ABSTRACT

The Proton Exchange Membrane Fuel Cell (PEMFC) is an electrochemical energy conversion device that converts chemical energy into electrical energy by Hydrogen Oxidation Reaction (HOR) and Oxygen Reduction Reaction (ORR) that uses hydrogen as fuel in the anode and oxygen/air as fuel in the cathode. Water and heat are the by-products of electrochemical reactions. The operating parameters like operating pressure, temperature, mass flow rate of reactants, stoichiometric ratio and humidification temperature of reactants, etc., and the design parameters like rib to channel width ratio (R:C), depth of the channel, number of passes on the flow channel, flow channel shape and size of flow channel dimensions influences the performance of PEMFC. Many researchers have numerically and experimentally investigated the influence of the operating and design parameters on the performance enhancement of the PEMFC system. So far, the combined effect of operating and design parameters on the serpentine and interdigitated flow fields' influence on the PEMFC is not carried out on the literature. Hence the immediate attention is required in the field of optimization of the combined effect of operating and design parameters on the performance of PEMFC. So, the present work is to identify the performance enhancement of PEMFC by optimizing best operating and design parameters.

The numerical investigation on PEMFC performance in an active area of 25 cm^2 with various ribs to channel width ratios on serpentine and the interdigitated flow fields have been investigated with 2 bar operating pressure and 323 K operating temperature by using CFD Fluent 14.0 software and the corresponding values were validated experimentally. The serpentine flow field with R:C of 1:2 have produced the numerical and

experimental peak power density of 0.296 W/cm^2 and 0.260 W/cm^2 respectively. Similarly, the interdigitated flow field with R:C of 1:2 has obtained the numerical peak power density of 0.303 W/cm^2 and experimental peak power density of 0.266 W/cm^2 with a reasonable numerical and experimental comparison.

The combined effect of design and operating parameters of various combinations for the performance enhancement of 25 cm^2 PEMFC has been studied by using optimization technique. In the Taguchi method of optimization, the 25 cm^2 PEMFC with serpentine and interdigitated flow fields was created by Creo parametric tool 2.0 and meshed by using ICEM 14.0. As per L16 orthogonal array of Taguchi method of optimization, four factors and four levels have been taken for optimization technique. The peak power densities have been found with the help of CFD fluent-14.0 software. The results revealed that, the rib to channel width ratio of 1:2, pressure of 2.5 bar, temperature of 343 K and stoichiometric ratio of reactants of 3.5 have produced the maximum power density of 0.304 W/cm^2 and 0.306 W/cm^2 respectively for serpentine and interdigitated flow fields. The percentage contribution of individual parameters, P-test and F-test on the serpentine and interdigitated flow fields for the performance of PEMFC has been studied.

A larger active area is required to meet the demand of power requirements, which requires scaling up or increasing the active area of the cells to much more than 25 cm^2. With the knowledge obtained by scaling up, it can be concluded that scaling up was found to reduce the power density of PEMFC. Hence, the present research work lies in scaling-up of PEMFC from 25 cm^2 to 36 cm^2 and from 25 cm^2 to 49 cm^2 using CFD fluent-14.0 software. The peak power performance has been reduced by 18 % for interdigitated flow field, when scaling up from 25 cm^2 to 36 cm^2 of PEMFC. Similarly, the

peak power performance has been reduced by 25.5 % interdigitated flow field, when scaling up from 25 cm^2 to 49 cm^2 of PEMFC. For the reliability of the numerical results, experimental validation of 36 cm^2 PEMFC with interdigitated flow field has been carried out for the rib to channel width ratio of 1:2, pressure of 2.5 bar, temperature of 343 K and stoichiometric ratio of reactants of 3.5.