Single Flow Channel PEM Fuel Cell Performance Analysis for Various Cell Voltages

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***Abstract*— The design and operating parameters are the key factors which are influenced in fuel cell performance. The creation of water droplets on the gas diffusion layer enriches the resistance for flow reactants stuck between cathode and anode side. So as to resolve the above issues single flow channel PEM fuel cell is selected to look out its performance for different cell voltages in the same operating conditions. This numerical analysis shows that the PEM fuel cell with a cell voltage of 0.4V contributes the extreme current density of 0.8698 A/cm2 in the midst of other cell voltages.**

Keywords*— Single flow channel, PEM fuel cell, Current density, Cell voltage.)

I. Introduction

With an accretion acquaintance of ecology apropos and a admiration for action independence, the development of renewable and apple-pie action sources has become the focus of cogent analysis activity. Hydrogen will play a above role in accomplishing the all-around action demands in future. Fuel cell, acting as a transducer, absorbs action from hydrogen abridgement and evolves electrical action emerged as an ideal best for use in a wide range ability supplies. The PEMFCs are currently beneath accelerated development and affiance to become an economically applicable bartering ability antecedent in abounding areas, abnormally for transportation, stationary, carriageable and automobile applications, because of their top action body at low operating temperatures and aught emissions [1]. In this exertion, numerous discriminating issues of PEMFC innovation should be tended to. One of the key issues is the execution improvement of power module by mulling over the impact of different working and configuration parameters. Ideal stream rate was fundamental for shallow channel profundity to keep up adequate weight to constrain reactant into channel furthermore to have fitting water parity [2]. The 'flooding' of a gas diffusion layer is a phenomenon often observed when cell performance decreases at higher current densities [3-5]. Weng et al. [6] have developed a transparent proton exchange membrane fuel cell in order to visualize the distribution of water and water flooding inside the cathode gas channels. Gas distributor or flow field is the vital part of the PEM fuel cell which supplies fuel and removes reaction products. Moreover, the flow fields can affect the water flow and distribution within fuel cell [7-9]. Mainly, the cathode gas diffusion layer causes a decrease in performance of fuel cell when the process is mass transport limited. The liquid water formation from the electrochemical reaction results in water flooding of the porous media, especially the cathode gas diffusion layer, which obstructs the reactant gas that is flowing to the catalytic electrodes [10-12].

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 Fig. 2.

III. Design

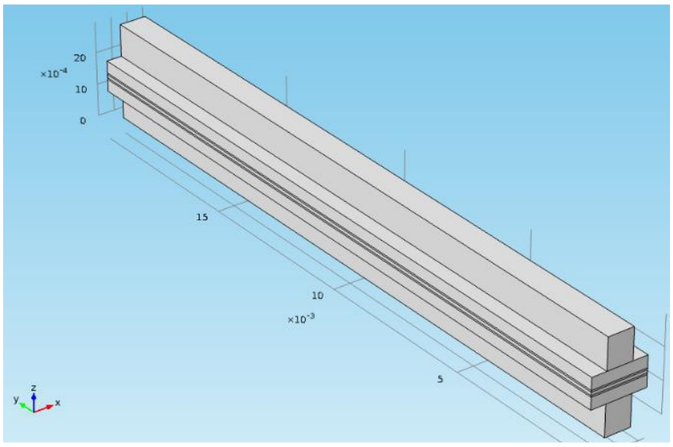

Fig. 1. Three dimensional model

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.

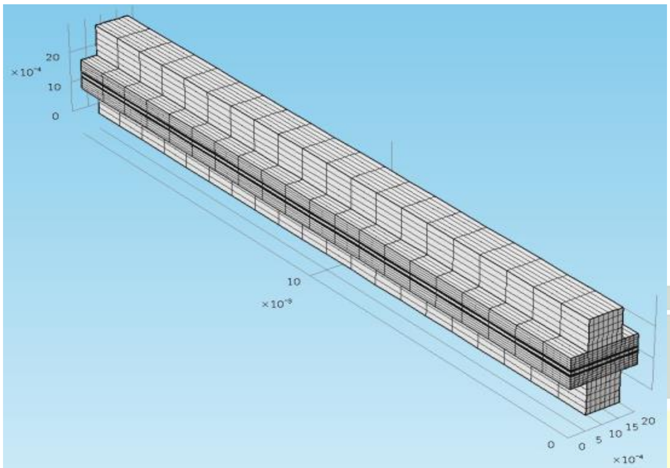

Fig. 2. Mesh model

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 H2O 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, N2-H2O binary diffusion coefficient, O2-N2 binary diffusion coefficient, O2-H2O 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

Fig.1 to Fig.11 depicts the numerically analyzed results of the membrane current density of Single Flow Channel PEM Fuel Cell for the eleven cell voltages likely 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 PEM fuel cell with a cell voltage from 0.4V to 0.9V yields the membrane current densities of 8698, 7252.5, 5848, 4509.5, 3269.7, 2170.6, 1267.1, 618.29, 245.69, 83.064 and 25.862 A/m2 respectively. Fig.12 shows the reactant gases flow velocity for all cell voltages in PEM fuel cell. It also depicts the membrane current densities of single flow channel PEM fuel cells are gradually decreased with the increasing cell voltages.

