

# Experimental study of different operating temperatures and pressure in PEM fuel cell

Sudhir Kumar Singh

M Tech, Bhabha Engineering and Research Institute Bhopal (M.P.)

Prof. S.S Pawar

Head. Department of mech engg. Bhabha Engineering and Research Institute, Bhopal (M.P.)

Email id: Narayan.sudhirsingh@gmail.com

**Abstract** :- This Paper also give the Various range parameter of temperature of using fuel cell and including current voltage power characteristic , uniformity of cell unit voltage, Gas, pressure impact and air flux impact operating temperature of fuel cell has been change in anode and cathode side. This paper also give the experimental approach of the fuel cell.

The effects of different operating parameters on the performance of proton exchange membrane (PEM) fuel cell have been studied experimentally using pure hydrogen on the anode side and air on the cathode side.

**Key words** : PEM fuel cell, anode material Cathode Material, Pressure Range,

**Introduction** : - Proton exchange membrane (PEM) fuel cells have been widely recognized as the most promising candidates for future power generating devices in the automotive, distributed power generation and portable electronic applications. The proton exchange membrane fuel cell (PEMFC) is of great interest in energy research field because of its potential application for direct conversion of chemical energy into electrical energy with high efficiency, high power density, low pollution and low operating temperature .

## Proton exchange membrane fuel cell Reactions

A stream of hydrogen is delivered to the anode side of the membrane electrode assembly (MEA). At the anode side it is catalytically split into protons and electrons. This oxidation half-cell reaction or Hydrogen Oxidation Reaction (HOR) is represented by:

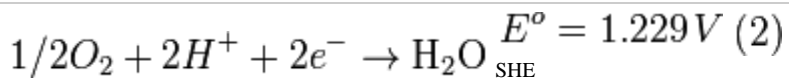
**At the Anode:**



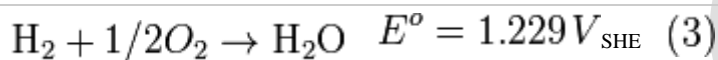
The newly formed protons permeate through the polymer electrolyte membrane to the cathode side. The electrons travel along an external load circuit to the cathode side of the MEA, thus creating the current output of

the fuel cell. Meanwhile, a stream of oxygen is delivered to the cathode side of the MEA. At the cathode side oxygen molecules react with the protons permeating through the polymer electrolyte membrane and the electrons arriving through the external circuit to form water molecules. This reduction half-cell reaction or oxygen reduction reaction (ORR) is represented by:

**At the cathode:**



**Overall reaction:**



The reversible reaction is expressed in the equation and shows the reincorporation of the hydrogen protons and electrons together with the oxygen molecule and the formation of one water molecule.

### **Polymer electrolyte membrane**

To function, the membrane must conduct hydrogen ions (protons) but not electrons as this would in effect "short circuit" the fuel cell. The membrane must also not allow either gas to pass to the other side of the cell, a problem known as gas crossover. Finally, the membrane must be resistant to the reducing environment at the cathode as well as the harsh oxidative environment at the anode.

Splitting of the hydrogen molecule is relatively easy by using a platinum catalyst. Unfortunately however, splitting the oxygen molecule is more difficult, and this causes significant electric losses. An appropriate catalyst material for this process has not been discovered, and platinum is the best option. One promising catalyst that uses far less expensive materials—iron, nitrogen, and carbon—has long been known to promote the necessary reactions, but at rates that are far too slow to be practical. Recently, a Canadian research institute has dramatically increased the performance of this type of iron-based catalyst. Their material produces 99 amperes per cubic centimeter at 0.8 volts, a key measurement of catalytic activity. That is 35 times better than the best no precious metal catalyst so far, and close to the Department of Energy's goal for fuel-cell catalysts: 130 A/cm<sup>3</sup>. It also matches the performance of typical platinum catalysts. The only problem at the moment is its durability because after only 100 hours of testing the reaction rate dropped to half. Another significant source of

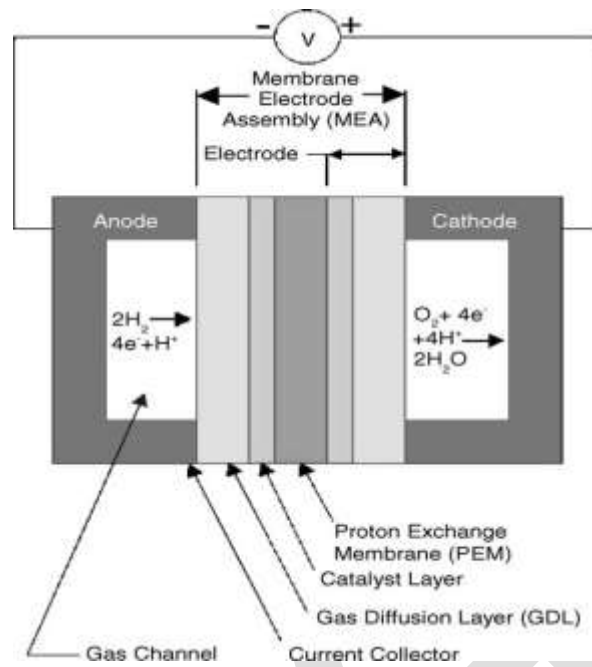
losses is the resistance of the membrane to proton flow, which is minimized by making it as thin as possible, on the order of 50  $\mu\text{m}$ .

