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C3Po1C-07: Study on the flow nucleate boiling heat transfer of slush nitrogen

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A three-dimensional numerical simulation method is developed to predict the heat transfer characteristics during the flow boiling of cryogenic slurry in horizontal circular pipes, based on Euler-Euler model with a boiling model for liquid-vapor mass transfer. The model incorporates the Ishii model for vapor-liquid interaction and the Huilin-Gidaspow model for solid-liquid interaction, also with the modification accounting for slush effective viscosity. The modification enables to simulate the effects of solid particle on bubble detachment. The model can well demonstrate the heat transfer characteristics of subcooled liquid hydrogen, and also the solid phase distribution in slush nitrogen pipe flow. The simulation results show that an increased heat flux can result in a higher vapor volume fraction at the wall and a corresponding decrease in solid volume fraction. At low heat flux, an increase in solid volume fraction enhances the boiling heat transfer, while at higher flux, the solid phase suppresses the heat transfer. Consistent trends are observed in both bottom and surrounding heating layouts. Furthermore, turbulence analysis shows that solid particles can increase turbulent kinetic energy near the wall but inhibit its diffusion toward the pipe center, which indicates that the bubbles will induce the solid particles to accumulate toward the pipe center, while the solid particles inhibit the bubbles releasing from the pipe wall, thereby suppressing the boiling heat transfer.

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