SOEC/Electrolyzer Supplementary Model Details

Below details various parameters used in the electrolyzer model. Many parameters are the same as used in [1].

Table 1. Electrolyzer parameters.

Description	**Value**
Cell Length (m)	0.225
Cell Width (m)	0.1
Number of cells	534,857
Cathode flow channel height, h_C, (m)	1×10^{-3}
Anode flow channel height, h_A, (m)	1×10^{-3}
Interconnect height, h_I, (m)	5×10^{-4}
Height electric conducting structure, h_S, (m)	5.7×10^{-4}
Porous cathode thickness (m)	5×10^{-4}
Porous anode thickness (m)	2×10^{-5}
Electrolyte thickness (m)	5×10^{-5}
Interconnect heat capacity, $C_{p,I}$, (J/kg-K)	500
Electric conducting structure heat capacity, $C_{p,S}$, (J/kg-K)	500
Density of electric conducting structure, ρ_S, (kg/m^3)	5900
Density of interconnect material, ρ_I, (kg/m^3)	8000
Electric conducting structure thermal conductivity, λ_S, (W/m-K)	2
Interconnect thermal conductivity, λ_I, (W/m-K)	25
Porous cathode electric conductivity, (1/ohm-m)	8×10^{4}
Porous anode electric conductivity, (1/ohm-m)	8.4×10^{3}
Electrolyte electric conductivity, (1/ohm-m)	1.9
Electric conducting structure emissivity ϵ_S, (unitless)	0.8
Interconnect emissivity, ϵ_I, (unitless)	0.1

SOEC/Electrolyzer Control

The electrolyzer conversion is controlled based on a simple proportional-integral (PI) controller. The controller reads the measured H_2O conversion and compares it to the setpoint of 72.5% (which is the conversion for thermoneutral operation of the cell at design conditions found by trial and error) and then outputs an average current density, j_{avg}, to be applied to a single cell. The average current density then calculates the potential and conversion of the cell until the setpoint is reached.

SOEC/Electrolyzer Discretization

The SOEC cell energy and mass balances are PDEs which need to be discretized in space to form ODEs in time that MATLAB/Simulink can solve. The mass balances are discretized with a first order backward difference (looking upwind) for the first derivatives. The energy balance for the cathode and anode stream is also discretized with a first order upwind difference for the first derivatives. The interconnect material and the electric conducting structure include second derivatives for space and they are discretized with a first order backward difference (looking upwind).

Parabolic Trough Collector Supplementary Model Details

Full detail with parameters and more information is supplied in [2].

References

[1] J. S. Kim, R. D. Boardman, and S. M. Bragg-Sitton, “Dynamic performance analysis of a high-temperature steam electrolysis plant integrated within nuclear-renewable hybrid energy systems,” *Appl. Energy*, vol. 228, no. July, pp. 2090–2110, 2018, doi: 10.1016/j.apenergy.2018.07.060.

[2] J. Immonen and K. M. Powell, “Dynamic optimization with flexible heat integration of a solar parabolic trough collector plant with thermal energy storage used for industrial process heat,” *Energy Convers. Manag.*, vol. 267, no. June, p. 115921, 2022, doi: 10.1016/j.enconman.2022.115921.