Dynamic Relative Humidity Model Development for a Polymer Electrolyte Membrane Fuel Cell Stack

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Motivation

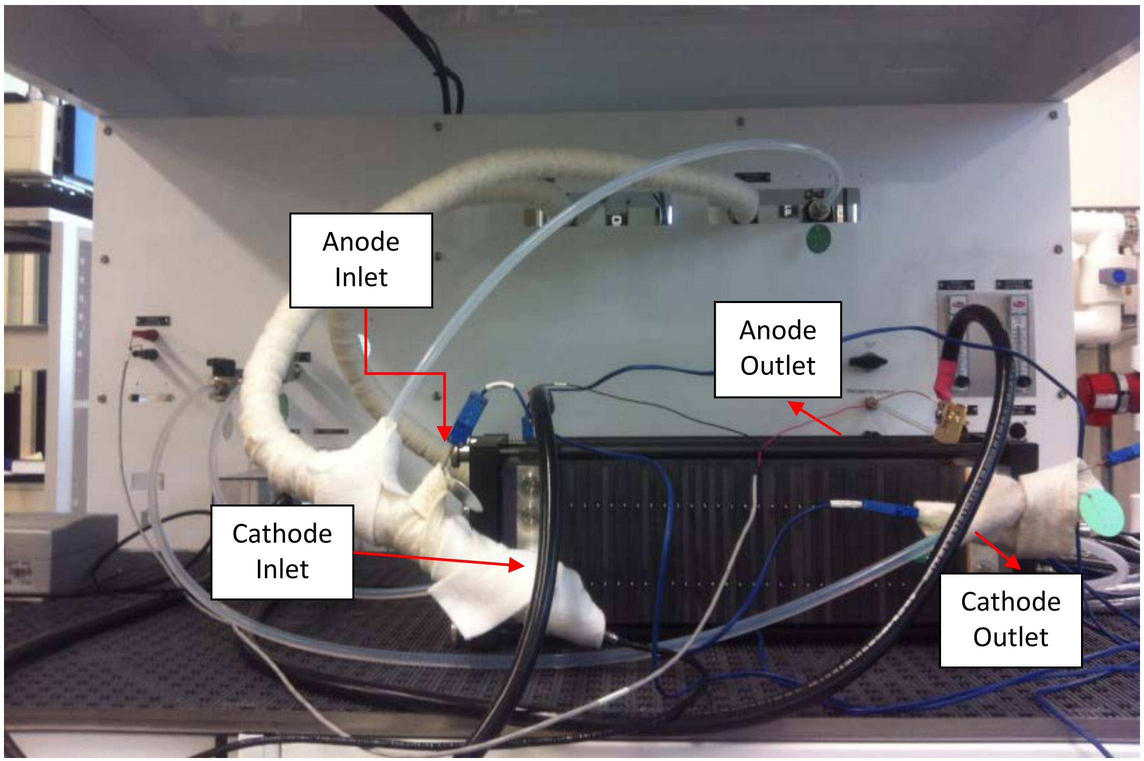
- **Proton-Exchange-Membrane (PEM) fuel cells are a promising technology for power generation applications**
  - Quick transient response
  - Only emission is pure water
- **Temperature and humidity management are still major challenges**
  - Poor humidity control can cause
    - Hot spots in the membrane
    - Liquid water blockages in the channel plate
  - Optimal Temperature around 80 Celsius
    - Difficult control due to the interconnected nature of fuel cells
- **Need a dynamic, control–oriented model for temperature, relative humidity, and cell output voltage**

Modeling Approach

- Thermal modeling is based on the conservation of mass and energy
  - 4 Control Volumes for anode, cathode, coolant and fuel cell body
- Relative Humidity modeling is based on saturation limits
  - Uses the results of the thermal model
  - RH from the mass of water calculated in the CV, and saturation limit

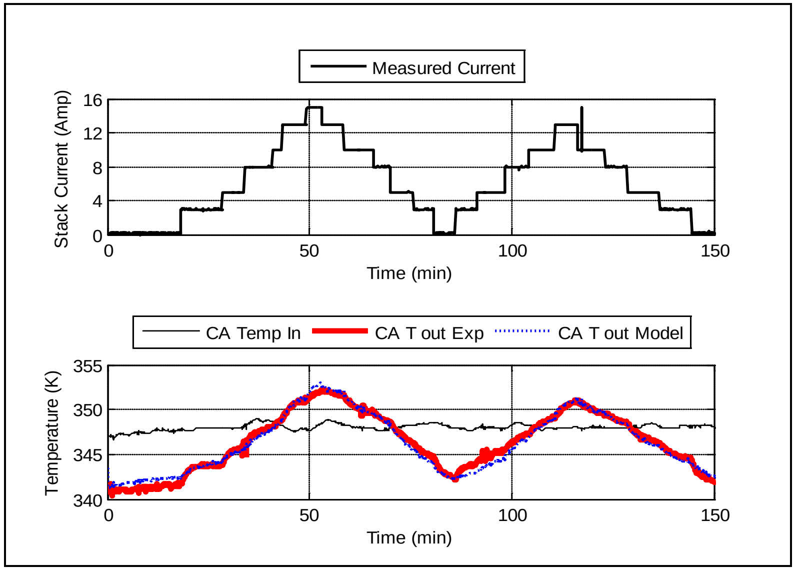
FIGURE 1: FUEL CELL STACK REPRESENTATIVE CONTROL VOLUMES

