Experimental Investigation of Supercritical Heat Transfer of Carbon Dioxide in Parallel Square Microchannels with a Single-Wall Constant Heat Flux Boundary Condition

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Abstract

In the vicinity of the pseudocritical point, supercritical carbon dioxide (sCO_2) undergoes a steep change in properties from "liquid-like" to "gas-like" as it is heated at a constant pressure. This is coupled with a large spike in specific heat which can yield high heat transfer coefficients and heat capacity rates. These unique properties have made sCO_2 an attractive working fluid in next generation power and HVAC&R technologies. In this thesis, a methodology is developed to experimentally characterize heat transfer for multiple parallel microchannels with a hydraulic diameter of 0.75 mm and an aspect ratio of 1. The predictive capabilities of previously developed supercritical heat transfer models were found to be poor with the lowest mean absolute percent error (*MAPE*) of 55.3% for the range of bulk fluid temperatures ($20 \leq T_{in} \leq 100$°C), heat fluxes ($20 \leq q" \leq 40$ W cm^{-2}), mass fluxes ($500 \leq G \leq 1000$ kg m^{-1} s^{-2}), and reduced pressures ($1.03 \leq P_R \leq 1.1$). Interestingly, the subcritical correlations investigated yielded much lower *MAPE* even though the effects of variable fluid properties were not taken into account. Buoyancy is expected to play a role in the heat transfer, especially when the bulk fluid temperature is below the pseudocritical temperature even at this small hydraulic diameter. However, the relative importance of flow acceleration was inconclusive. Despite the apparent importance of buoyancy effects, heat transfer did not degrade, therefore, the flow geometry and the non-conventional heated boundary improved the heat transfer under supercritical conditions.

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