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A new approach for predicting the pool boiling heat transfer coefficient of refrigerant R141b and its mixtures with surfactant and nanoparticles using experimental data

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Abstract

In the present study, the pool boiling process for the refrigerant R141b and its mixtures with Span 80 surfactant and TiO_2 nanoparticles has been examined. The results for the heat transfer coefficient (HTC) were taken at various boiling pressures (0.2, 0.3, 0.4 MPa) in the range of the heat fluxes 5.8–56.4 kW m^{-2} and for the internal boiling characteristics (IBC) such as the bubble departure diameter, frequency and velocity of bubble growth at atmospheric pressure in the range of the heat fluxes 29.6–57.0 kW m^{-2}. We found that the additives of Span 80 and Span 80/TiO_2 nanoparticles enhance the HTC at the lower heat flux densities and pressures. However, at higher values of the heat flux and pressure the HTC was deteriorated by the additives. At the same time, no significant impact was obtained for the IBCs. An analysis of the Rensselaer Polytechnic Institute model performance for the case when experimental data on the nucleation sites density is unavailable has revealed no qualitative agreement between experimental and predicted data on the HTC. Thus, we proposed a new approach that combines limited set of the experimental data (LSED) with correlations of the IBC's versus heat flux and pressure. Finally, the LSED allowed to achieve both qualitative and quantitative agreement (within ± 10%) between predicted and experimental data on the HTC.

Keywords Pool boiling · Heat transfer coefficient · Experiment · Model · Surfactant · Nanoparticles · Nanofluid