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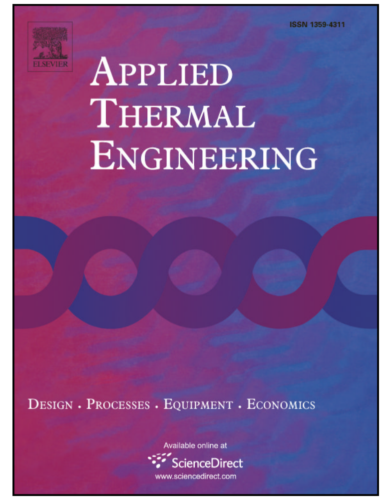

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Vinicius K. Scariot, Gustavo M. Hobold, Alexandre K. da Silva

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ON THE SENSITIVITY TO CONVECTIVE HEAT TRANSFER CORRELATION UNCERTAINTIES IN SUPERCRITICAL FLUIDS

Vinicius K. Scariot, Gustavo M. Hobold and Alexandre K. da Silva*

Department of Mechanical Engineering, Federal University of Santa Catarina, Florianopolis, SC 88040-900, Brazil

Abstract

Most industrial heat transfer applications involve the utilization of heat transfer correlations to estimate heat flow. Due to their simplicity, these equations often carry significant uncertainty in their utilization. This study theoretically investigates the effect of the uncertainty of convective heat transfer correlations on measurable bulk flow properties such as the temperature and enthalpy using a steady state, dimensionless, one-dimensional internal flow model of a supercritical fluid heat exchanger. The sensitivity of bulk quantities to uncertainties in a correlation is shown to be a function of various parameters, including flow geometry, and, more importantly, thermophysical properties, through the Stanton number. The analysis shows that the fluid's bulk temperature and enthalpy exhibit varying sensitivity to a correlation uncertainty, depending on local thermophysical properties. In fact, the uncertainty in temperature is attenuated near the critical temperature, whereas the uncertainty in enthalpy peaks as the flow crosses the pseudo-critical line. This behavior is further demonstrated to be a consequence of the strong property variations near the critical point, almost independently of the correlation used to estimate heat transfer. The thermodynamic location where the minimal temperature and maximal enthalpy sensitivity occur agree well with the pseudo-critical line, particularly close the critical point, for many fluids, confirming the thermodynamic nature of the phenomenon. Finally, the analysis is applied to data reported in the literature indicating the practical impact of propagated sensitivity.

Keywords: supercritical fluid, convection heat transfer, correlations, uncertainty.

* Corresponding Author: A. K. da Silva, Email: a.kupka@ufsc.br