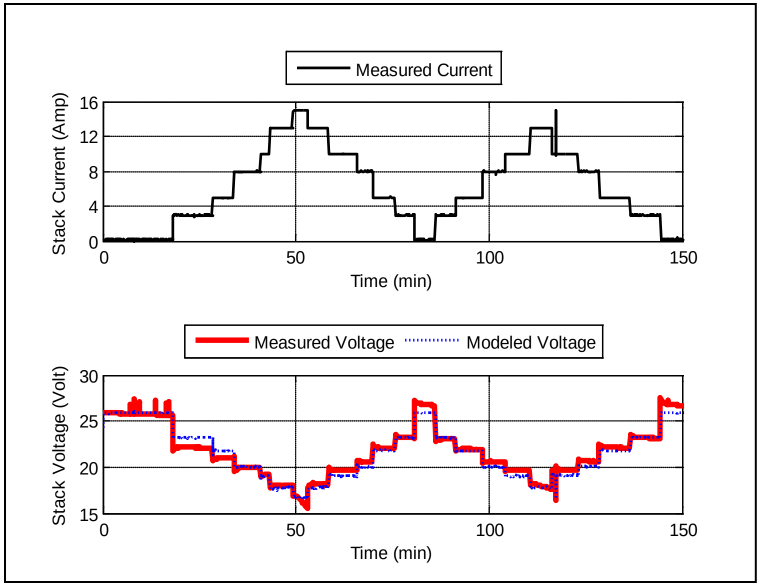
Experimental Setup

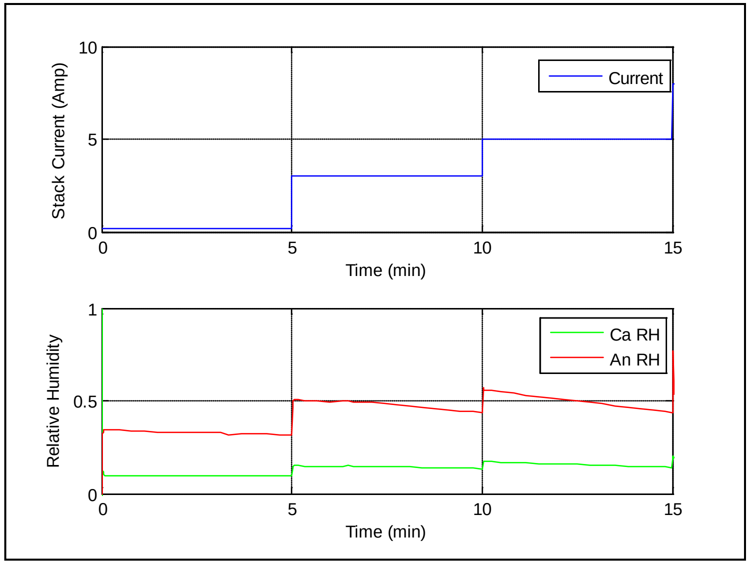


- 1.5kW, 30 cell stack
- Temperature, pressures, inlet RH, etc. controlled through test station
- For the RH testing, RH sensors installed in the inlet and outlet of the cathode channel
- Five–layer membrane electrolyte assemblies (MEAs)
- Machined graphite plates used for flow fields
  - o Serpentine line flow
  - o Cross flow configuration for anode and cathode
- Hydrogen of 99.999% used for experiments

Results


Measured Current
Stack Current (Amp)
16
12
8
4
0
0
50
100
150
Time (min)
CA Temp In
CA T out Exp
CA T out Model
Temperature (K)
355
350
345
340
Time (min)


Measured Current
Stack Current (Amp)
Time (min)
Measured Voltage
Modeled Voltage
Stack Voltage (Volt)
30
25
20
15
0
50
100
150
Time (min)


Current
Stack Current (Amp)
10
5
0
0
5
10
15
Time (min)
Ca RH
An RH
Relative Humidity
1
0.5
0
Time (min)