ABSTRACT

The Proton Exchange Membrane Fuel Cell (PEMFC) is an electrochemical device that continuously converts chemical energy into electrical energy as long as Hydrogen and Oxygen are supplied. Water and heat as by-products of electrochemical oxidation and reduction reactions, have to be precisely balanced to prevent the problem of flooding and dehydration of the membrane. Excess amount of water in liquid phase would result in blocking of the pores in the catalyst layer and Gas Diffusion Layer (GDL) whereas an insufficient amount of water would result in membrane dehydration, thereby leading to poor performance of the PEMFC. Hence, the water management is one of the critical issues, influencing the steady and transient performance of PEMFC system. Various flow field designs have been developed for effective removal of water from the flow channels of PEMFC. The water accumulation on the cathode side of the flow channel is carried out by the reactants, whereas the water accumulation in the interfacial of cathode flow field landing and GDL is very difficult to remove. This accumulated water blocks the flow of reactant from GDL to the catalyst layer, thereby reducing the performance of PEMFC. In this concern, a porous landing could facilitate passive water removal in the cathode flow field and significantly improve PEMFC performance. So there is a need for a new, simple and economical method of water removal in the landing surface of the cathode flow field. Hence, the objective of this work is to address the water flooding on the landing through the design modification on the cathode flow field by inserting the porous carbon inserts/pellets along the landing surface.

A single PEMFC having an active area of 25 cm^2 with various flow field designs, namely serpentine, uniform and zigzag patterned pin

types; and flow fields with 2 mm cubical porous carbon inserts on the uniform and zigzag patterned pin types has been experimentally investigated. The influence of porosity of porous carbon inserts on the cell performance has also been studied by varying the porosity of porous carbon inserts in the ranges of 60-70%, 70-80% and 80-90% respectively. The results show that the flow field with zigzag positioned porous carbon inserts having 80-90% porosity improves the power density and current density by 11.5% and 7% respectively, when compared to the serpentine flow field.

In order to meet the power requirements of PEMFC, a larger active area is mandatory, which is called as scaling up of PEMFC. To reduce the effect of flooding on the larger active area of PEMFC, an enhanced flow distribution is essential. Hence, the present research work lies in preventing water flooding in scaling up studies of an active areas of 36 cm^2 and 70 cm^2 PEMFCs. As the strategy of incorporating of porous carbon inserts on the landing surface of the cathode flow field has improved the performance of the PEMFC with the active area of 25 cm^2, the same strategy is applied to scaling up studies of the PEMFCs with the active areas of 36 cm^2 and 70 cm^2. Hence, the various flow field designs, namely serpentine, uniform and zigzag patterned pin types; and flow fields with 2 mm cubical porous carbon inserts on the uniform and zigzag patterned pin types in the cathode side on the performance of 36 cm^2 and 70 cm^2 PEMFCs have been experimentally investigated. When compared to serpentine flow field on cathode, the zigzag positioned porous carbon inserts on the pin type flow field on the cathode side increases the current and power densities by 2.8% and 6.3% respectively on 36 cm^2 PEMFC; and 8.7% and 20.6% respectively on 70 cm^2 PEMFC.

The porous carbon inserts on the landing surface of the pin type flow field on cathode remove the accumulated water in between landing and

GDL through the capillarity of its porous structure and eliminates the stagnant region under the landing, thereby enhancing the performance of PEMFC in scaling up studies. While comparing the peak power densities of three active areas of PEMFC with different flow field designs, it can be concluded that the PEMFC with active area of 36 cm^2 yields a higher power density compared to 25 cm^2 and 70 cm^2 PEMFCs due to the reduction in the ohmic losses, higher mass transportation in the cell and a reduction in the resistance of the cell components, and reduced amount of water produced inside the cell. So it is concluded that the active area of 36 cm^2 is the optimum active area of single cell PEMFC.