EXPERIMENTALLY ANALYZING A POLYMER ELECTROLYTE MEMBRANE FUEL CELL EXPERIMENTAL SETUP

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Abstract

The objective of this paper is to analyze a Polymer Electrolyte Membrane (PEM) fuel cell by changing its operating conditions, such as: fuel cell stack temperature, hydrogen humidifier temperature, and air humidifier temperature. This experiment was conducted using a TVN System UO-1001 fuel cell testing device. Then data was compiled and computed from the field test to give a final analysis report on what was determined to be the best possible operating conditions to produce the maximum amount of energy with minimal ohmic loss.

Introduction

Proton exchange membrane fuel cell (PEMFC) technology was first introduced by General Electric in the 1960s for U.S. Navy and Army [1]. PEMFC technology then served as part of NASA's projects in its early space program [1]. Polymer electrolyte membrane fuel cells convert chemical energy into electrical energy. It has a cathode and an anode made of the same catalyst material separated by the polymer electrolyte membrane. The anode converts the diatomic hydrogen molecules into hydrogen protons and electrons [2]. The protons flow freely from the anode material to the cathode material through the polymer electrolyte. The electrons cannot travel through the electrolyte and thus must take a separate path to the cathode material. Through this path, the electron flow is converted into electricity in a circuit and then returns to the cathode.

Once the electrons reach the cathode the hydrogen protons bond to the electrons and an oxygen atom pulled from air to form water [2]. During the analysis of the data from the PEM fuel cell there are three main areas of loss: activation loss, ohmic loss, and concentration loss. Activation loss is caused by the initial startup of the fuel cell and levels out after the reactions equalize. Ohmic loss, which is being measured, is due to the natural resistance in the wire of the circuit and fuel cell components. Concentration loss is due to the change in concentration of the hydrogen and oxygen at the electrodes as the reaction occurs [3].

Problem statement

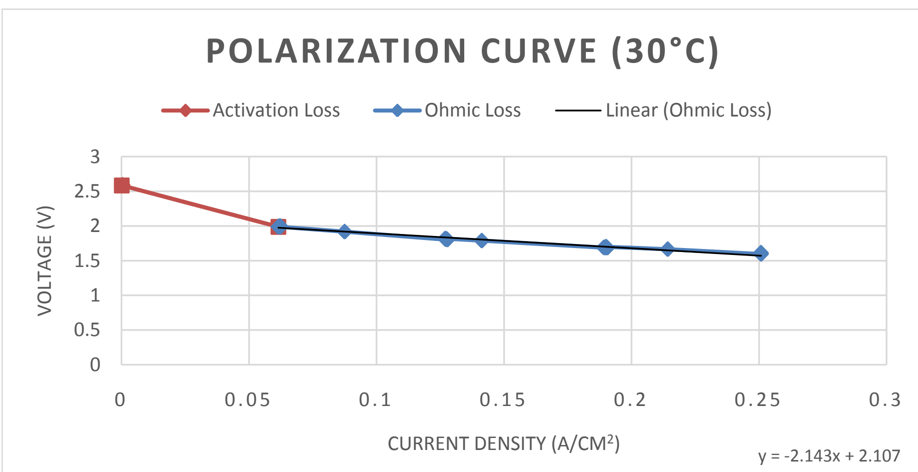
The purpose of this research is to analyze a polymer electrolyte membrane fuel cell at different temperatures and determine what the optimum conditions would be for the system.

Objectives

- Determine the ohmic loss through an independent series of tests conducted at different temperatures on the TVN System UO-1001 fuel cell testing device.
- Determine which temperature will produce the most power with the smallest amount of ohmic loss.

Evaluation

The goal of this research was to measure to ohmic losses in the fuel cell at different temperatures. The data was compiled and analyzed in an Excel file and the results are shown in Figure 1. This figure is a plot of the voltage measured in the entire stack versus the current put into the stack divided by the area of the three fuel cells in the stack being researched.



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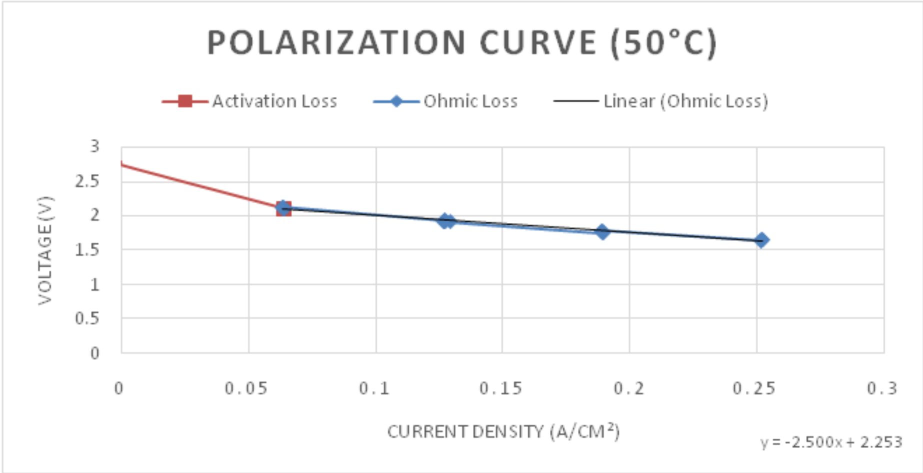

