Pressure Drop and Voltage Response of PEMFC Operation under Transient Temperature and Loading Conditions

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Proton Exchange Membrane Fuel Cells (PEMFCs) are seen as a viable replacement for the IC engine for automotive transportation. Transportation powertrains need to be versatile in power generation. The PEM fuel cell stack within these vehicles often operates under part load and varying conditions. Load conditions change based on the driving and can be very dynamic in nature. Making the PEMFC powertrain load following would reduce the requirement for large storage systems on board the vehicle (1).

Most studies reported in literature focus on and quantify the steady state behavior of fuel cells. Very few experimental studies have been reported on the performance characterization under transient conditions. In this regard, pressure drop offers a good diagnostic tool for observing two-phase flow in PEMFCs (2) with distinct pressure drop signatures for each flow regime (3) and can be utilized for characterizing the transient performance.

An in-situ setup is used for the current investigation into the transient effect of temperature and load conditions. A Greenlight Technology G40 fuel cell test stand is used to control the flow of reactants and apply load conditions to the cell. The fuel cell used has an active area of 50 cm^2. Straight reactant channels are used to deliver the reactants to the cell, with differential pressure measurement between the manifolds and individual channel pressure drop measurement in the entrance region for measuring the instantaneous gas flow rate through each channel. Four 1kW powered in-line heaters are used to heat the cell with coolant loops in the compression plates. A 2 kW industrial powered cooling system is placed in-line for cooling the cell at a fast rate along with a temperature controlled water bath with 0.5 kW of cooling. The gas temperature and humidity are controlled while being delivered to the cell.

The current work investigates the pressure drop in the reactant channels and voltage response of the fuel cell under transient conditions. Temperature of the cell is changed over 20°C - 60°C in short time periods (<600 seconds) to observe the transient response of the cell. Additionally, the load conditions are also changed by 0.4 and 0.6 A/cm^2 in 300 seconds to observe the voltage and pressure drop response of the cell. Figure 1 shows the voltage response from a load change of 1.0 A/cm^2 to 0.6 A/cm^2. Figure 2 shows the voltage response to a temperature change from 60 to 80°C. The corresponding pressure drops are also being investigated for the different tested conditions.

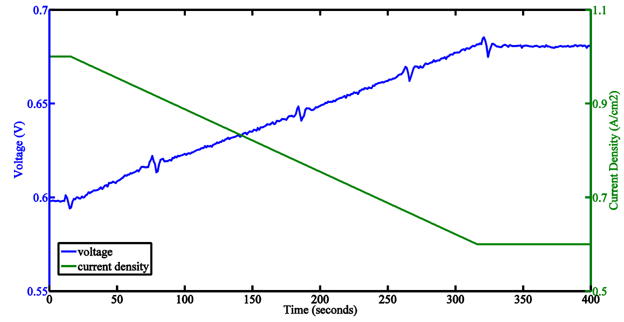

Figure 1: Transient voltage response from change in current density.

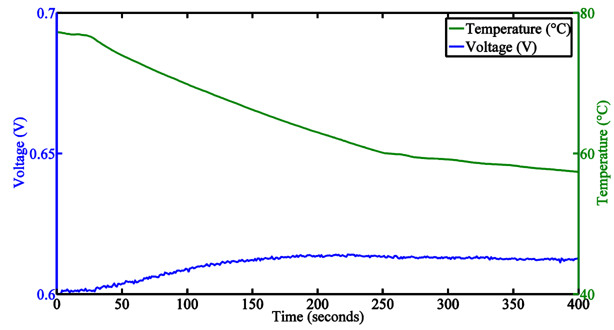

Figure 2: Transient voltage response from change in temperature.

The work investigates the rate of change of current density, the rate of change of temperature and the absolute changes in temperature and current density on the resulting voltage and pressure drop from the perspective of obtaining an improved water management strategy under transient conditions.

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