Experimental Study of Transient response for a PEMFC

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Introduction

A fuel cell is an electrochemical device that converts the chemical energy of fuel directly into electricity. Various experimental studies about PEM fuel cell have been done, such as, water management[1, 2], Clamp-torque effect[3], CO poisoning effect[4]. These studies were conducted for the steady state cell performance. The control, design, and optimum operation of PEM fuel cells will require an understanding of its transient dynamics when the current, voltage, or power changes. These dynamics would be important for residential applications and for automotive systems performing in a Federal Urban Driving Scenario. Some of these dynamics have been predicted with mathematical models by Shimpalee et al.[5]. In their study, an overshoot and undershoot behavior of current density was predicted for 10 cm^2 cell when the cell voltage step change was applied. In an effort to enhance understanding of the overshoot undershoot behavior, experimental data were obtained at selected flow conditions. In this study, the effect of changing the electrical load and the resulting current for 25 cm^2 cell were examined.

Experimental

The objective of this study is to observe the transient current responses in short period of time (order of seconds) when the voltage step change was applied for various operating conditions. The voltages applied in the transient experiment were 0.674V and 0.478V. Before the transient test, steady state cell performance test was conducted to obtain a polarization curve. From the polarization curve, the corresponding current to the voltage 0.674V and 0.478V were 12A and 30A, respectively.

For the transient experiment, two different conditions (starving and non-starving) were tested. In the starving condition, the flow rate was 101/420 cm^3/min for both H_2 and air (i.e., flow rate for 12A). At this condition, if the cell voltage is changed from 0.674V to 0.478V, the current is increased from 12A to 30A. However, the fuel supplied to the cell is not enough to generate 30A. So the current drops down some time later when the fuel inside of the cell was used up. We call this condition as 'starving condition'. The other condition, so called 'non-starving condition', is opposite to the starving condition. In this case, the H_2 and air supplied to the fuel cell were 252 and 1050 cm^3/min, respectively (i.e., flow rate for 30A). When the cell voltage changes from 0.478 V to 0.674 V, the corresponding current decreased from 30 A to 12 A. In this case, the fuel cell has enough fuel when the cell voltage changed to 0.674V.

In the experiment, a digital oscilloscope (two channel, TDS 200-Series by Tektronix Inc.) was employed to observe the current response in the short period of time. The cell used was a 25 cm^2 cell (actual active area was 20 cm^2 due to sub-gasket). The flow field was a triple serpentine channel. The gas diffusion media (GDM) used for both anode and cathode were CARBEL CL. The stoic. used in the experiment were 1.2 and 2.0 for hydrogen and air, respectively. The anode and cathode humidification temperatures were 85 and 75 ^oC (estimated due points were 80 and 70 ^oC for anode and cathode). The cell was operated at the temperature of 70 ^oC and the backpressure was 1 atm.

Fuel cell stations manufactured by Scribner Associates, Inc. were used in this experiment. The gases used in this experiment were bottled hydrogen (ultra high purity) and bottled air.

Results and Discussion

Figure 1 shows the transient response of current density due to the voltage step change (from 0.674V to 0.478V). The data were collected under the non-starving condition. No overshoot is observed in this case. The behaviors are like that of the first order response. However, undershoot behavior is observed in Figure 2. It displays the data collected under the starving condition. In this case, a voltage change was made from 0.478V to 0.674V. The current density drops down when the cell voltage increases. Then it goes up and approaches some value.

Acknowledgement

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References

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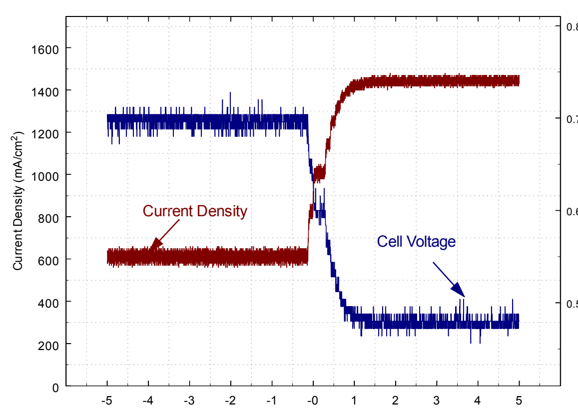

Figure 1. Non-starving condition transient response of current density for voltage step change from 0.674V to 0.478V at the flow rate of (A/C)=252/1050 cm^3/min

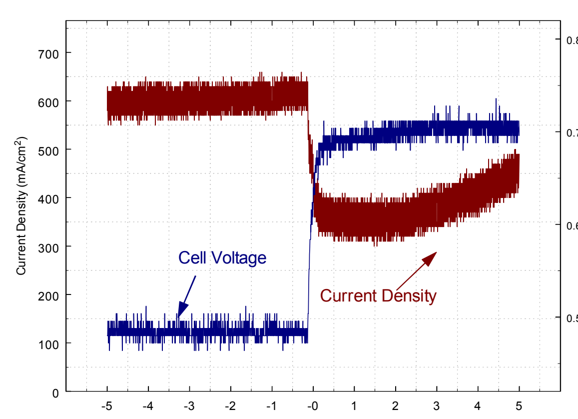

Figure 2. Starving condition transient response of current density for voltage step change from 0.478V to 0.674V at the flow rate of (A/C)=101/420 cm^3/min