ABSTRACT

This thesis involved the study of a proton exchange membrane fuel cell (PEMFC). The main aims of the study were to test, build and model a PEMFC. The tests were performed on a PEMFC purchased from ElectroChem Inc. (an overseas fuel cell company). The effects of temperature, pressure, humidification, oxidant (air *vs.* pure oxygen), and carbon dioxide dilution on the performance of the fuel cell were tested.

Results showed that increasing the temperature of the fuel cell increases the performance. There was an average increase of 1.6 % in the maximum current density and 1.5 % in the maximum power density for a 10 °C increase in temperature. Increasing the cell pressure by 1 atm resulted in an average increase in the maximum current density of 9 % and 15 % in the maximum power. Humidification resulted in a 10 % increase in the maximum current density and a 26 % increase in the maximum power density at 60 °C. The performance of the cell was very dependant on the state of humidification of the membrane and severe drop in performance was observed with the unhumidified cell run at temperatures greater than 60 °C. The air *vs.* pure oxygen test showed that the use of pure oxygen improved the cell performance significantly. There was a 21 % increase in the maximum current density and a 50 % increase in the maximum power density when oxygen was used as compared to air.
An increase in the carbon dioxide concentration resulted in a decrease in cell performance. An increase in carbon dioxide concentration from 0 % to 50 % resulted in a 17 % decrease in the maximum current density and 31 % decrease in the maximum power density.

A method for the preparation of the catalyst paste and the electrode was selected and modified after initial tests of various other methods. The main change made to the original method was that of lowering the solvent and Nafion® content by 50 % and 50 % respectively. This resulted in a catalyst paste that was thicker and easier to apply. A hot-press, used for assembling the membrane-electrode-assembly (MEA), was manufactured. The hot-press consisted of a G-clamp, with two metal plates placed in-between the clamp. The MEA was placed in-between the metal plates. A procedure for hot-pressing was developed. MEA's were manufactured and tested. The main problems encountered during the manufacturing process were cracking of the catalyst layer and twisting of the MEA during hot-pressing. The manufactured MEA showed an average decrease of 23 % in the maximum current density and 26 % in the maximum power density as compared to commercial MEA's.

A one dimensional, multicomponent model describing the performance of the fuel cell was developed and a simulation programme written. The model was used to simulate the performance of the cell under various operating conditions. The predicted profiles and the experimental results showed the same trends.