Numerical Simulation on Flow and Heat Transfer Characteristics of Supercritical Fluids in Mini-Channels

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Abstract
This paper investigated the flow and heat transfer characteristics of supercritical carbon dioxide (SC-CO_2) and supercritical water (SC-H_2O) in horizontal micro-channels using a CFD approach. Model of a straight circular pipe of stainless steel with internal and external radii of $R_i = 0.475$ mm and $R_o = 0.865$ mm, respectively, and a heated length of 55 mm was considered. For the simulation, carbon dioxide and water at supercritical pressures of 9.5 MPa and 22.07 MPa respectively were used, while uniform heat was applied on the outer surface of the tube. The thermodynamics properties for both fluids were obtained from the NIST Chemistry Web book. The simulated temperature and heat transfer coefficient variation were compared with experimental results from literature. In general, the simulation results were close to the experiment. Both the simulation and experimental results showed that the wall temperature increased along the tube length. As expected, the heat transfer coefficient values for both supercritical fluids decreased as the length of the tube. This was due the reason that a maximum and dominant convection heat transfer occurred at the entrance of the heated section of the pipe. The results from this study could assist in decisions regarding the use of supercritical fluids in industries which involve heat transfer.

Index Terms—Supercritical fluid, Computational fluid dynamics, heat transfer, simulation.