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Effect of flow channel design on the performance of fuel cell - review

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Abstract: Flow channel is the main component of proton exchange membrane (PEM) fuel cell. It is also called as flow field plate. They distribute the fuel towards the gas diffusion layer (GDL) with a help of flow channel which spread the fuel all over the area of gas diffusion layer (GDL). The flow channel can be designed in different types, this result in various types of flow inside the flow channel which produces various amount of watt around the work area. This paper revises about various types of flow channel design, and also concludes with the best way of design to develop a flow channel.

Key words –PEM, Flow channel, GDL, fuel, design.

I. INTRODUCTION

The environmental pollution of the world is increasing day by day due to the use of fossil fuels by theautomobiles and some power generating systems. So there is a necessity to find out the alternate power sources. Thefuel cells are one of the high efficient power generating sources with zero/very low emissions.Fuel cell is anelectrochemical device which converts chemical energy of fuel into electricity, heat and water. Due to theexothermic reactions, heat is generated from the fuel cell. Based on the operating temperature, fuel cells areclassified into low, medium and high temperature fuel cells. Compared to all other fuel cells, the Proton ExchangeMembrane fuel cells (PEMFC) are having high efficiency and working at atmospheric temperature and pressure.The Hydrogen Oxidation Reaction (HOR) is carried out in the anode side and Oxygen Reduction Reaction (ORR) iscarried out in cathode side as follows in the proton exchange membrane fuel cell.

Anode side: $H_2 \rightarrow 2H^+ + 2e-$ (1)

Cathode side: $2H+ + 2e- + ½\ O_2 \rightarrow H_2O$ (2)

Overall reaction:

$H_2 + ½O_2 \rightarrow H_2O$ + Electricity + Heat (3)

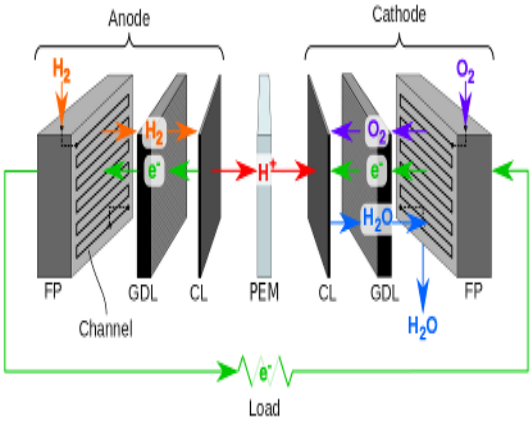

Fig. 1 Arrangement of PEM fuel cell

II. LITERATURESURVEY

1) Toghyani et al. made a study on different five flow field patterns like parallel, single path serpentine, dual path serpentine, triple path serpentine and quadruple path serpentine and concluded that serpentine flow field provide better distribution of current density and also indicates that 2-path patterns is relatively advantageous in terms of pressure drop. [12]

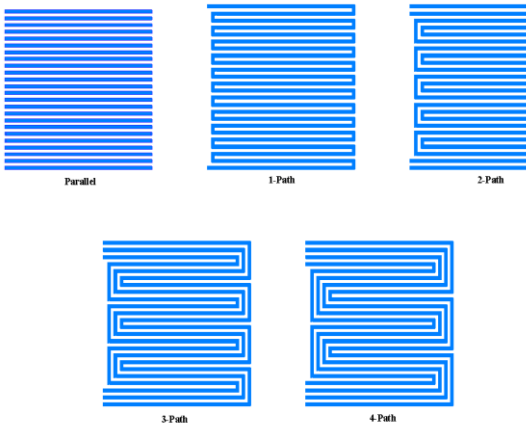

Fig. 2 Different flow field patterns [12]

2) Alizadeh et al. discovered that the distribution of gases in PEMFC plays a pivotal role in current density, temperature distribution and water management. They introduced a new cascade type serpentine flow field and the result shows that the flow field produces a uniform current density and also water management is improved. [2]

