International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-8 Issue-9, July 2019

Analysis of Characteristics of Pem Fuel Cell

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Abstract*: *In present scenario non conventional energy sources plays an important role in various applications. This paper focuses on study of Proton Exchange Membrane (PEM) fuel cell and verification of its polarization characteristics by using "Matlab Simulation".

Index Terms: PEMFC, Fuel Cell, Matlab, Polarization Characteristics

I. INTRODUCTION

The essential requirement for the growth of economy globally and progress of the human beings is safe, clean, reliable and low cost energy supply. Over last couple of years in all developed and under-developing countries, electrical energy has become inevitable requirement. In future the energy and electricity demand will become tremendous and it has become critical to develop clean and sustainable energy sources. In a few years traditional mineral energy sources such as fossil fuels will be depleted and results serious problems on economic growth. Hence renewable energy sources play a vital role in energy power generation [1] - [3]. Fuel cell is a environmentally sound renewable energy source which reduces the reliance on fossil fuel. Fuel cell which is a electrochemical device uses air & hydrogen as its fuel. Because of zero emission potential, low temperature, high efficiency, long stack life and high power density Proton Exchange Membrane (PEM) fuel cells are more advantageous compared to other fuel cells. Fuel cell finds various applications in different fields. The input for the fuel cell is hydrogen and output is dc power at the stack. The three primary sources from which losses of fuel cells are originated are a) ohmic polarization, b) activation polarization, and c) concentration (mass transport) polarization curve which is shown in Fig.1 [4].In Fig.1 it is observed that there is nearly linear decrease in the cell voltage when there is increase in the load current, Hence there is a need to regulate the output voltage to obtain the desired value.

Revised Manuscript Received on July 09, 2019

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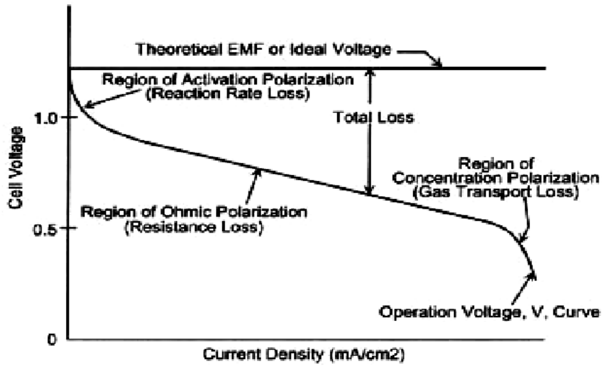

Fig1 Cell Voltage Vs Current Density

There is a need to control the parameters like humidity, pressure and temperature to get the polarization curve at a steady level [4].

II. PEM FUEL CELL'S POLARIZATION CHARACTERISTCS

The polarization characteristic of Fuel Cell is a curve which is obtained by plotting cell voltage versus current density. The primary sources from which the losses occurred are "Ohmic, Activation and Concentration losses."

A. Activation losses

The "activation losses" are non linear with current. Typically with increase in load current initially there will be a sudden drop in "open circuit EMF due to "activation losses". These losses occur due to chemical process has not started initially. "Activation losses" occurs only when current density and temperature of the fuel cell is low [4].

$$V_{FC} = E_{NERNST} - V_{act} - V_{ohmic} - V_{con}$$

Where, "E_{Nernst}" represents "thermodynamic potential" and "reversible voltage"; "V_{act}" represents"voltage drop" due to "the activation of the anode and cathode", "V_{ohmic}" represents "ohmic voltage" and "V_{con}" represents "voltage drop due to reduction in concentration of the reactants gases or, alternatively, from the transport of mass of oxygen and hydrogen". There is a need to take into account one more "voltage drop" related to "internal current and/or fuel crossover" even at no-load operation using a fixed current density[5].

B. Activation voltage drop

There will be variant consequences on the fuel cell "theoretical voltage" due to these losses. Initially the chemical process has not begun which results in activation loss. Thus there is necessary of activation energy to ensure that the "response is regarding the water and electricity formation, as opposed to the reverse".

$$Vact = N_0 \frac{RT}{2} \alpha F \ln \frac{Idc}{Io}$$

C. Ohmic voltage drop

In any electrical device the most common source of loss which can also be seen in the fuel cell is "Ohmic loss". These losses are due to the "resistance" for the "flow of electrons". These losses increases when there is increase in current[4]. "Ohmic losses" are considerable losses in both "low and high temperature fuel cells".

$$V_{ohmic} = I_{dc} R_{FC}$$

D. Cell reversible voltage

The Cell reversible voltage (E_{Nernst}) is the cell potential which has been acquired from an "open circuit thermodynamic balance" (without load).