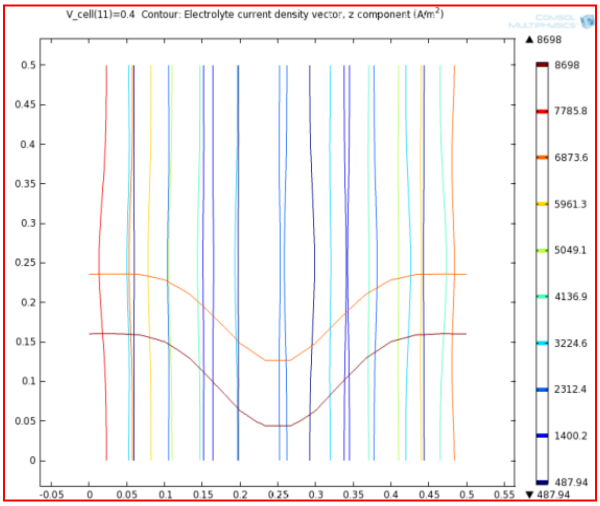

Fig. 3. Membrane current density at 0.4V

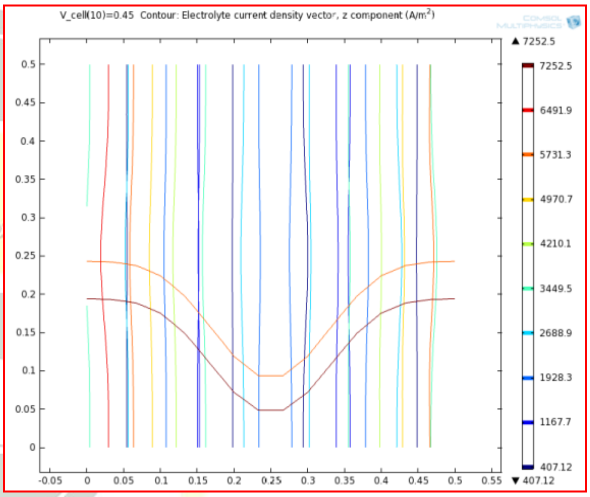

Fig. 4. Membrane current density at 0.45V

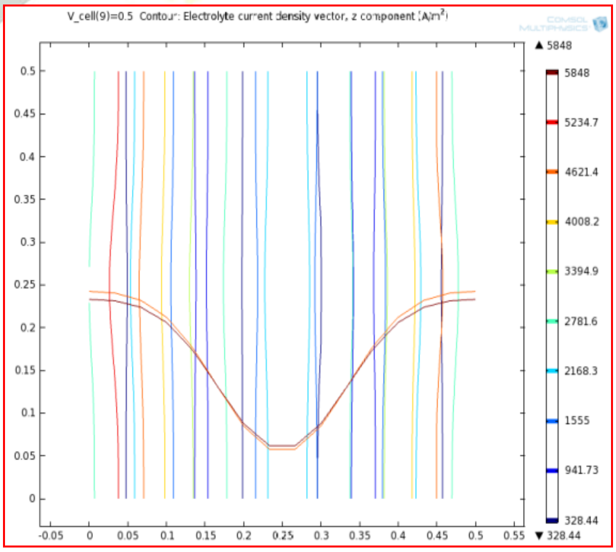

Fig. 5. Membrane current density at 0.5V

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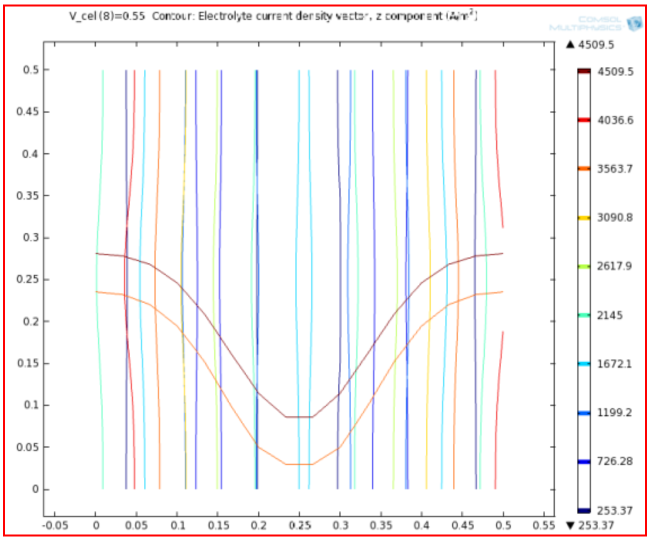

