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Performance Evaluation of PEM Fuel Cell with Change in Fuel Temperature

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ABSTRACT: Energy is the lifeblood of global economy. It is the prime propellant of growth, modernization, progress and prosperity. The existing source of energy such as oil, coal uranium etc. may not be adequate to meet the ever increasing energy demands. As we head into never millennium it is time to put renewable energy and planet friendly technology at the top our priorities. Few technologies have the potential to change the world for the better as fuel cell which offers potentially non polluting and renewable way to generate electricity .In the present paper the performance evaluation of PEM fuel cell with change in fuel temperature has been carried out. Initially the PEM fuel cell was tested with atmospheric condition & further it is tested with variation in fuel temp of 40°C & 60°C etc. Accordingly the behavior of PEM fuel cell is studied and results are plotted on the graph.

Key words : PEMFC Proton exchange membrane fuel cell.

I. INTRODUCTION

The proton exchange membrane fuel cell is a device which converts chemical energy of fuel and oxidant into electrical energy and heat energy without classical combustion. The normal PEM fuel cell work with polymer electrolyte in the form of thin permeable sheet (Naffion membrane). This membrane is small and light and it works at room. temperature. To speed the reaction a platinum catalyst is used on both sides of membrane. Next to catalyst anode and cathode (GDL-gas diffusion layer) of about 235-427 micrometer is provided on both side. The total assembly is known as MEA i.e. Membrane electrode assembly. The MEA is provided with flow field pattern on either side. The hydrogen is supplied from anode side and oxygen is supplied on cathode side. Hydrogen atoms are ionized at the anode and the positively charged proton diffuse through one side of the porous membrane and migrate towards the cathode. The electrons pass from the anode to the cathode through an exterior circuit and provide electrical power along the way. At the cathode the electron, hydrogen proton and oxygen from the air combine to form water. The heat energy also produces during the process.

Chemical Reaction

- Reaction are as follows:-
- Anode Reactions: $2H_2 => 4H^+ + 4e^-$
- Cathode Reactions: $O_2 + 4H^+ + 4e^- => 2 H_2O$
- Overall Cell Reactions:$2H_2 + O_2 => 2 H_2O$ + Heat + Electricity

II. DESIGN AND DEVELOPMENT OF PEM FUEL CELL

In this fuel cell setup 13 cell have been connected in series. Each cell is combined with other cell. The conventional PEM fuel cell consist of square section MEA but in this stack rectangular cross section bipolar plate and MEA is preferred and it is unique of its own kind.

A. Bipolar plates

Bipolar plates perform a number of functions within the PEM fuel cell. They have been used to distribute the fuel and oxidant within the cell, separate the individual cells in the stack, carry current and water away from each cell, humidify gases and keep the cells cool. Plate topologies and materials facilitate these functions.

B. Anode and Cathode flow field Geometry

The bipolar plates with parallel flow arrangement are made with the polyvinyl chloride and composite material having graphite deposition on it; the dimensions are 65 x 20 x 2.2 mm. It is thoroughly machined on CNC machine keeping width of each strip is about 0.7 mm and land is about 0.7 mm. Totally 34 grooves flow field have been incorporated on the bipolar plate.

No separate cathode is provided in this system. Only one bipolar plate act as anode and cathode

MEA (Membrane Electrode assembly) The MEA is made up of perflorocarboxylic acid membrane and supported by composite material. The size of the MEA is chosen as 65 x 20 x 0.01 mm. The MEA is perforated and is sandwiched between two bipolar plates along with the carbon diffusion layer. Thickness of gas diffusion layer is 0.22 mm with the platinum coating. Up till today the test is made up with the 5 cm square section MEA but here rectangular cross section MEA is chosen.

C. Air Breather

A separate breather to feed oxygen is incorporated in the system. It is micro exhaust fan operated on its own by generated current, it blows required quantity of air to the fuel cell and the same may be flowing.

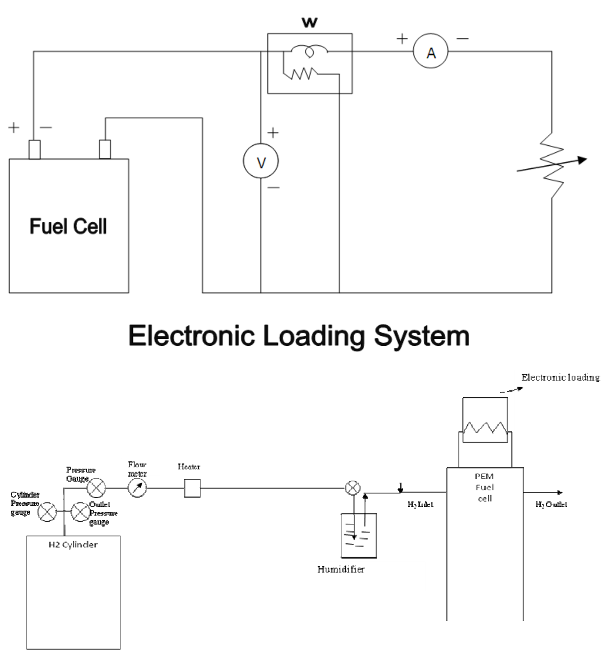

Fig. 1.

