A Technical Review on PEM Fuel Cell

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Abstract— Proton Exchange Membrane fuel cell (PEMFC) is a power generating device with high efficiency, zero emissions and working at atmospheric temperature and pressure. The Proton Exchange Membrane (PEM) Fuel cells is producing power without spoiling the environment. In this paper, the parameters influencing the performance of PEM fuel cell are viewed reviewd from various sources. The performance of the fuel cell is highly influenced by the operating parameters like temperature, pressure, humidity and mass flow rates of reactant gases; and the design parameters like flow channel designs and dimensions, rib size, channel length, thickness and porosity of GDL, membrane type etc. It is concluded that the controlling of flow field design and operating parameters can improve the performances of PEM fuel cell.

Key words: PEM Fuel Cell, Power, Performance, Channel Design

I. INTRODUCTION

Proton exchange membrane fuel cells, also known as polymer electrolyte membrane fuel cells (PEMFC). It is a device which is used to convert the chemical energy into electrical energy. It consists of membranes and electro catalyst which are the main components of PEM fuel cell. Increasing the fuel cell power is the major problem, because the operating conditions and the flow channel geometries cause the performance of the PEM fuel cell. Due to their light weight, PEMFCs are most suited for transportation applications. PEMFCs used in automobiles as condensed hydrogen for fuel, which can operate at up to 40% efficiency. Generally PEMFC's are implemented in buses over smaller cars because of the available volume to house the system and store the petroleum.

II. LITERATURE SURVEY

A. Performance by Operating Parameters

Tetsuro Kariya et al.[1] investigated the effects of the porous structures in the porous flow field type separators on fuel cell performances. Due to this investigation Separator-B-partition and Separator-C-groove, developed porous flow field type Separator-D-network with finely dispersed space networks by utilizing the mixture of alloy powders and binders in its fabrication process demonstrated excellent performances for both lower pressure loss and higher power densities.Separator-D-network are considered to have a great potential for the development of high-performance fuel cell in future.

Suthida Authayanuna et al.[2] Studied the effect of water transport on the electrical performance of PEM fuel cell . results show that the performance of PEMFC can be improved when increasing operating temperatures and fuel and air humidity. Increasing the humidity of the fuel gas and air leads to a significant improvement of cell performance

Mozhdeh Noorkami et al.[3] investigated the Effect of temperature uncertainty on polymer electrolyte fuel cell performance.Result is temperature variation has the greatest effect at lower nominal operating temperatures and higher currents. Temperature will be the key parameter for determining PEFC performance and uncertainty in this parameter is reflected in the variability in the polarisation response .

Chen-Yu Chenav et al.[4] studied the behavior of a Proton Exchange Membrane Fuel Cell in Reformate of Gas.Using this study performance is influenced by the operation of current, concentration of nitrogen and the carbon monoxide concentration for a proton exchange membrane fuel cell which uses Pt/Ru as the anodic catalyst. the effect of nitrogen dilution enhances the poisoning effect of carbon monoxide in the reformate gas

Khazaee et al.[5] investigated the experimental and thermodynamics of a triangular channel geometry PEM fuel cell at different working conditions.This study is based on the increase in the inlet temperature of hydrogen and oxygen cell temperature and inlet pressure can enhance exergy efficiency and cell performances, and reduce the fuel cell irreversibility . When the flow rate of hydrogen increases, the irreversibility of the cell developed, but the exergy efficiency is at a peak value.

Jaydeep Deshpande et al.[6] investigated effect of Vibrations on Performance of Polymer Electrolyte Membrane Fuel Cells. from this it is explained important insights into performance predictions of fuel cell over its operational lifetime in impermanent units. In this method The assessment of gas leakage is a very crude estimation since it neglects throttling effects and internal energy of hydrogen and enthalpies.

Hamid Kazemi Esfeha et al.[7] discussed the Temperature Effect on Proton Exchange Membrane Fuel Cell Performance Part I: Modelling and Validation.From this performance analysis both anodic and cathodic over-potential have significant effect on modeling results but the effect of anode over-potential is much less than its cathode. anode over-potential has significant effect and cannot be omitted in the PEM fuel cell.