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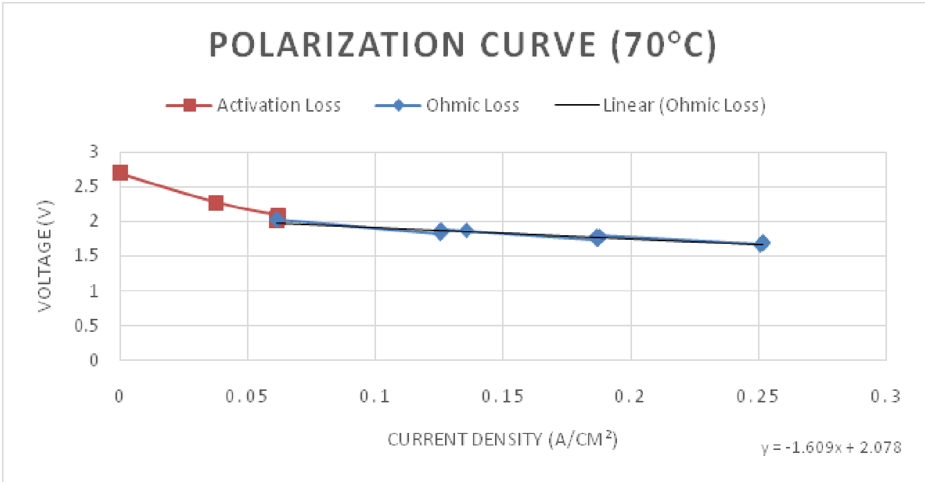

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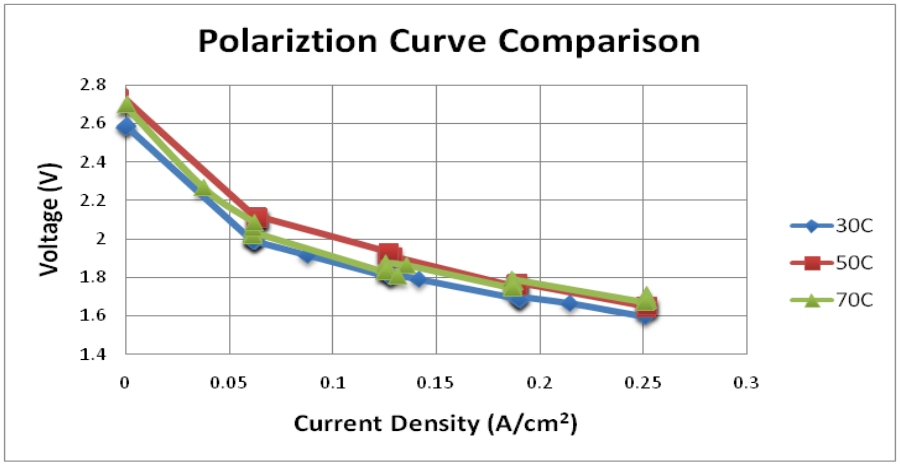
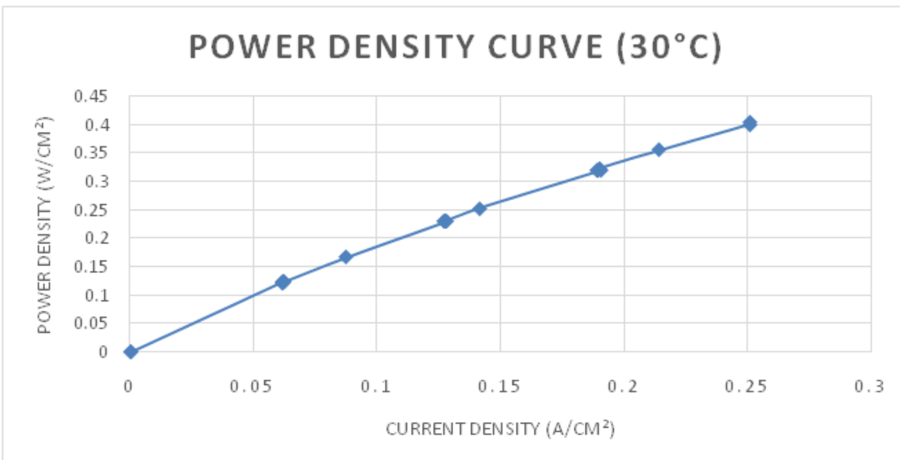


d

Figure 1. The curve of the voltage vs. current density at a.)30°C b.)50°C c.) 70°C d.) Comparison Curve