II. EXPERIMENTAL SETUP

The experimental test rig consists of self breathing rig PEM fuel cell as shown in the figure. The hydrogen fuel will be supplied towards the anode side. A hydrogen cylinder with a pressure regulator (2 in no.) will govern the supply of hydrogen to the PEM fuel cell .For 12 w fuel cell the inlet pressure of hydrogen is maintained between 0.4 to 0.5 bar. In the path of hydrogen flow a flow meter is installed to know the quantity of hydrogen being supplied to PEM fuel cell. The flow meter is of rotameter type having the graduation from 25ml to 275 ml /min in a step of 25 ml. Next to flow meter an electric heater is installed in a path and its temperature can be changed with the variable input.

The fuel cell will be tested in different ways. In this test the fuel cell is tested with change in fuel temperature i e (hydrogen) .Initially it is constantly supplied to PEM fuel cell at room temperature from anode side and later its temperature is changed to 40 c and 60 c..Since, the PEM fuel cell is self breathing hence it is not necessary to measure oxygen quantity. It takes as per its requirement .Due to this PEM fuel cell produces maximum power output.

Later the PEM fuel cell is loaded electronically with rheostat and ammeter by changing the resistance from 10 ohm to 200 ohm, Accordingly the variation in the voltage and current output is recorded. It may be also tested with variation in fuel ie in a step of 25ml/min to 275ml/min . From the observation table different graphs have been plotted which is shown below accordingly.

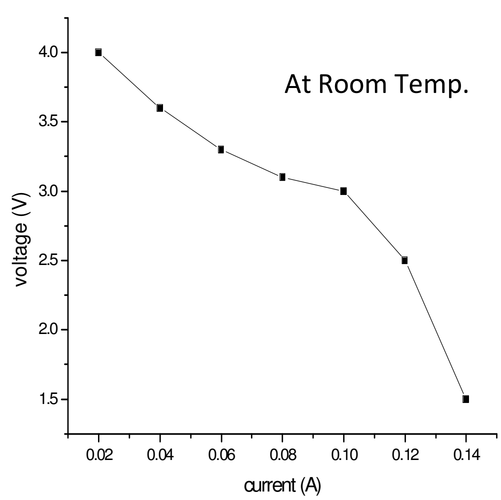

Fig. 2.

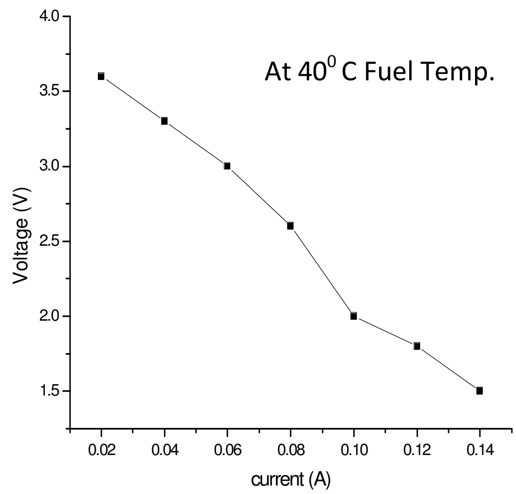

Fig. 3.

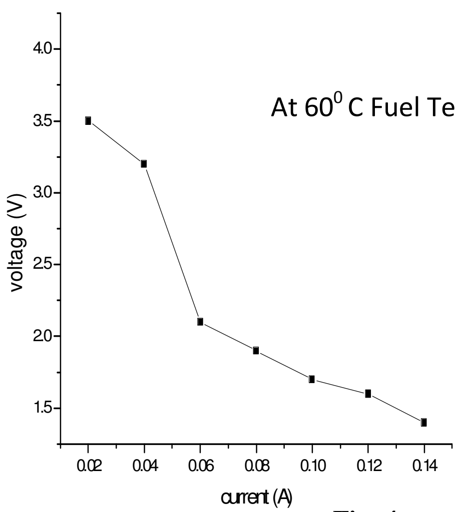

Fig. 4.

III. CONCLUSION

It is observed from the above experimentation and plots that the variation in input temperature of fuel has very little effect on the performance of fuel cell. At room temperature the performance shows positive response whereas with change in temperature of the fuel at 40^{o}C and 60^o C has poor performance.

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