## **Fuel cell applications**

- 1 Transportation
- 2 Distributed power generation
  - 2.1 Grid-connect applications
  - 2.2 Non-grid connect applications
- 3 Residential Power.
- 4 Portable Power
  - 4.1 Direct methanol fuel cells for portable power

Fuel cell systems operate without pollution when run on pure hydrogen, the only by-products being pure water and heat. When run on hydrogen-rich reformat gas mixtures, some harmful emissions result although they are less than those emitted by an internal combustion engine using conventional fossil fuels. To be fair, internal combustion engines that combust lean mixtures of hydrogen and air also result in extremely low pollution levels that derive mainly from the incidental burning of lubricating oil.

A PEM fuel cell is an electrochemical cell that is fed hydrogen, which is oxidized at the anode, and oxygen that is reduced at the cathode. The protons released during the oxidation of hydrogen are conducted through the proton exchange membrane to the cathode. Since the membrane is not electrically conductive, the electrons released from the hydrogen travel along the electrical detour provided and an electrical current is generated. These reactions and pathways are shown schematically in [Fig..1](#)



**Fig.1.**

**Experimental setup-** Experimental setup are the combination of two major plates such as , anode plates and cathode plates , which has been well design and construction with using parameter. A single unit cell with active surface area of  $7.4 \times 7.4$  c.m. was used for experiment in this study. The membrane electrode assembly (MEA) consists of a Nafion in combination with platinum loadings of  $0.4 \text{ mg/cm}^2$  per electrode. The gas diffusion layers are made of carbon fiber cloth. The MEA positioned between two graphite plates is pressed between two gold-plated copper plates. The graphite plates are grooved with serpentine gas channels. In the test station, reactant gases are humidified by passing through external water tanks. Regulating the water temperature controls the humidification of the reactant gases.

### Experimental procedure

The procedure for each experiment is as follows:

1. Power on the Fuel Cell Test Station and open the valves of the gas cylinders of hydrogen, oxygen.
2. Before starting experiments, purge the anode side with hydrogen to ensure no oxygen is present.
3. Set the experimental parameters of mass flow rate of the gas cylinders of hydrogen, oxygen.

4. Set the maximum voltage, minimum voltage and voltage increment step of the fuel cell polarization data by A meter and voltmeter
5. Set the delay between every two voltage and current data points



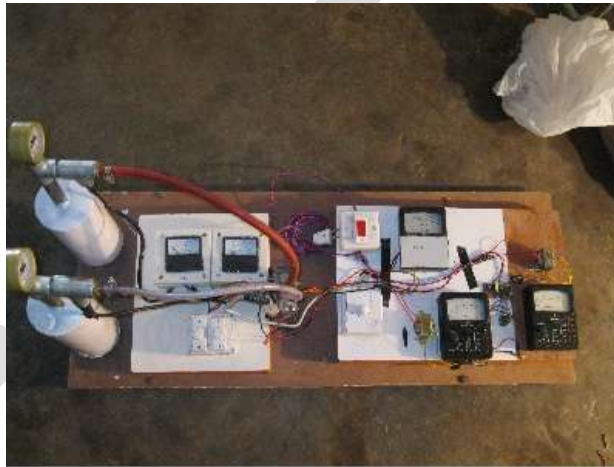
**Fig.2. Control pane**



**Fig.3. Pressure gauge**



**Fig.4. Connection pipe**



**Fig.5. Experimental zone**

## **Result and discussion-**

### **Effect of the humidification in plates**

When the anode humidification temperature is at 40°C, the current density of the fuel cell is the lowest at a given voltage. graph shows that the linear portion of the polarization curve for different anode humidification temperatures are almost parallel to each other, which indicates that the electrical resistance of the fuel cell causing the ohmic losses does not vary significantly.