Fig. 6. Membrane current density at 0.55V

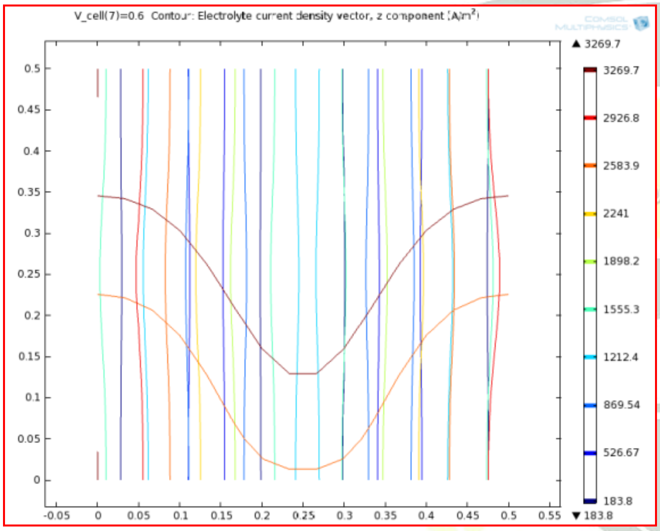

Fig. 7. Membrane current density at 0.6V

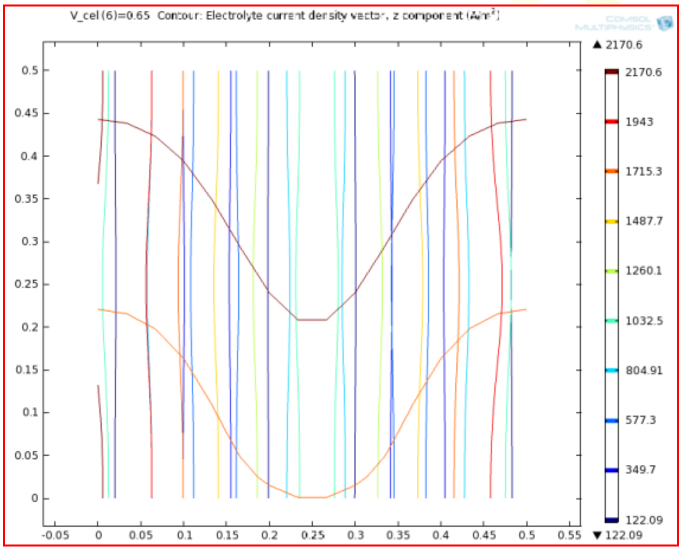

Fig. 8. Membrane current density at 0.65V

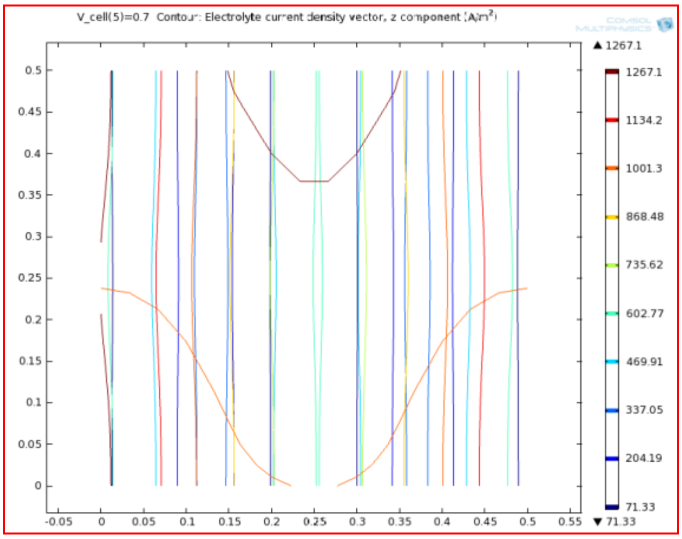

Fig. 9. Membrane current density at 0.7V

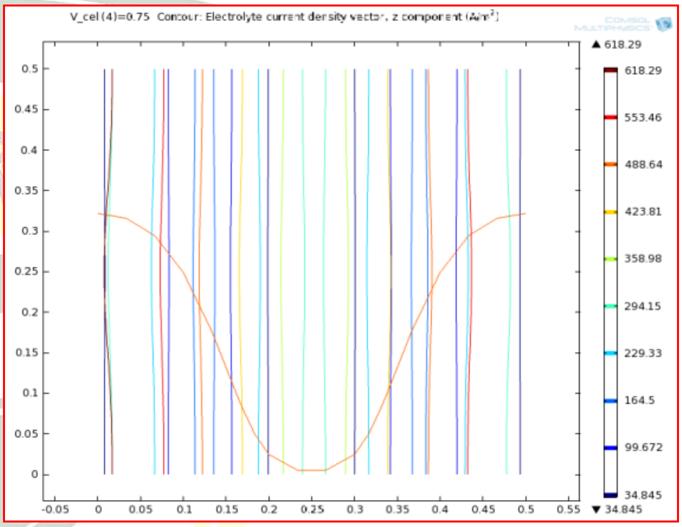

