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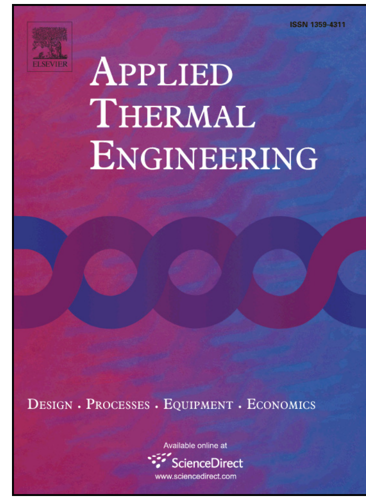

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Numerical analysis on nonuniform heat transfer of supercritical pressure water in horizontal circular tube

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Abstract

A numerical simulation is conducted in this paper aiming to further reveal the nonuniform heat transfer mechanism of supercritical pressure water in horizontal circular tube. The governing equations are solved by finite volume method, and the renormalization group k-ε turbulence model (RNG k-ε model) with enhanced wall treatment is utilized to predict the coupled wall-to-fluid heat transfer. A good agreement between the numerical results and experimental data indicates high accuracy and reliability of the numerical method. On this basis, the nonuniform heat transfer characteristics of supercritical water and corresponding mechanism are analyzed, and the lateral secondary flow and the criteria for onset of buoyancy effect on heat transfer are also discussed. The numerical results exhibit that: (1) the RNG k-ε turbulence model with enhanced wall treatment is recommended; (2) the strong circumferential nonuniformity in heat transfer exists in horizontal tube due to the flow asymmetry, and the variation of heat flux and pressure can bring on a remarkable change in heat transfer; (3) the lateral secondary flow results from the buoyancy and thermal acceleration, and the interactive influence between secondary flow and thermophysical properties of supercritical water exerts significant effects on heat transfer; and (4) the criterion of Jackson–Hall $Gr/Re^{2.7}$ accurately evaluates the onset of buoyancy effect and predicts heat transfer deterioration for horizontal flow of supercritical water.

Key words: Numerical simulation; RNG k-ε model; Supercritical pressure water; Nonuniform heat transfer; Buoyancy; Secondary flow