Reactant Gases Velocity Distribution on PEM Fuel Cell with Different Landing to Channel Width of Flow Channel

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***Abstract*—Proton Exchange Membrane Fuel Cell (PEMFC) is an encouraging power breeding device with great efficiency, zero emissions and operating at atmospheric temperature and pressure. Different operating parameters like cell voltage, open circuit voltage, lumped anode resistance, membrane resistance, cell temperature, oxygen reference concentration, gdl porosity, gdl permeability, inlet oxygen mass fraction (cathode), inlet hydrogen mass fraction (anode), inlet velocity, outlet velocity, fluid viscosity, and the design parameters like rib width, plate width, gdl height, channel length, channel height, channel width, membrane thickness, and gas diffusion layer thickness etc. are governing the performance of the fuel cell. In this analysis, the effects of reactant gases velocity distribution at gas diffusion layer for different landing to channel width of flow channel were analyzed numerically. The entire three-dimensional models of a proton exchange membrane fuel cell is modeled with a constant channel length of 100 mm and with dissimilar landing to channel width in mm of 0.5x0.5, 1x1, 1.5x1.5, 2x2. From the analyzed results, it was found that the PEMFC with landing to channel width of 2.0x2.0 mm yields better reactant gases velocity distribution at gas diffusion layer compared to other three designs. Also it numerical result shows that the smaller width of landing and channels are required for lower reactant gases velocity distribution at gas diffusion layer and smaller width of landing and channels are required for better reactant gases velocity distribution at gas diffusion layer**

Keywords*— PEMFC, Reactant gases velocity, Single flow channel, Landing to channel widt.

I. INTRODUCTION

The environmental contamination of the world is growing progressively due to the use of fossil fuels by the vehicles and some power breeding systems. So there is a compulsion to find out the replacement power sources. The fuel cells are one of the high well-organized power generating sources with zero/very low emissions [1]. The PEMFCs are presently under speedy development and potential to become an economically viable marketable power source in many areas, particularly for transportation, stationary, moveable and vehicle applications, because of their high power density at low operational temperatures and nil emissions [2]. The flow field is one of the vital constituents of a PEMFC, which assists as both the current collector and the reactant distributer. The reactants, as well as the products, are transported to and from the cell over the flow channels. The necessary requests for the flow field are identical scattering of reactants over the all-inclusive electrode surface and active exclusion of products from the cell, to abate the concentration polarization. To this end, dissimilar flow field formations, containing parallel, serpentine, interdigitated, and various other united varieties, have been established [3]. Finest flow rate was needed for narrow channel depth to preserve satisfactory pressure to force reactant into channel and also to have appropriate water equilibrium [4]. Flow channel dimensions and shape in the flow field of end plates in a single pass serpentine flow field