This is given by,

$$E_{Nernst} = \frac{\Delta G}{2F} + \frac{\Delta S}{2F}(T - T_{ref}) + \frac{RT}{2F}[\ln(P_{H2}) + \frac{1}{2}\ln(P_{o2})]$$

In the above equation "**ΔG**" represents "free Gibbs energy change(J/mol)"; "**F**" represents "Faraday constant (96.487 C)"; "**ΔS**" represents "change of the entropy (J/mol)" "**R**" represents "universal constant of the gases (8.314 J/K.mol)"; whereas " PH2 and PO2" are the "partial pressures of hydrogen and oxygen (atm)", respectively.

III RESULTS AND DISCUSSION

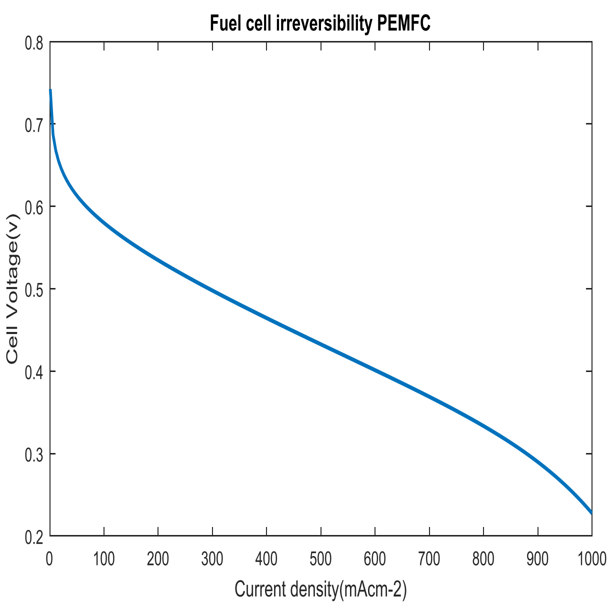

Fig 3.1. Cell Voltage vs Current density

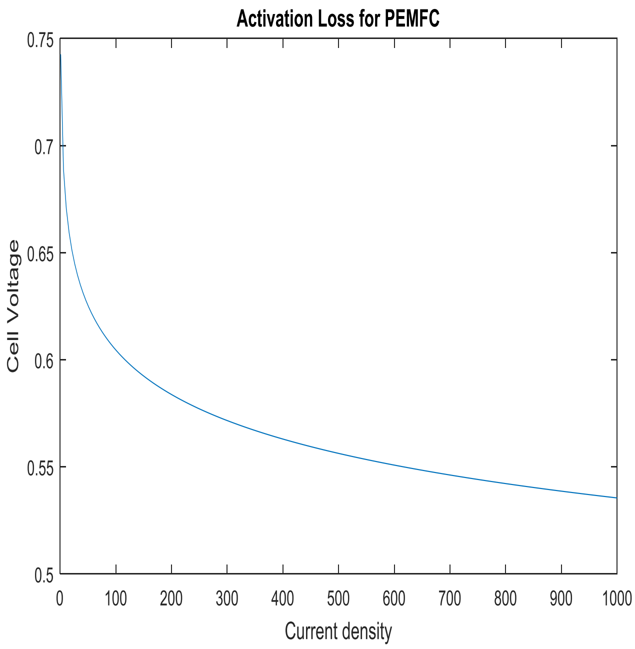

Fig 3.2. Activation Loss graph

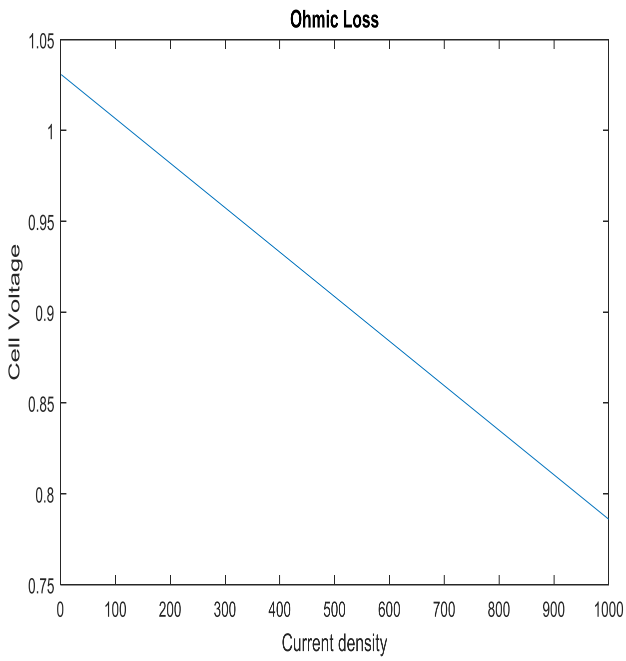

Fig 3.3 Ohmic Loss graph

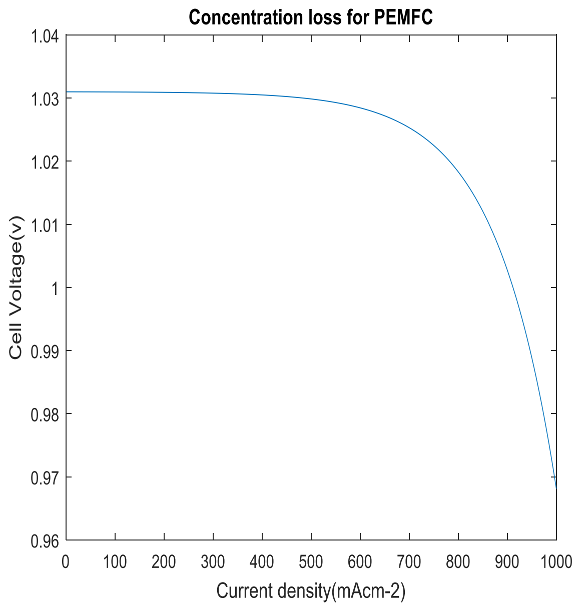

Fig 3.4 Concentration Loss graph

Figure 3.1 show that “a cell voltage reduces at a great rate by increasing the current density in case of low temperature fuel cells”.
Figure 3.2, activation loss graph shows that “losses can be reduced by operating the cell at higher value of current density” .
Figure 3.3 Ohmic loss graph shows that “cell voltage is linear to the current density”.
Figure 3.4 Concentration Loss graph shows that “the “cell voltage is constant around 600mAcm-2 and rapid drop as current density increase above 600mAcm-2”

IV. CONCLUSION

