Parametric optimisation of supercritical CO_2 thermal-hydraulic characteristics in microchannels using response surface methodology

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ABSTRACT

This study aims to determine the optimum geometrical and operating parameters of supercritical carbon dioxide ($ScCO_2$) flow through a straight pipe for enhanced heat transferusing the Response Surface Method (RSM). Inlet pressure, inlet temperature, mass flow rate, and pipe inner diameter are selected as design variables while Nusselt number (Nu) and pressure drop are chosen as response functions. The ranges of the input variables considered in the study are inlet pressures (7–10 MPa), inlet temperature (35–80 °C), mass flowrate (0.02–0.05 kg/s), and tube inner diameter (2.8–4.5 mm). The accuracy and validity of the developed mathematical models are validated by comparing the simulation results with published experimental values. The sensitivity analysis results of Nu indicated that the best heat transfer in ScCO2 cooling is found to be associated with the lowest inlet pressure and temperature, the lowest tube diameter, and the highest mass flow rate. Moreover, the best flow conditions with minimum pressure drop are associated with the highest and lowest inlet pressure and temperature, respectively, as well as the highest tube diameter and lowest mass flow rate. These parameter combinations could help reduce the pumping power associated with a high pressure drop.

KEYWORDS

Heat exchanger; Heat transfer; Numerical simulation; Pressure drop; Response surface methodology (rsm); Supercritical carbon dioxide

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