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Performance Analysis PEM Fuel Cell

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Abstract :he performance of a ducted type air breathing proton exchange membrane (PEM) fuel cell operating with hydrogen fed at the anode and oxygen fed through free convection mode at the cathode is studied through experimental analysis. Systematic parametric studies are conducted experimentally to evaluate the effects of cathode geometry, cell orientation and hydrogen flow rate on the performance of ducted air-breathing PEM fuel cell.

Key words: PEMFC % Air breathing % Ducted cathode % Performance characteristics

INTRODUCTION

Proton exchange membrane (PEM) fuel cells have been under development for many years and are considered as promising candidates for efficient energy conversion (chemical energy is directly converted into electricity). Oxygen supply in air- breathing fuel cell takes place due to buoyancy flow on the cathode side of the fuel cell rather than forced convection supply of air using a blower or compressor as in conventional fuel cell. Because of its compactness, light weight and less cost, Air Breathing Fuel Cell (ABFC) is of particular interest even though the performance obtained is lesser than the conventional fuel cell. Since the oxidant supply on the cathode side of the fuel cell takes place due to natural convection phenomena the channel dimensions and the cell orientation will have significant affect on the fuel cell performance [1, 2]. Effect of cathode channel dimensions, the orientation of the cell and the flow rate of hydrogen on the anode side of the cell on the cell performance is experimentally studied here.

Experimental Setup: The schematic of the experimental setup is shown in Fig.1. Hydrogen was supplied to the anode side from a compressed hydrogen cylinder. Pressure regulator was used to reduce the pressure of hydrogen gas from cylinder pressure to the required supply pressure of 1 bar. Flow of hydrogen to the fuel cell was controlled using a mass flow controller. An electronic load was used to vary the load on the fuel cell. Oxygen supply to the cathode of the fuel cell is by natural convection process due to the temperature and concentration gradients that exist in the fuel cell.

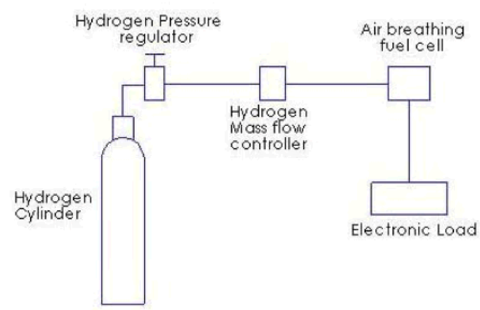

Fig. 1: Schematic of ABFC- Experimental Setup STUDY

Single Cell Description: Standard MEA imported from Lynntech Inc, USA with an active area of 25 cm^2 was used for the experimental study. Hydrophobization of 20% was used on the anode side gas diffusion layer (GDL) and a hydrophobization of 30% was used on the cathode side of the MEA. 40% Pt/C with a loading of 1mg/cm^2 was used on both anode and cathode catalyst layer. The electrolyte membrane used was Nafion 117. Single serpentine flow channel of dimension 1mm X 1mm machined on the graphite plate was used as the anode side flow field. Silver coated copper plate is used for current collection at anode side. Cathode side flow field designs used for the study are listed in Table1. Graphite plates with channels of dimensions of 2X2 mm, 4X4 mm and 6X6 mm machined on

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Table 1: Ducted Cathode Designs

Cathode Design	Channel	Design
Design 1	2 mm X 2 mm	
Design 2	4 mm X 4 mm	
Design 3	6 mm X 6 mm	

them were used as cathode flow field plate. Current collector on anode and cathode side is made of silver coated copper plate.

RESULTS AND DISCUSSION

Effect of Cathode Channel Dimension: Fig. 2 shows the effect of duct dimensions on the performance of air-breathing PEM fuel cell with ducted cathode when the cell is operated at dead end mode. The cell performance was limited to very low current densities when the cathode dimensions were 2mm X 2mm. The performance of the fuel cell with 6mm X 6mm is better compared to the cell with 4mm X 4mm ducted cathode.

With 2mm X 2mm ducted cathode, the performance was mainly limited due to the high flow resistance offered by the small hydraulic diameter channels for the buoyancy induced flow. As the hydraulic diameter of the channels increases the resistance offered by the channels for the flow decreases and hence better flow and performance is obtained for the cell with 6mm X 6mm channel. The portions of the GDL beneath the ribs are the places with large proximity for liquid water formation. Liquid water formation was observed near to the ribs during the experiments and is shown in Fig.3. As the contact area increases the area available for liquid water formation also increases. The contact area for 2mm X 2mm, 4mm X 4mm and 6mm X 6mm ducted cathodes are 72%, 64% and 44% respectively and hence significantly contributes for the cell performance.

Effect of Cell Orientation: Effect of cell orientation on the cell performance is shown in Fig.4. The different cell orientation studied are (i) Horizontal (Cathode up/ Cathode down) (ii) Inclined (Cathode up/ Cathode down) and (iii) Vertical. Cell performance was better when the orientation of the cell was in the vertical direction [2].