Fig. 10. Membrane current density at 0.75V

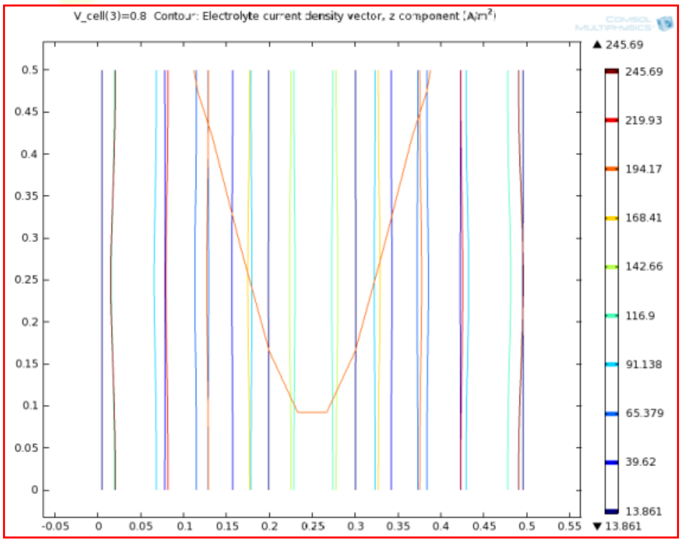

Fig. 11. Membrane current density at 0.8V

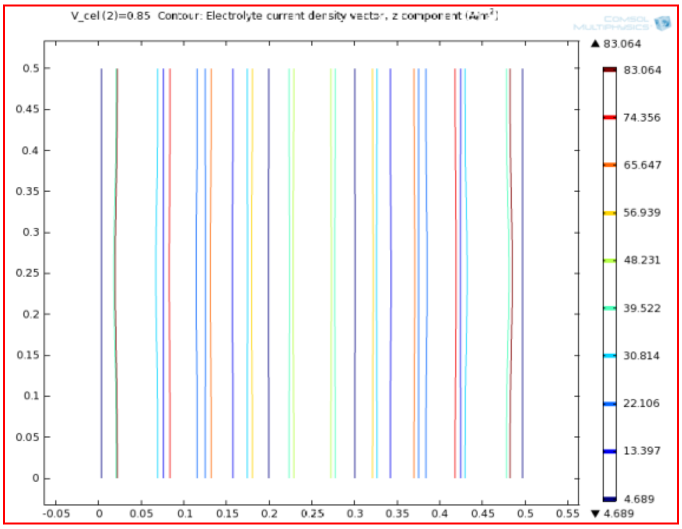

Fig. 12. Membrane current density at 0.85V

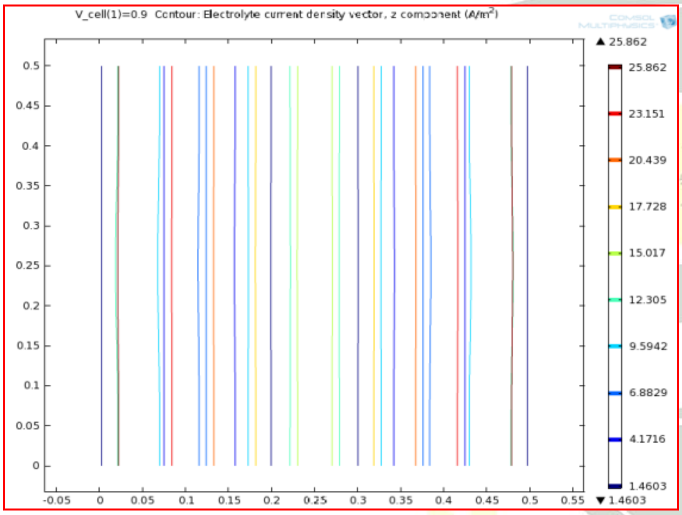

Fig. 13. Membrane current density at 0.9V

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