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EMPIRICAL MODELING OF A POLYMER ELECTROLYTE FUEL CELL BASED ON WATER TRANSPORT INVESTIGATION AND CURRENT INTERRUPT MEASUREMENT

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ABSTRACT–Water management is an important factor in the optimal performance of a polymer electrolyte fuel cell (PEFC). In this paper, a PEFC model that facilitates the control of PEFC membrane humidity is presented. An efficient modeling procedure using a combination of mathematical and experimental techniques is proposed. A simple mathematical structure for the model is adopted, and experiments to measure PEFC irreversibilities and net water transport across the membrane electrode assembly (MEA) are performed. The developed PEFC model effectively quantifies the irreversibilities in the PEFC output voltage and clarifies the relationship between PEFC performance and steady state water transport through the MEA. The proposed modeling procedure can effectively save time and cost during the controller / control algorithm design phase in PEFC system development.

KEY WORDS : Polymer electrolyte fuel cell, Modeling, Net water transport, Membrane conductivity, Activation polarization

NOMENCLATURE

a	: activity [–]
c	: concentration [mol cm^{-3}]
F	: faraday constant, 96485 [C mol^{-1}]
I	: load current [A]
i	: current density, [A cm^{-2}]
M	: atomic weight [g mol^{-1}]
$\dot{m}$	: mass flow rate [g s^{-1}]
m	: mass [g]
N	: molar flux [mol cm^{-2} s^{-1}]
P	: pressure, [kPa]
p_i	: partial pressure of component i [kPa]
R	: area specific resistance [Ω cm^2]
$\mathcal{R}$	: universal gas constant, 8.3143 [J mol^{-1} K^{-1}]
T	: temperature [K]
t	: thickness [cm]
V	: voltage [V]
x	: mole fraction [–]
α_c	: cathodic transfer coefficient [–]
λ	: membrane water content, [–]
η	: voltage loss [V]
ρ	: density [g m^{-3}]
σ	: membrane conductivity [Ω^{-1} cm^{-1}]
ν	: stoichiometric coefficient [–]

SUBSCRIPTS

ν	: activation polarization
Air	: air
ACh	: anode inlet flow channel
ACond	: anode side condenser
AN	: anode electrode
ARHc	: anode side RH chamber
CA	: cathode electrode
cell	: unit cell
CCh	: cathode inlet flow channel
CCond	: cathode side condenser
CI	: current interrupt
CRHc	: cathode side RH chamber
H_2	: hydrogen gas
H_2O	: water
M	: membrane electrode assembly (MEA)
m	: membrane
N_2	: nitrogen gas
o	: standard state condition
O_2	: oxygen gas
ohm	: ohmic polarization
stack	: stack
V	: water vapor
1,2,3,4	: interface 1,2,3,4

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