Least performance was obtained with horizontal orientation of the cell with cathode facing upwards.

With the cell oriented in the vertical direction, the buoyancy flow happens in the vertically oriented channels taking away the by-product water and supplying fresh oxygen to the cathode. When the cell is oriented 45° inclined to the horizontal, only a component of the

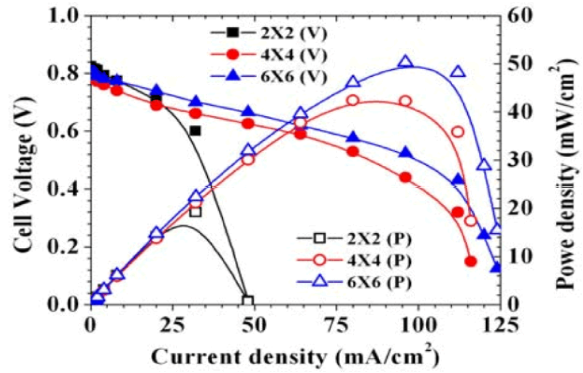

Fig. 2: Effect of cathode channel dimension

Fig. 3: Water Droplet Formation on Cathode Ribs

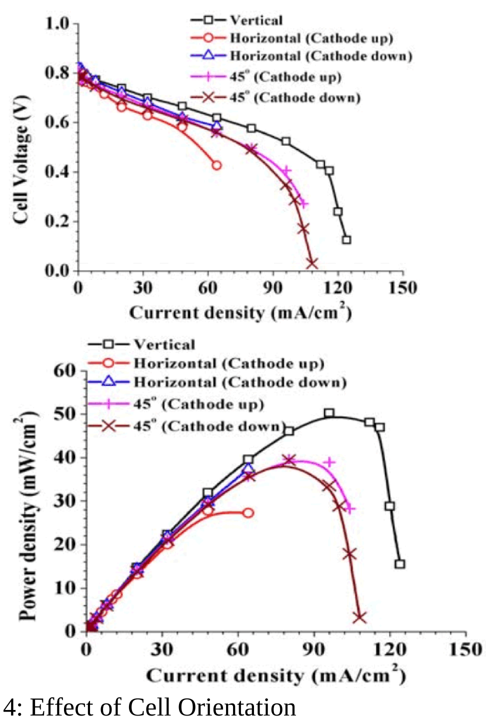

Fig. 4: Effect of Cell Orientation

buoyancy force helps in maintaining a continuous flow of air along the cathode channels. Therefore the cell performance is less compared to vertical orientation where the entire buoyancy force helps in maintaining a continuous flow on the cathode side. When the cathode duct is oriented horizontally, the buoyancy force doesn't aid in having a continuous air flow in the cathode duct. Therefore the heat and mass transport in this case are mainly due to diffusion rather than convection, which lead to very low performances. With horizontal orientation of the cell and with cathode facing down the gravity assists in the removal of liquid water. Therefore the performance is better with cathode facing down in the case of horizontal orientation of the cell [3].

CONCLUSION

The following conclusions can be drawn from the present study:

Hydraulic diameter of the channel has a significant effect on the air-breathing fuel cell performance. When the hydraulic diameter was small [4], the fuel cell performance was limited to low current densities due to insufficient oxidant available in the cathode catalyst layer. At higher hydraulic diameters the cell performance was limited due to liquid formation inside the fuel cell.

The catalyst and GDL below the current collecting ribs are areas which are more prone to flooding. The current collector points needs to be optimally designed for proper current collection and to avoid flooding issues [5].

The cell orientation has significant affect on the cell performance. Vertical orientation gives the best performance, whereas horizontal orientation with cathode facing up gives the worst performance.

REFERENCES

1. Tatyana Aleksandrovna Skalozubova and Valentina Olegovna, 2013. Reshetova Leaves of Common Nettle (Urtica dioica L.) As a Source of Ascorbic Acid (Vitamin C), World Applied Sciences Journal, 28(2): 250-253.
2. Rassoulinejad-Mousavi, S.M., 11M. Jamil and 2M. Layeghi, 2013. Experimental Study of a Combined Three Bucket H-Rotor with Savonius Wind Turbine, World Applied Sciences Journal, 28(2): 205-211.
3. Vladimir G. Andronov, 2013. Approximation of Physical Models of Space Scanner Systems World Applied Sciences Journal, 28(4): 528-531.
4. Ahmed, Naseer, 2013. Ultrasonically Assisted Turning: Effects on Surface Roughness World Applied Sciences Journal, 27(2): 201-206.
5. Tatyana Nikolayevna Vitsenets, 2014 Concept and Forming Factors of Migration Processes Middle-East Journal of Scientific Research, 19(5): 620-624.