ABSTRACT

World Health Organisation's (WHO) study on outdoor air quality states that about nine out of ten people live in places that do not adhere to WHO air quality guidelines. The usage of clean energy technologies such as Proton Exchange Membrane Fuel Cells (PEMFC) will lead the way to better air quality. However, durability issues in fuel cells including water management and scaling up are barriers to commercialisation of fuel cells.

This work attempts to find ways of minimising the problems related to water management and scaling up through flow channel modifications. To achieve the same the properties of different flow channels designs were studied and the design most suitable for performance enhancement, water management and scaling up was opted for flow channels of cross section 2 mm x 2 mm with an active area of 25 cm^2. The best combination was then scaled up to 50 cm^2 and 100 cm^2 active area.

Considering better reactant dispersion and performance the serpentine pattern was considered at the anode. As the design of the cathode flow channel is important for water removal, the channel having better water removal characteristics is to be taken at the cathode side. The parallel flow field is capable of water removal but has lower reactant dispersion and reactant utilisation. Hence the parallel flow field was modified with funnelled inlet/outlet with various inlet/outlet angles for uniform flow distribution. The flow field capable of rendering uniform flow at the minimum size and electrical losses was considered for further analysis.

This modified flow field with uniform flow distribution was further modified with different number of bends for better utilisation of reactant by enhancing under rib convection. The channel with better performance was opted for further analysis.

Now, the channel has been modified for better dispersion of reactants by selecting the optimal inlet/outlet funnel angle and better performance by selecting the optimal number of bends in the flow channel through numerical analysis. This novel flow channel is called a ‘sinuous’ flow channel.

The optimal result was validated through experimental analysis and further modification for better water removal was carried out experimentally by inducing a mild slope. The performance of the novel sinuous flow field with slope is compared with the conventional serpentine flow field. The water removal capability of the novel sinuous flow field and serpentine flow fields are assessed experimentally by absorption technique to determine the effect of the slope. Additionally, the resistance offered by these flow field configurations was assessed by electrochemical impedance spectroscopy to ascertain the experimental results. Then durability of the novel serpentine-sinuous combination was assessed.

The serpentine flow field at anode, novel sinuous flow field with slope at cathode has maximum power density hence was considered for scaling. This novel flow field configuration was then experimentally analysed for 50 cm^2 and 100 cm^2 active area and the results were compared with the conventional serpentine flow field of equivalent area.

The results establish that serpentine sinuous flow field configuration is more compatible with scaling as it is capable of producing more power density, removing a higher quantity of water from flow channels, has more durability and than conventional serpentine flow field.