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

Alexander J. Headley
Advised by Dongmei “Maggie” Chen
Department of Mechanical Engineering
The University of Texas at Austin

January 8, 2012
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
  - Serpentine line flow
  - Cross flow configuration for anode and cathode
- Hydrogen of 99.999% used for experiments
Results

- Stack Current (Amp)
  - Measured Current

- Temperature (K)
  - CA Temp In
  - CA T out Exp
  - CA T out Model

- Stack Voltage (Volt)
  - Measured Voltage
  - Modeled Voltage

- Relative Humidity
  - Ca RH
  - An RH

 Mechanical Engineering