Hamid Kazemi Esfeha et al.[8] studied the temperature effect on Proton Exchange Membrane Fuel Cell Performance Part II: Parametric Study.From this study they found the rising in temperature decreases the concentration loses in all range of temperature but decreasing the activation over the potential upto 80°C. Effect of the partial pressures of reactant gases and electrochemical Pt surface areas of the cathode and anode layers on cell behavior.

Guo Li et.al [9] investigated the performance of Proton Exchange Membrane in the Presence of Mg21. From this investigation The injection of Mg2þ can decrease the voltage of fuel cell under the same current density. The voltage decreases with the increase of poisoned time and

Mg2þ concentration The power density decreases with the increasing of Mg2þ concentration over time.

Rodolfo Taccani and Nicola Zuliani [10] investigated the effect of flow field design on performances of high temperature PEM fuel cells.From this investication 5 step serpentine gives best performance also it induces an higher pressure drop transversely the cell. whilst using parallel channels the pressure drop is reduced but the performance decreases as the current density increases. Further performance improvement can be expected by optimizing the channel aspect ratio and the width of the ribs. A relatively low loss of performance with high CO content fuels was measured

Arvay et al.[11] studied the nature inspired flow field designs for proton exchange membrane fuel cell.By this study they found the nature inspired designs can show improved fuel cell performance over standard designs by promoting uniform gas distribution and reducing drop of pressure. This is true when nature inspired designs are used in combination with standard interdigitated designs. there is much more work to be done in the areas of design evaluation and new design creation of nature inspired flow field designs, they have tremendous potential to become the new standard for performance of the fuel cell, reliability and cost.

M.Muthukumaret et al.[12] investigated the numerical studies on PEM Fuel Cell with Different Landing to Channel Width of Flow Channel . The current density values were obtained and the polarization and power density curves were drawn While operating the fuel cell at different voltages. that the PEMFC with landing to channel width of 0.5 x 0.5 mm has produced the better performance with peak power density of 0.4473 W/cm2 and peak current density of 1.1183 A/cm2 compared to other three designs

Nattawut Jaruwasupanta Yottana Khunatorna [13] investigated the effects of difference flow channel designs on Proton Exchange Membrane Fuel Cell using 3-D Model.By this design of flow field on Proton Exchange Membrane Fuel Cell for distributions in gas reaction. The flow field design was studied the effects of channel configurations of flow field plates on the performance of a PEMFC. three-dimensional computational fluid dynamics (CFD) model was investigated the effects of serpentine flow channel designs on the performance of proton exchange membrane fuel cells.

M. Zerouala et al.[14] found the effect of gas flow velocity in the channels of consumption reactants in a fuel cell type (PEMFC). By this investigation, they found that the decreasing the rate of gas flow in the channels makes consumption of reagents more uniform. consumption of reagents increases behind the obstacle, but less reactive flow in the GDL. The residence time becomes shorter by increasing the speed of gas flow in the channels.

Yasser Ben Salah et al.[15] found the gas channel optimisation for PEM fuel cell using the lattice Boltzmann method.by this optimization that the rectangular channel offers the best removal of water characteristics under a moderate drop of pressure. While using hydrophilic gas channels, larger droplet is drawn up, which may produce better performances of fuel cell. Two channels containing the same cross-section areas, height and width are checked . unusual gas channel geometries for the PEM fuel cell have been compared by means of simulations help of a two-phase flow lattice Boltzmann method (LBM) scheme with large density difference.

III. OTHER ASPECTS

J.Marquis and M.-O.Coppens [16] analysed the achieving ultra-high platinum utilization via optimization of PEM fuel cell cathode catalyst layer microstructure.By this analysis hierarchical optimization can increase platinum utilization 30-fold over existing catalyst layer designs while maintaining power densities over0.35W/cm2. This paper presented results on the optimization of the cathode catalyst layer of a low-temperature PEM fuel cell with respect to the platinum utilization. catalyst layer microstructures of Careful control can significantly enhance cell performance.