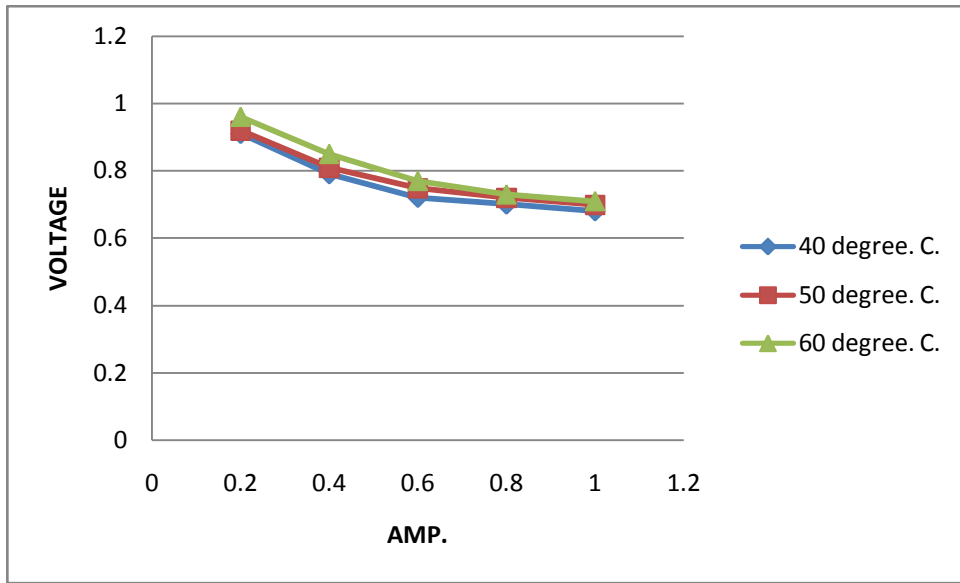
At low current densities, the lower the anode humidification temperature, the lower the cell voltage. This phenomenon could be explained by the decrease of the active catalyst surface area caused by lack of water in the catalyst layers. When the anode is dry, the water transfer through the membrane from the cathode side to the

anode side due to back-diffusion is dominant. This is even more pronounced at low current densities, when water transfer due to electro-osmosis is low.

The result of the combined effect is water deficiency in the cathode catalyst layer. At higher current densities, the cell voltages at different anode humidification temperatures come closer. This, again, could be explained by hydration of the catalyst layer. At high current densities, water generation rate is high and water transfer due to electro-osmosis is high. Thus the cathode catalyst layer is better hydrated even though the anode humidification is low

**Table .1.humidification temperature , hydrogen flow rates are 1.0 M<sup>3</sup>/Min. and Oxygen flow rates 2.0 M<sup>3</sup>/Min.**

Sr. No.	Current density (A/cm <sup>2</sup> )	Voltage at humidification temperature 40 Degree C	Voltage at humidification temperature 50 Degree C	Voltage at humidification temperature 60 Degree C
1	0.2	0.91	0.92	0.96
2	0.4	0.79	0.81	0.85
3	0.6	0.72	0.75	0.77
4	0.8	0.70	0.72	0.73
5	1.0	0.68	0.70	0.71



**Fig.6.**

**Table .2.humidification temperature , cathode sides and and hydrogen flow rates are 2.0 M<sup>3</sup>/Min. and Oxygen flow rates 4.0 M<sup>3</sup>/Min.**

Sr. No.	Current density (A/cm <sup>2</sup> )	Voltage at humidification temperature 40 Degree C	Voltage at humidification temperature 50 Degree C	Voltage at humidification temperature 60 Degree C
1	0.2	1.11	1.13	1.20
2	0.4	0.96	0.98	0.99
3	0.6	0.94	0.95	0.96
4	0.8	0.92	0.93	0.94
5	1.0	0.90	0.91	0.92