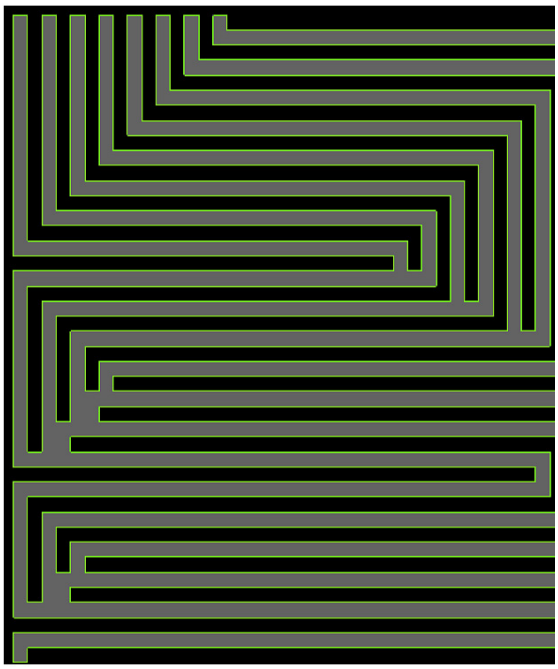

Fig. 3 Cascade type serpentine flow field [2]

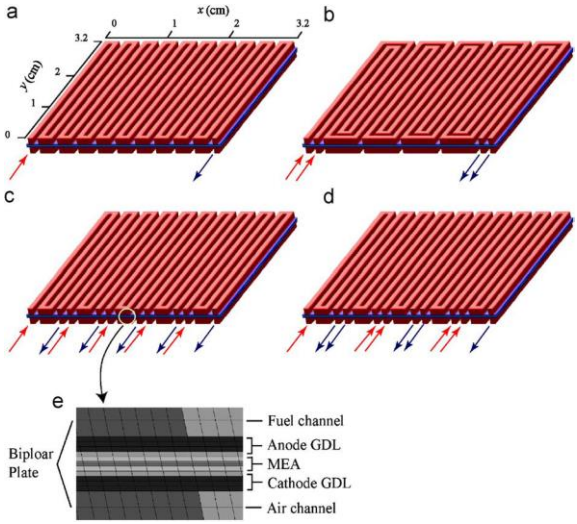

Fig. 4(a) single channel flow-field; (b) double channel flow-field; (c) cyclic-singlechannel flow-field; (d) symmetric-single channel flow-field; (e) the detailed schematic ofcomputational domain.[3]

3) Jeon et al. have discovered that the twofold channel stream field was anticipated to have better polarization execution and uniform current density at high delta sickness. They concluded that the cyclic single channel and symmetric single channel stream field would have advantage for substantial scale framework at low gulf moistness. [3]

4) Rahimi-Esbo et al. have made seven flow fields which are 1-Serpentine, 2-Serpentine, 3-Serpentine, 2-1-Serpentine, 3-2-Serpentine, 4-3-Serpentine and 5-4-Serpentine. Their result shows that 2-1-Serpentine flow field has the highest performance especially at high current densities and found that operating voltages are over 0.5V. [10]