This paper analyses the characteristics of “PEMFC dynamic model” by applying “MATLAB”. Simulation is performed for various current density values, and is observed that “losses can be reduced by functioning the PEM fuel cell at higher current density”[6]. Further by varying the temperature of cell, electrodes roughness, concentration of reactant and pressure activation overvoltage can be reduced. This intern reduces the more activation loss and hence cell becomes more reliable. Reduction of internal resistance of fuel cell can be achieved “by using more conductivity electrodes, and using thin electrolyte” which reduces ohmic losses and efficiency of fuel cell can be improved.

REFERENCES

1. Aliasger Zaidy, Pooja Pokharkar, Rajesh Krishnan, Dayaram onawane, “Dynamic Modeling and Simulation of a PEM Fuel Cell: MATLAB and LabVIEW modeling approach”,2014 1st International Conference on Non Convential Energy,2014
2. http://www.eere.energy.gov/hydrogen and fuel cells
3. http://www.fuelcelltoday.com
4. Pratik H.Savasani: “Characteristics and Modelling of PEM Fuel Cell”Vol.2 Issue 9 September-2013
5. Koan-Yuh Chang: “The optimal design for PEMFC modeling based on Taguchi method and genetic algorithm neural networks”,International Journal of Hydrogen Energy,2011
6. Puranik,Sachin V,Ali Keyhani and Farshad Khorrami,”Neural Network Modeling of Proton Exchange Membrane Fuel Cell”,IEEE Transactions on Energy Conversion 2010.

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