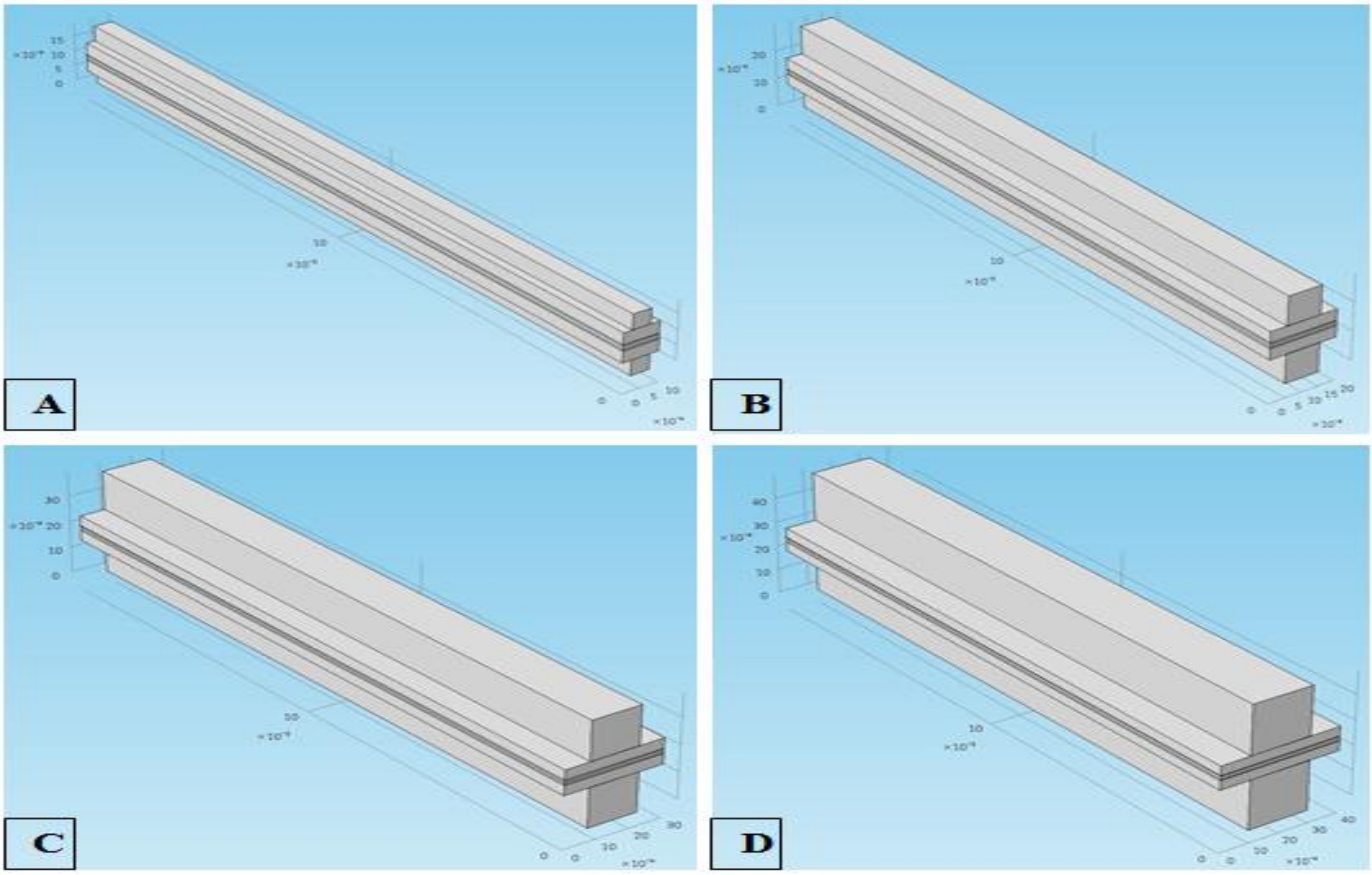

Fig. 1. Three dimensional model of (A) 0.5x0.5, (B) 1x1, (C) 1.5x1.5, (D) 2x2

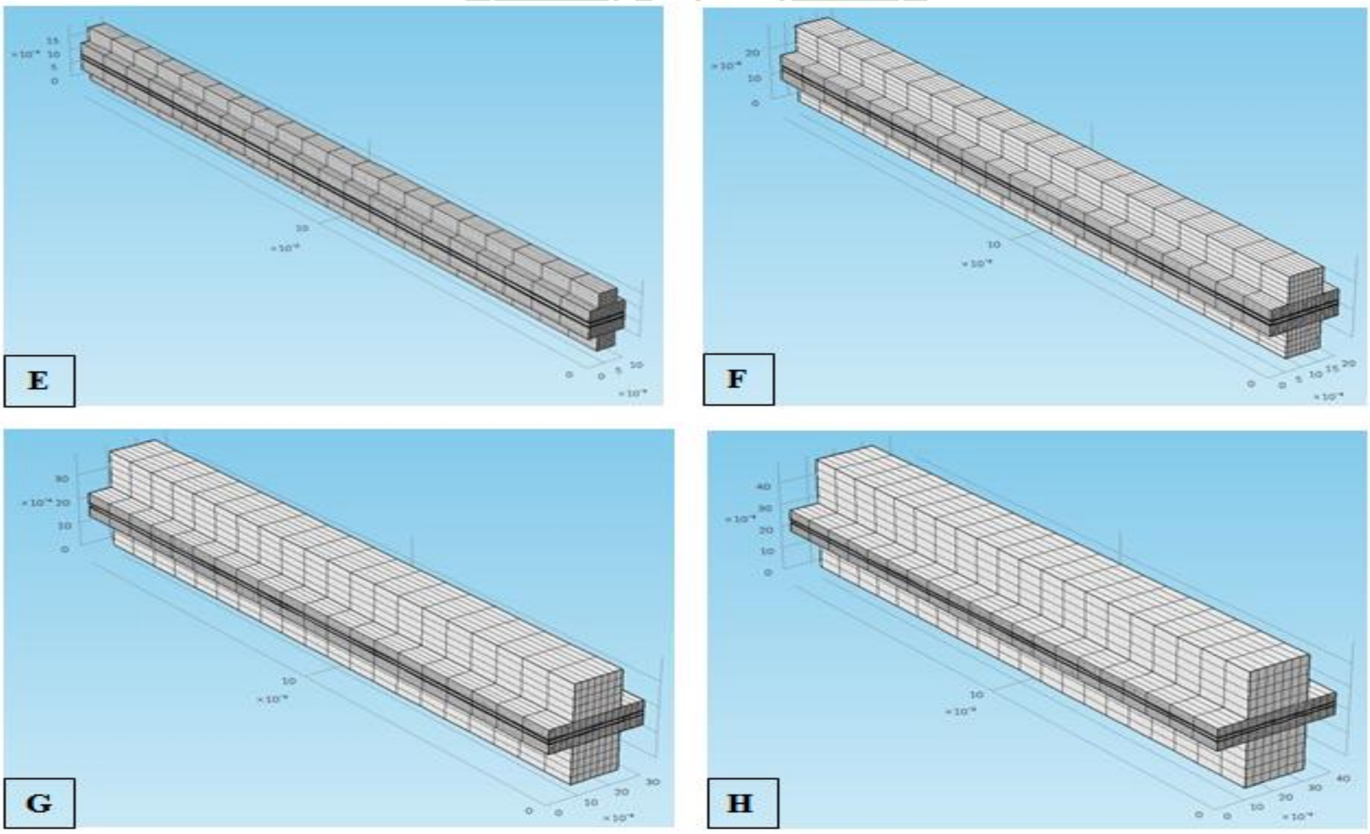

Fig. 2. Mesh model of (E) 0.5x0.5, (F) 1x1, (G) 1.5x1.5, (H) 2x2

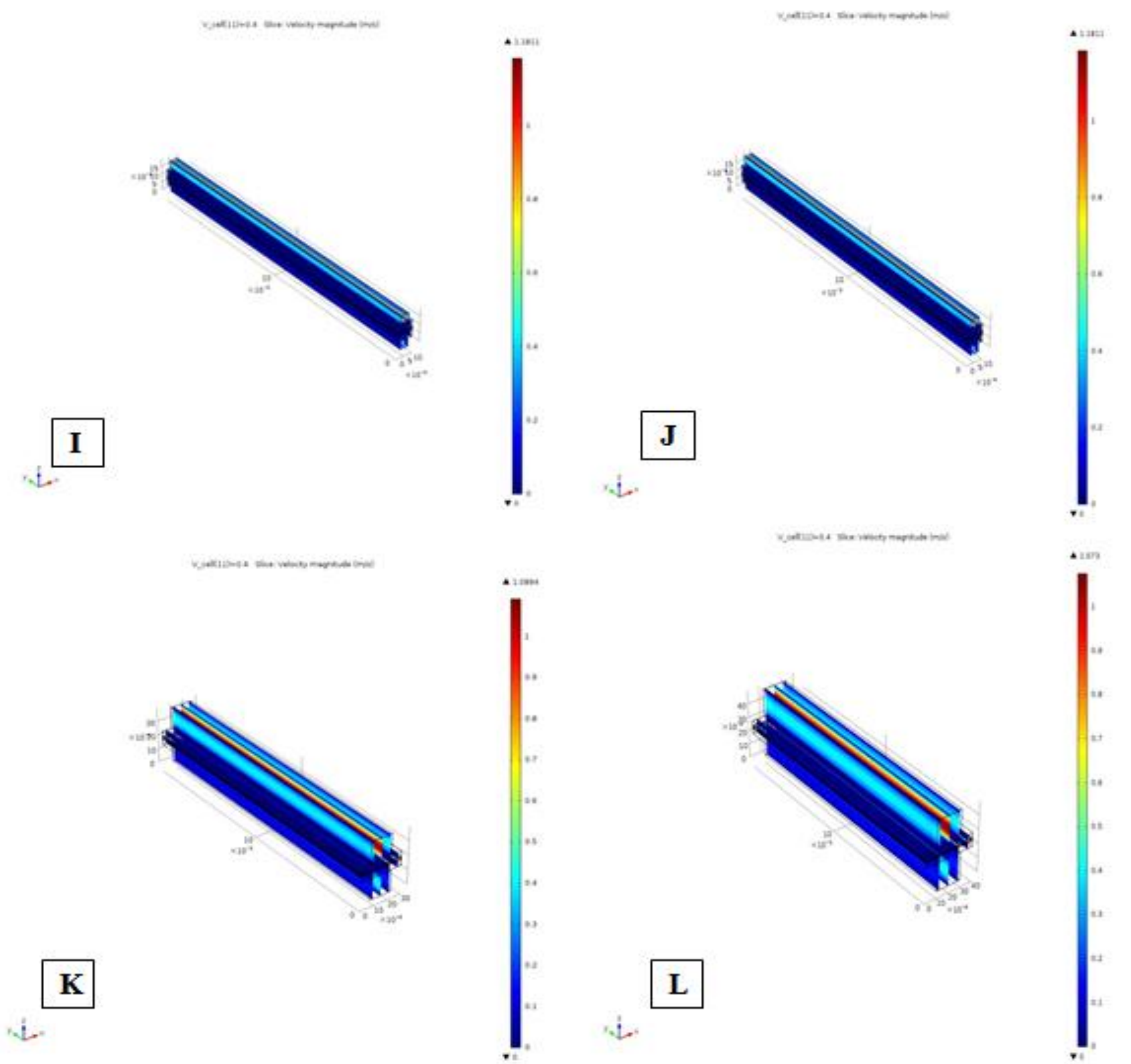

Fig. 3. Reactant gases velocity distribution at GDL of (I) 0.5x0.5, (J) 1x1, (K) 1.5x1.5, (L) 2x2

designs were optimized. The triangular and hemispherical shaped cross section lead to in 9% additional hydrogen ingestion in anode side, thus it can encouragement the boosted performance of the PEM fuel cell [5]. The foremost design viewpoint is established on the determination of an applicable pressure descent beside the flow channel so that all the liquid water in the cell is vaporized and detached from, or carried out of, the cell by the gas stream in the flow channel [6]. It has been agreed that the flow field design has a deterministic role on mass transportation and water managing, and thus great efforts have been made for the prime design of flow field such that high and steady cell performance can be succeeded [7,8]. Water flooding in the GDL that directly caused the concentration polarization and also the liquid water accumulated more rapidly under channel ribs with the increase in current density, because liquid water under ribs was harder to be expelled due to the longer transport route [9]. Consequently, augmenting convection over the GDL by enhancing the flow field is a real way to diminish water swamping at the cathode, improve the mass transport, and therefore improve together cell performance and operating constancy [10]. So in this analysis four different landing to channel width of flow channels were designed and analyzed under eleven cell voltages.