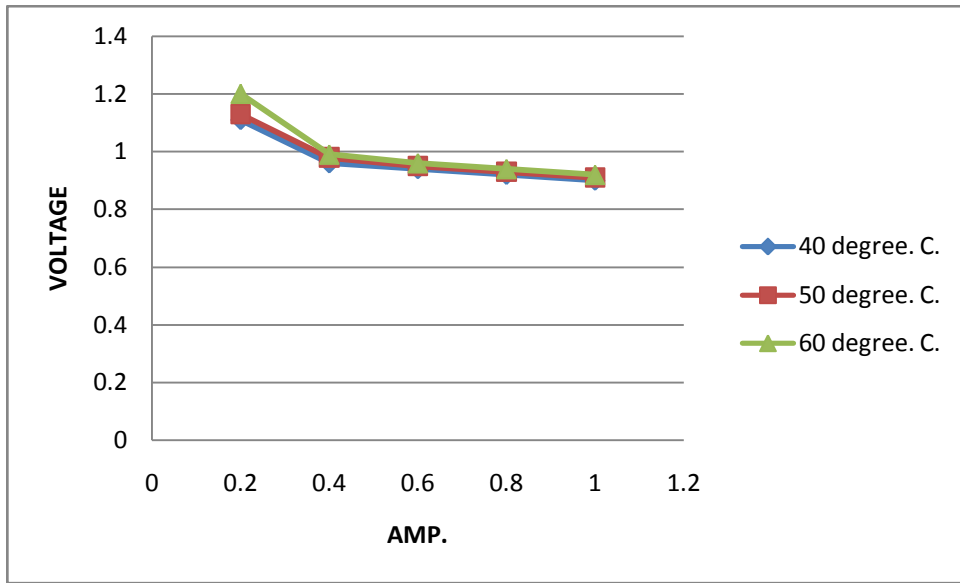
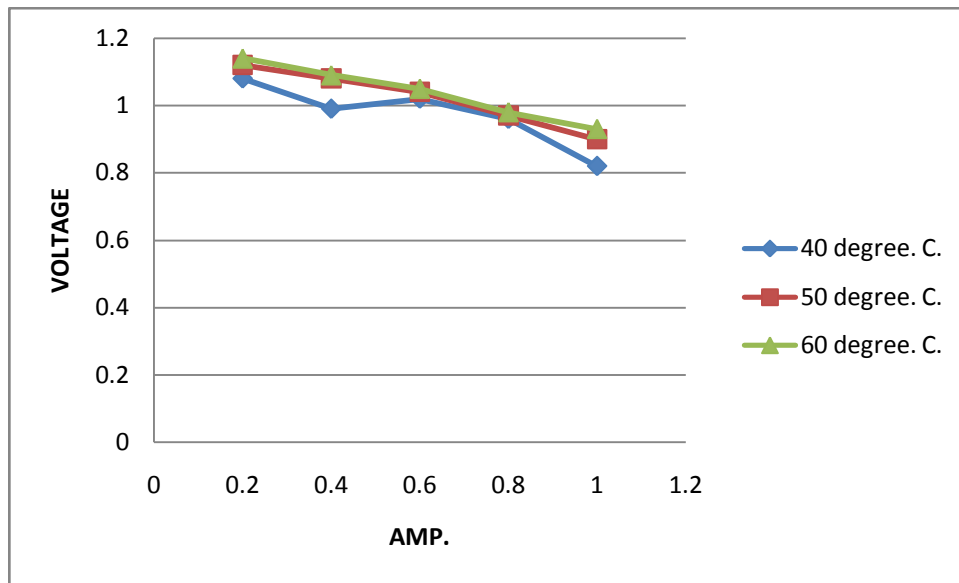


Fig.7.

**Table .3.humidification temperature, hydrogen flow rates are 3.0 M<sup>3</sup>/Min.and Oxygen flow rates 6.0 M<sup>3</sup>/Min.**

Sr. No.	Current density (A/cm <sup>2</sup> )	Voltage at humidification temperature 40 Degree C	Voltage at humidification temperature 50 Degree C	Voltage at humidification temperature 60 Degree C
1	0.2	1.08	1.12	1.14
2	0.4	0.99	1.08	1.09
3	0.6	1.02	1.04	1.05
4	0.8	0.96	0.97	0.98
5	1.0	0.82	0.90	0.93



**Fig.8.**

## Conclusion

1. The anode humidification temperature has considerable effects on fuel cell performances. In the low current density region, the lower the degree of humidification, the lower the fuel cell performances. At high current densities, the effect of anode humidification temperature is not significant.
2. The cathode humidification temperature has no significant effects on fuel cell performances, especially at high current densities.

## REFERENCES:

- 1-On-line fault diagnostic system for proton exchange membrane fuel cells Luis Alberto M. Et.al,Paper from science direct
- 2- Effects of operating conditions on cell performance of PEM fuel cells with conventional or interdigitated flow field Wei-Mon Yan Et.al Paper from science direct
- 3- A review of water flooding issues in the proton exchange membrane fuel cell Hui Li Et.al,Paper from science direct
- 4- Increasing the efficiency of a portable PEM fuel cell by altering the cathode channel geometry: A numerical and experimental study T. Henriques, Et.al,Paper from science direct
- 5- Development of a fast empirical design model for PEM stacks Xiao-guang Lia Et.al,Paper from science direct
- 6- Parametric analysis of a hybrid power system using organic Rankine cycle to recover waste heat from proton exchange membrane fuel cell Pan Zhao, Et.al Paper from science direct
- 7- A parametric study of PEM fuel cell performances Lin Wang, Et.al,Paper from science direct
- 8-Performance studies of PEM fuel cells with interdigitated flow fields Lin Wang Et.al,Paper from science direct
- 9-An improved model for predicting electrical contact resistance between bipolar plate and gas diffusion layer in proton exchange membrane fuel cells ZhiliangWua Et.al,Paper from science direct