Yogeshwar Sahai and Jia Ma [17] explained the advances in producing cost-effective direct boro hydride fuel cells and road to its commercialization .From this investigation a direct borohydride fuel cell (DBFC) converts chemical energy stored in borohydride ion (BH_4^-) and an oxidant directly into electricity by redox processes. The use of hydrogen peroxide as an oxidant is good for air deficient applications, such as for power in submarine or power in space.

Ju-hyeong Sima et al.[18] studied the hydrogen generation from solid-state NaBH4 particles using NaHCO3 agents for PEM fuel cell systems . Catalytic hydrolysis has been widely used to extract hydrogen from NaBH4 alkaline solution but is still problematic in terms of the catalyst durability and disposel of by product. NaHCO3 is a solution ,which used as a solution of catalytic to extract hydrogen from the NaBH4 solid particles stored in a reacting chamber.

Bruno G. Pollet et al.[19] explained about hydrogen south africa (HySA) systems competence centre, Aim , Goals ,technological achievement and breakthroughs .by this The Hydrogen South Africa (HySA) programme is based upon the beneficiation of the country's large Platinum Group Metal (PGM) resources. HySA Systems has delivered successfully and has advanced extremely well against their Business Plans since 2008.

Kaijie Lin et al.[20] presented a paper about active screen plasma nitriding of 316 stainless steel for the application of bipolar plates in protonexchange membrane of fuel cells. SS steel bipolar plates offer many advantages over the conventional graphite bipolar plate, As low material and fabrication costs, good mechanical behaviour and ease of mass production

Yousri M.A.Welaya et al.[21] briefly explaind about steam and partial oxidation reforming options for hydrogen production from fossil fuels for PEM fuel cells. From their investigation Natural gas appears to be the best fuel for hydrogen rich gas production due to its favorable composition of lower molecular weight compounds. paper presents a study for a 250 kW net electrical power PEM fuel cell system utilizing a partial oxidation in one case study and steam reformers in the second.

M.Zerouala et al.[22] produced the paper about numerical study of the effect of the inlet pressure and the height of gas channel on the distribution and consumption of reagents in a fuel cell (PEMFC).From this paper they explained about Proton exchange membrane fuel cell

(PEMFC) engines can potentially replace the internal combustion engine for transportation because they are all very clean, noiseless, energy efficient and modular having capable of start-up very quickly.Enhancing the inlet pressure will improve consumption of reagents and more homogeneous distribution

Yutaka Tabe et al.[23] studied the analysis of ice formation process in cathode catalyst layer of PEFC at cold start. From this study they explained higher startup densitiy of current, ice growing from the membrane place to the gas diffusion layer side and that this becomes more pronounced when increasing the current density. At higher current density, more ice is finally formed near the GDL side.

Abhishek Raj and Tariq Shamim [24] Investigated the effect of multidimensionality in PEM fuel cell.From this a computational investigation conducted to study the influence of multidimensional effects in modeling of PEM fuel cell. This is attained by developing two similar 2D and 3D models so as to attribute any variation in the results to the effect of multidimensional. The effect of multidimensionality is measured by using species difference in concentrations. result issue a significant influence of multidimensionality under some selected working conditions. Tough species, domains in the fuel cell model and operating conditions exhibiting multidimensional effects are identified by comparing the species concentration in lower and higher dimensional models.

K.T.Koshekov et al.[25] explained fuel cell diagnostics using identification of measurement Theory.From this theory The subjects under examination is the application of signal identification measurement theory for evaluation of fuel cell condition by electric noise signals containing components of stationary and nonstationary. It is important and enough to measure the temporal and probabilistic characteristics of electric fluctuations and noise.

IV. Conclusion

Literature survey is fully based on the investigation of PEM fuel cell. In this review paper we explored different aspects of PEM fuel cell. Rising in temperature has a positive effect on PEM fuel cell by decreasing the concentration losses in all experimental range (up to 120°C) but temperature only has positive effect on decreasing the activation overpotential up to 80°C. Increasing the humidity of the fuel gas and air leads to a significant improvement of cell performance because an increase in high water vapor causes the membrane to have more water content and higher gas diffusivity and membrane conductivity.

Further performance improvement can be expected optimizing the channel aspect ratio and the width of the ribs. A relatively low loss of performance with high CO content fuels was measured.

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