ABSTRACT

In this thesis, the performance of the single PEM fuel cell was investigated using different materials; poco graphite, composite graphite, pure aluminum alloy, and Stainless steel 316, as bipolar plate materials of construction. The effect of various operating parameters; namely, cell temperature ranges from 25 ^{o}C to 70 ^{o}C, different reactant relative humidity (50%, 80% & 100%), stoichiometric air flow rate (0.5, 1.0, 1.5 &3) and reactant back pressure (0, 5, 10 & 15) Psi on the cell performance was studied. Three control systems were designed and implemented in this thesis; hydrogen purging valve, air cooling system, and programmable electronic load.

To perform these experiments a fuel cell test station was used in order to control the operating parameters and also to get the output results. Also a control circuit was used to control the fuel cell performance. A single Polymer Electrolyte Membrane (PEM) fuel cell with active surface area of 10 cm^2 was used for all experiments. The Membrane Electrode Assembly (MEA) consists of a Nafion 212 membrane sandwiched between two electrodes that have platinum supported on carbon Vulcan XC-72R. The platinum loading was 0.4 mg/cm^2 per electrode spreaded on gas diffusion layers made of carbon paper.

The results showed that the performance of PEM fuel cell increases with the increase of operating cell temperature where the maximum power density increases from 120 mW cm^{-2} at 25 ^{o}C to 180 mW cm^{-2} at 70 ^{o}C, reactant back pressure where the maximum power density increases from 80 mW cm^{-2} at atmospheric pressure to 120 mW cm^{-2} at 15 psi and air flow rate stoichiometric ratio where the maximum power density increases from 115 mW cm^{-2} at stochiometric ratio 0.5 to 145 mW cm^{-2} at stochiometric ratio 3. Poco graphite bipolar plate has higher performance than composite graphite, aluminum alloy, stainless steel 316 where the maximum power density was 55, 78, 45 and 117 mW cm^{-2} using poco graphite, composite graphite, aluminum alloy and stainless steel 316, respectively. The humidification of the electrodes (anode and cathode) and the use of wet-proof gas diffusion layer in cathode side have significant improvement on the performance of PEM fuel cell where the maximum power density increases from 430 mW cm^{-2} at 50% RH to 180 $mWcm^{-2}$ at 100% RH and the maximum power density increases from 118 mW cm^{-2} to 100 mW cm^{-2} when using wet proof and non wet proof gas diffusion layer.

The designed and implemented three control loops for hydrogen purge valve, stack air cooling system and programmable electronic load performed well according to their objectives.