These plots show a trend line that begins with the activation loss followed by the ohmic loss. The slope in the trend line equation in the bottom corner of each plot shows the ohmic loss. At 30°C the ohmic loss is -2.14, at 50°C the ohmic loss is -2.50, and at 70°C the ohmic loss is -1.61. These results show that the optimal temperature is 70°C. The ohmic loss appears to increase from 30°C to 50°C but greatly decreases when the temperatures are at 70°C. To further evaluate this effect more data points would need to be gathered such as temperature increases at 10°C increments.

Figure 2 shows the power density vs. the current density. With this curve, an optimal point at which the current density input into the stack would allow for the maximum power density output can be found. Due to error, this optimal point was unable to be observed. Data from higher currents would need to be tested in order to reach this point.



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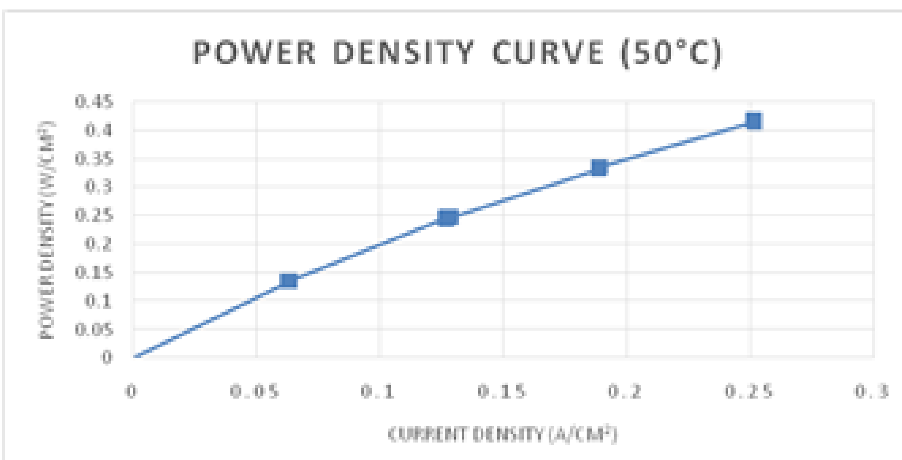

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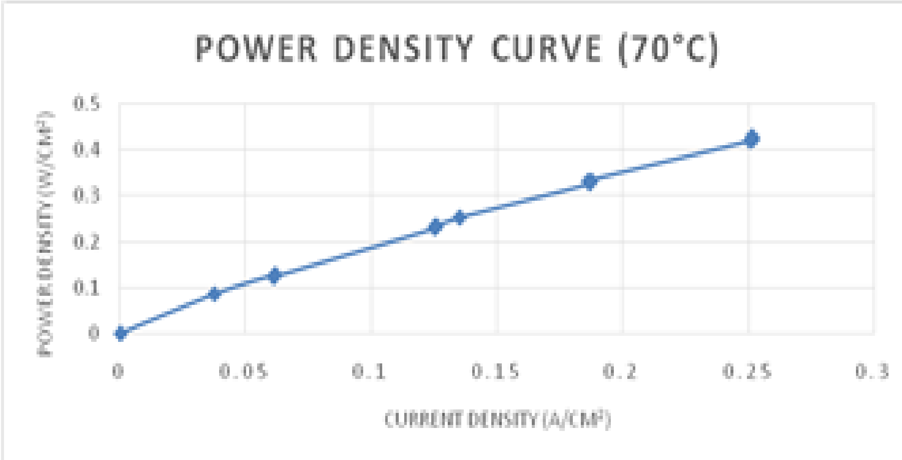

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Figure 2. Power density vs. Current density
a.) at 30°C b.) at 50°C c.) at 70°C

Conclusion

Error was encountered during this research due to failure of the third fuel cell in the stack. Once the current was increased to five amperes, the voltages of the third fuel cell decreased sharply to a negative voltage. This affected the current by decreasing the input and would not allow the TVN System UO-1001 fuel cell testing device to increase the current any further. This caused the test to be only performed up to four amperes. Four amperes does not provide an effective range of data points to show the inevitable concentration loss that should have been observed. Due to the test being conducted by increasing the current by one ampere per minute, the activation loss was not clearly observed. The test would need to be conducted at smaller increments of amperes per minute to affectively show the activation loss.

Bibliography

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