Estimating Air Flow Rates in a Fuel Cell System using Electrochemical Impedance
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This work proposes a method to estimate the air flow rate in a fuel cell system from electrochemical impedance spectroscopy (EIS).

Advantages of air flow estimation:
1) Eliminate flow meters thus reducing system cost and the need for frequent calibration.
2) Run the system at lower air flows, thus reducing power loss to the compressor/blower.

Impedance Sweeps 0.1Hz to 15,000Hz, current density at 0.7amp/cm² hydrogen is held at a constant flow rate of 15.4slm and as the air flow decreases from 60.9 to 48.7 slm to 36.5slm the real and imaginary parts of impedance increase at lower frequencies.


\[ V = E - R_a \frac{RT}{\alpha F} \frac{C_o}{i} - R_s \frac{RT}{\alpha F} \frac{i}{\delta_l - i} \]

\[ Z = R_s + A \frac{1}{i} \]

The dependence of the impedance Z on the air flow rate is through the limiting current density i.

We focus on impedance measurements taken at the low frequency of 0.1Hz, the absolute value of the derivative of the DC voltage will be a reasonable approximation for the impedance.

Estimated vs. Measured Air Flow Rates

Estimated flow rates are within 3.5% of the measured

Air is held at a constant flow rate of 60.9slm and the hydrogen flow decreases from 20.5 to 19.4 to 15.4slm. No change in impedance measurements.

Impedance Magnitude and Phase measured at 3Hz. Different air flows have distinguishable impedance magnitude and phase values at operating conditions for a current density of 0.7amp/cm², while measured voltage shows little change.

Impedance Magnitude and Phase measured at 3Hz and 0.1Hz, different air flows have distinguishable impedance magnitude values at 0.1Hz but not at 3Hz.