II. Modeling Of PEMFC

The complete three dimensional models of PEM fuel cell with four different landing to channel width were generated and investigated using commercial analysis software as shown in Fig.1 and also the complete mesh model for all four designs were shown in fig.2. A fuel cell with single straight flow channel of length 100 mm with square cross-section was considered. The landing area of the PEMFC is used for steering the electrons that generated during Hydrogen Oxidation Reaction (HOR), from anode side to the cathode side via external circuit. The channel area is used for flowing and dispensing of reactant gases on anode and cathode sides. The PEM fuel cell was consisting of seven layers. The seven layers under consideration were membrane, anode and cathode catalyst layers, anode and cathode Gas Diffusion Layers (GDL), anode and cathode flow channels. The complete three dimensional models construction started with the "PEMFC addition domains". By using "advanced description domains", the mandatory geometries were engendered with respect to the appropriate geometry factors (Length, height, width, etc.). The Cartesian coordinates were used to designate the complete geometry in the mandatory coordinate position. In conclusion the entire model had been created by reclaiming the data from design parameters table in the software.

III. RESULTS & DISCUSSIONS

The four models of PEM fuel cell with seven layers specifically membrane, anode and cathode catalyst layers, anode and cathode GDL, anode and cathode flow channels were functioned at the similar functional situations of 45°C temperature and 1.5 bar pressure. Initially the PEMFC with landing to channel width of 0.5x0.5 mm was engaged and evaluated at the directly above said operating conditions. The extreme reactant gases velocity distribution of 1.1811 mol/m3 was obtained corresponding to the cell potential of 0.4 V at a temperature 45°C. Subsequent the PEMFC with landing to channel width of 1x1 mm was taken. The great reactant gases velocity distribution of 1.1811 mol/m3 was attained corresponding to the cell potential of 0.4 V at a temperature 40ºC. Next the PEMFC with landing to channel width of 1.5x1.5 mm was taken. The concentrated reactant gases velocity distribution of 1.0894 mol/m3 was gained corresponding to the cell potential of 0.4 V at a temperature 40ºC. Finally the PEMFC with landing to channel width of 2x2 mm was taken. The maximum reactant gases velocity distribution of 1.0730 mol/m3 was acquired corresponding to the cell potential of 0.4 V at a temperature 40ºC. The corresponding better reactant gases velocity distribution was 1.0894 mol/m3. An effective reactant gases velocity distribution for all four designs corresponding to the cell potential of 0.4 V at a temperature 40ºC were demonstrated in Fig.3.

IV. SUMMARY

The complete three dimensional representations of proton exchange membrane fuel cell with four dissimilar landing to channel width were numerically evaluated using commercial existing software platform to find out the effect of landing to channel width on the effective reactant gases velocity distributions of PEMFC. The landing width and the channel width of 0.5x0.5, 1x1, 1.5x1.5 and 2x2 mm were taken into account for this analysis. Except for the channel deepness, landing and channel width, completely other design parameters and the operating parameters were retained persistent for all the designs. From the reactant gases velocity distribution values achieved corresponding to the cell potential from the analysis, the effect of velocity were drawn for all the designs. From the results, it can be concluded that the PEMFC with landing to channel width of 1.5 x 1.5 mm has shaped the better reactant gases velocity distribution of 1.0894 mol/m3 compared to other three designs. Even if the dynamic areas of other designs were additional, the effectiveness of the systems was less. Due to the superior water managing, the performance of the 0.1.5x1.5 mm design is better than former design. Also it was found that the peak reactant gases values of all four designs were acquired corresponding to the cell voltage of 0.4 V.

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