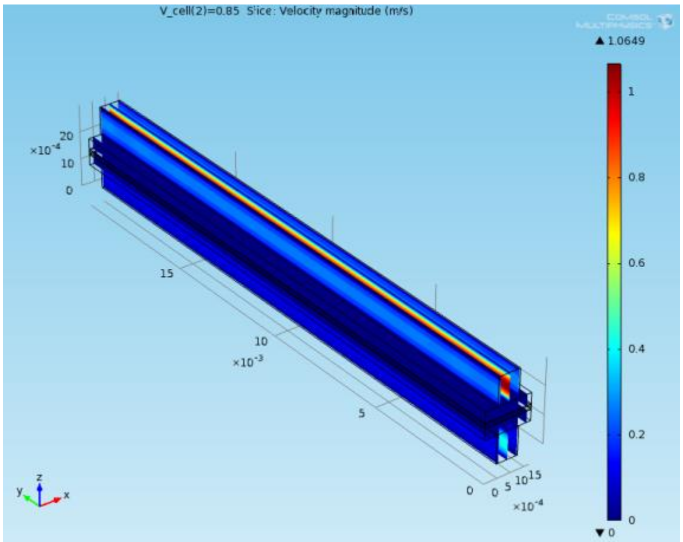

Fig.11. Reactant gases flow velocity at 0.85V

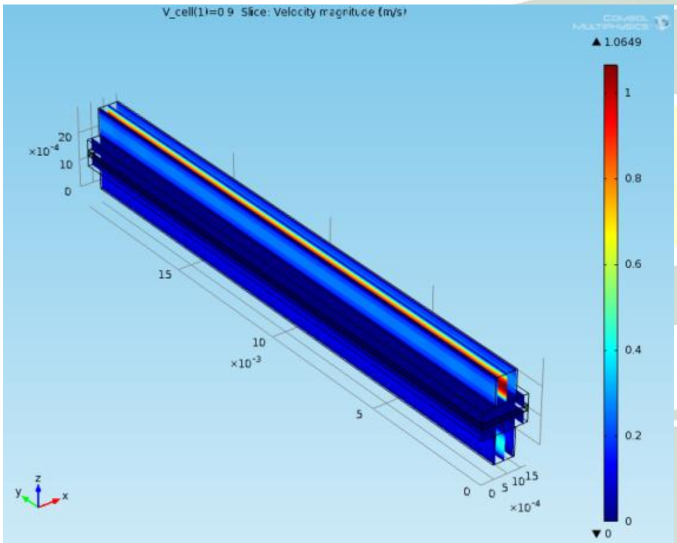

Fig.12. Reactant gases flow velocity at 0.9V

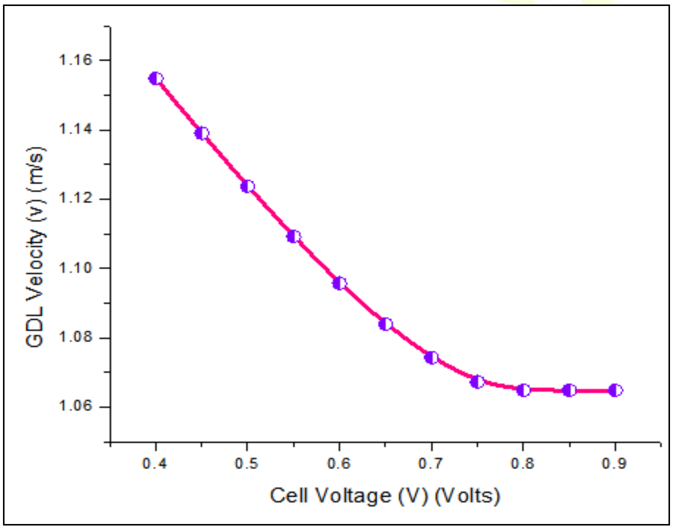

Fig.13. Effect of reactant gases velocity for all cell voltages

The PEM fuel cell with a cell voltage of 0.4V-0.9V yields the maximum reactant gases velocity distribution of 1.1549, 1.1391, 1.1238, 1.1093, 1.0958, 1.084, 1.0743, 1.0673, 1.0649, 1.0649, and 1.0649 m/s respectively. Fig.13 shows the reactant gases flow velocity for all cell voltages in PEM fuel cell. It also depicts the velocity distribution of reactants are gradually decreased with the increasing cell voltages.

VI. SUMMARY

In this analysis, PEM fuel cell with single flow channel configuration is selected for numerical analysis to investigate the effect of the velocity distribution of reactant gases on gas diffusion layer under eleven cell voltages. Different geometrical and operating parameters were considered and analyzed by using commercial analysis software. The numerical shows that the single flow channel PEM fuel cell with a cell voltage of 0.4V yields the maximum and better reactant gases flow velocity distribution (1.1549 m/s) on gas diffusion layer among the other ten cell voltages.

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