Influence of Equations of State and Mixture Models on the Design of Heat Exchangers for Supercritical Power Cycles using CO2-based Mixtures

Sebastian Rath[1, S, C] and Andreas Jäger[1]

[1]*Thermal Power Machinery and Plants, TU Dresden, Dresden, Germany*
sebastian.rath@tu-dresden.de

Due to its potential for considerably higher efficiencies by a simultaneous reduction in complexity and size of individual components, there is an increasing interest in supercritical CO_2 to be used as working fluid in power cycles. In this context, mixtures are also being considered in order to better adapt the process to existing boundary conditions, e.g., aiming for higher efficiencies or facilitate re-cooling at elevated ambient temperatures [1]. While for most pure fluids highly accurate equations of state (EoS) are available and easily accessible in common design tools, the options for evaluating mixtures are often rather limited. Consequently, in many cases the EoS for mixtures available in the design tools are used without considering the validity of the mostly simpler formulations, e.g. cubic equations of state or predictive approaches. It has already been shown that different equations can lead to considerable deviations in component design even for pure CO_2 [2]. As the properties of mixtures are usually calculated by a combination of multiple EoS and mixture models, there is a possibility of even greater variations that must be taken into account, e.g. when solutions gained with different equations are to be compared.

Using the example of a heat exchanger, designed for a CSP application within the research project SHARP-sCO_2, this work demonstrates how different EoS and mixture models may influence the design result for this device. By using the in-house heat exchanger design tool fhex, which relies on the thermodynamic property software TREND [3], designs for a selection of mixture candidates are carried out with different combinations of EoS and mixture models. Herein, predictive approaches are also included, which are particularly of interest given that often mixtures are considered for which no or only a limited amount of adjusted parameters are available (e.g., CO_2+Xe , CO_2+Ne or CO_2+SF_6, cf. [1,4–7]).

Results show considerable differences in the design results even for adjusted equations. An exemplary overview of the suitability of individual equations of state for the design of components for sCO_2-based mixtures is provided.

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