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Heat Transfer Characteristic Analysis of Supercritical CO_2 Based on Heat Current Method Combining with Entransy Dissipation

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Extended Abstract

Supercritical carbon dioxide (CO_2), as the non-poisonous, incombustible and environment-friendly working medium has been widely used in various industrial fields such as refrigeration systems, nuclear plants, and solar thermal power plants [1]. Meanwhile, the drastic variation of fluid physical properties with the temperature and pressure generates new obstacles for the analysis and optimization of thermal systems. Some numerical [2] and experimental [3] investigations for calculating the convective heat transfer coefficient by some empirical correlations are not convenient to the consideration of the fluid properties, heat exchanger structure and operational parameters in the analysis and optimization of thermal systems. Therefore, this contribution introduces the entransy dissipation concept [4, 5] and heat current method [6] to analyze the heat transfer process of supercritical CO_2. Firstly, a physical model of a counter-flow heat exchanger between the supercritical CO_2 and water is constructed and used for simulating the heat transfer process under different supercritical pressures. The comparison between the simulation and the experiment results in the reference shows that the calculation model is feasible for this research.

On this basis, we calculate and obtain the entransy dissipation-based thermal resistance along the flow direction of supercritical CO_2, and analyze the influences of the flow diameter, length, pressure and the inlet temperatures of the supercritical CO_2 and water on the thermal resistance, respectively. The results show that the thermal resistance is a general parameter that can represent the heat transfer performance of a supercritical CO_2 heat exchanger influenced by various factors including the flow rates, heat transfer area, and thermal properties. The distribution of thermal resistance represents that the heat transfer ability will decrease and then increase from the inlet to the outlet of supercritical CO_2. Meanwhile, the minimum of thermal resistance exists in the heat exchanger that shows the best heat transfer performance where the heat capacity rate is the largest due to the largest specify heat capacity. The inlet thermal resistance of the heat transfer process is the maximum. Besides, with the increase of the working pressure, the minimum of thermal resistance will increase due to the decrease of the heat capacity rate. That is, the thermal resistance is convenient and significant for integrated analyzing the heat transfer characteristic of supercritical CO_2 with consideration of fluid property variation.

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