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Methodology to Develop Off-Design Models of Heat Exchangers with Non-Ideal Fluids

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Abstract

Supercritical CO₂ (sCO₂) closed Brayton cycles are promising heat engines for next-generation thermal power plants since they are efficient, highly scalable, and compatible with a variety of heat sources. A potential application for these cycles is load-following concentrating solar power plants with thermal storage, which will frequently operate at off-design conditions. Accurate and computationally efficient models of the cycle's heat exchangers and turbomachinery are required to assess and optimise its off-design performance. The printed circuit heat exchangers (PCHEs) used in the sCO₂ closed Brayton cycle are challenging to model since they exhibit non-ideal-gas effects and typically use zigzag channels, for which flow patterns and heat transfer mechanisms are not completely understood. Moreover, heat transfer correlations that capture all effects relevant to a given geometry and flow conditions are often unavailable.

We present a methodology to develop accurate and computationally efficient on- and off-design models of heat exchangers that exhibit complex nonlinear behaviours. This methodology involves fitting a 1D discretised heat exchanger model to experimental data using nonlinear least-squares optimisation. Unknown internal heat exchanger geometric parameters are used as fitting parameters.

We demonstrate the proposed methodology by developing numerical models for two PCHEs: (1) an sCO₂-sCO₂ PCHE operating far from CO₂'s critical point and (2) an oil-sCO₂ PCHE oper-

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