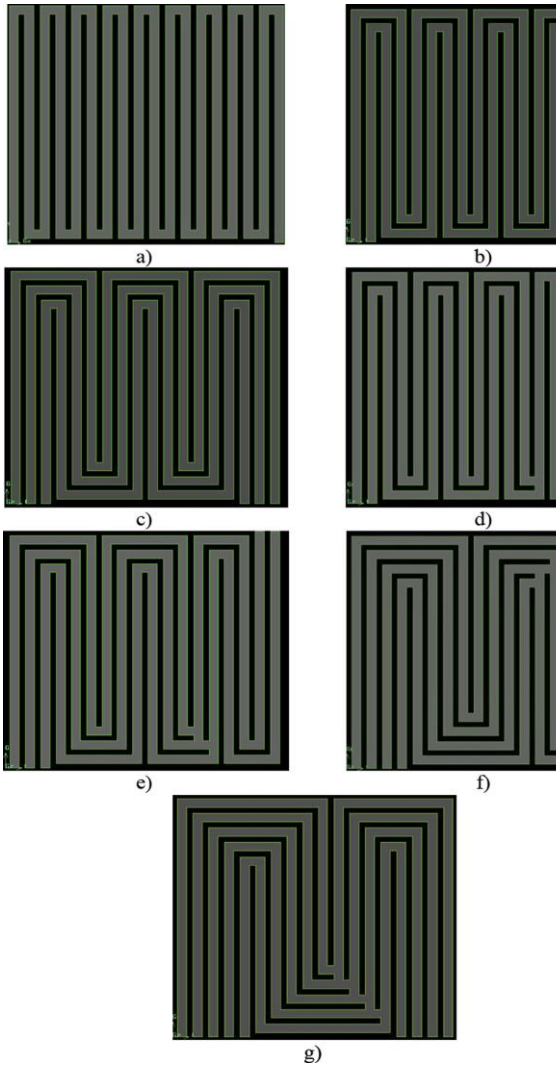

Fig. 5 (a) 1-Serpentine: (b) 2-Serpentine: (c) 3-Serpentine: (d) 2-1-Serpentine: (e) 3-2-Serpentine: (f) 4-3-Serpentine: (g) 5-4-Serpentine. [10]

5) Yupeng Yang et al. have discovered three flow fields which are parallel, serpentine and interdigitated. The result shows that interdigitated flow field has most stable cell performance under both constant pressure and swing supply nodes. [13]

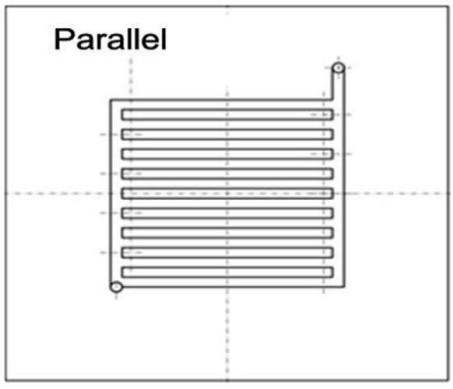

Fig. 6 Parallel flow field[13]

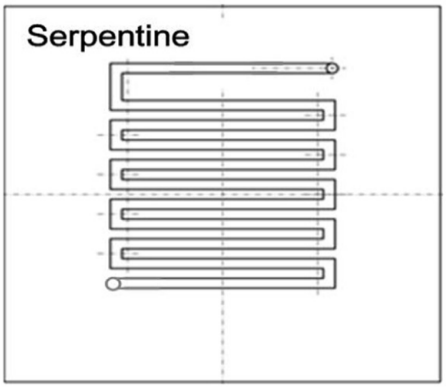

Fig. 7 Serpentine flow field[13]

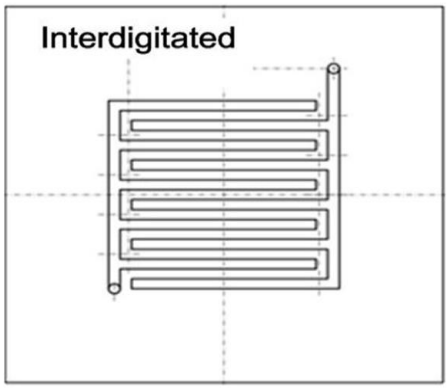

Fig. 8Interdigitated flow field.[13]

6) Afshari et al. havemade three type of flow channels which are Two parallel flow channels, Locally baffle restricted flow channels and Metal foam as a flow distributor. Theresult shows that metal foamincreases oxygen concentration and current density. [1]

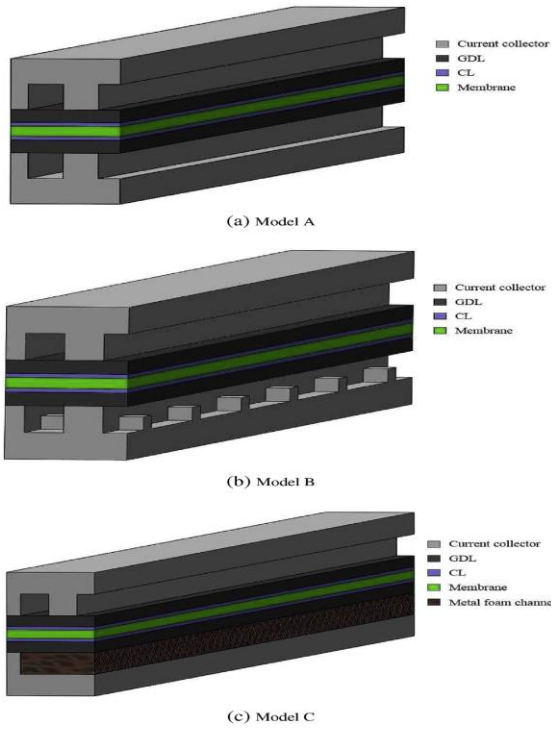

Fig. 9Two parallel flow channels, (b) Locally baffle restricted flow channels and (c) Metal foam as a flow distributor. [1]

