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Modelling Of Subcooled Flow Boiling For Saline Solution Using New Bubble Dynamic Parameter Models

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Extended Abstract

Flow boiling heat transfer has been widely used in the industrial applications due to its high heat transfer coefficient. In water shortage regions such as Xinjiang province of China, for the purposes of freshwater saving and environment protection, the treated heavy oil recovery wastewater containing salts with positive solubility (solubility increases with the increase of temperature such as sodium chloride) is required to be recycled in the steam-injection boiler. The heat transfer performance of the saline solution is somewhat different to those of pure water, causing great challenge for the design and safe operation of steam generator. Bubble dynamic parameters during boiling are believed to be one of the most important aspects can help us to deeply understand the heat transfer differences. In this work, the bubble dynamic parameters, including bubble departure diameter (D_w), departure frequency (f) and active nucleation site density (N_w), for subcooled flow boiling of NaCl solutions with concentration of 0%-6% were experimentally studied. After the careful analyses of the experimental data, the influences of the operating parameters, including the mass flux, heat flux, wall superheat, inlet fluid subcooling and solution concentration, for each of the three bubble parameters were determined. The dimensionless groups, which can be used to characterize the variations of D_w, f and N_w were suggested. The results show that the dimensionless parameters including Boiling number (Bo), density ratio (ρ^*), dimensionless surface tension, Prandtl number and a suggested dimensionless temperature (Λ_T), can be used to characterize the variation of D_w. The dimensionless groups of Bo, ρ^*, Λ_T, and the non-dimensional bubble departure diameter, can be used to correlating with the non-dimensional departure frequency. As for N_w, the wall superheat and solution concentration are the most critical influencing factors. Furthermore, the prediction models for D_w, f and N_w were built using the correlation method based on the analyses of the influencing parameters and dimensionless groups. The prediction accuracy for the new developed models were validated against the experimental data. For further verification, the new models were incorporated into the RPI (Rensselaer Polytechnic Institute) model using the User-Defined Function (UDF) to simulate the heat transfer of subcooled flow boiling of saline solution. The predicted results agree well with the experimental data, indicating a great prediction performance of the new models.

Keywords: subcooled flow boiling; salt solutions; bubble parameter models; key influencing parameters; dimensionless parameters