7) TamerabetMonsaf et al. have made a spiral flow field design. Their result shows that spiral flow field influences the cell performance andmakeshigher contact area between channel and GDL. [11]

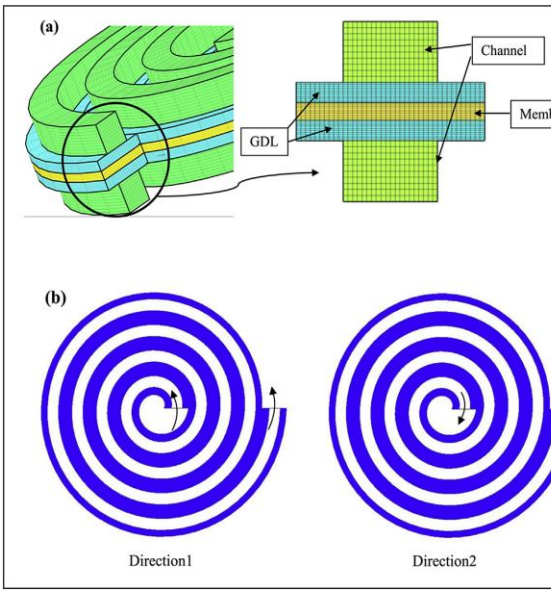

Fig. 10(a) Three-dimensional computational domain, (b) gas flow directions. [11]

8) MoosaAshrafi, Mehrzad Shams in their research, proposed a 3D numerical model based on VOF method. They simulated the effort of gravity on the gas-liquid two-phase flow in a full-scale single-serpentine flow-field. The result shows that horizontally located channels having inlet manifold embedded on upper side of the flow field and the pressure drop on the lower side is better than other models. [6]

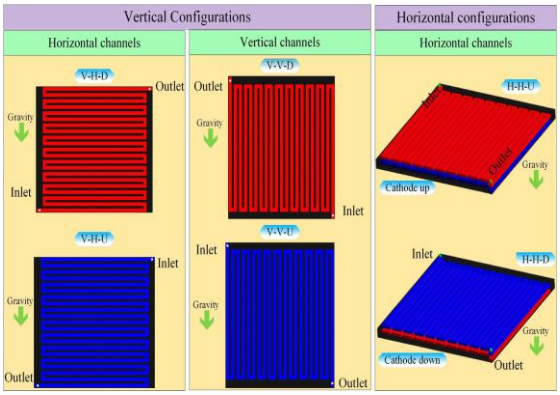

Fig. 11 Effort on water management. [6]

9) Muthukumar et al. discoveredthat among the various flow fields the serpentine flow field gives better performance. And also result shows that 2, 3 and 4 pass serpentine flow field yield almost same density.[7]

10) Muthukumar et al. created models with different flow field channel cross-section like Rectangular, Trapezoidal, Triangular and Semicircular. From the comparison of all types of flow channels the Rectangular cross-section has better performance.[8]

11) Karthikeyan et al. analyzed a serpentine flow channel with Zigzag and Uniform positioned carbon inserted on cathode flow plate. The result shows that carbon inserted on cathode flow gives better performances. [4]

12) Karthikeyan et al. in his paper they created a numerical model of single channel PEM fuel cell in which design and operation are carried out using Taguchi method and result shows power density is increased.[5]

13) Muthukumar et al. developed a three dimensional model of PEM fuel cell with different Landing to Channel width (LxC) in mm of 0.05 x 0.5, 1x1, 1.5x1.5 and 2x2. Result shows that channel width of 0.5x0.5 mm has produced the better performance with high power density and smaller width is used for high current.[9]

III. CONCLUSION

The flow channel is mainly affecting the performance of fuel cell. It is concluded that serpentine flow channel design is the most preferred flow design created by theengineers. In the various types of serpentine flow the two way path flow channel has more sufficient energy compared to other path flow like 1 path, 3 path, 4 path, 5path and zig-zag path.

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