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Numerical study of the gas-liquid separation of cryogenic fluids with porous structures

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Abstract
Gas-liquid phase separation based on the porous media is vital for the stable operation of rocket engines in microgravity. To reveal the mechanism of nonisothermal phase separation with the porous media, a pore-scale numerical simulation is conducted to investigate the gas breakthrough at the porous array structure. Liquid oxygen and oxygen vapor are taken as the working fluids. The phase-field method is adopted to capture the gas-liquid interface. The influences of the inlet temperature and solid-liquid heat transfer on the flow characteristics are investigated. The results show that the bubble size increases rapidly under superheated inlet temperature when compared to that under subcooled inlet temperature. Without considering heat transfer, the critical pressure increases with the increase of the inlet temperature. Under subcooled inlet temperature, the condensation rate is reduced with the increase of the heat flux, and even the evaporation rate is stronger than the condensation rate. The bubble breaks into small daughter bubbles easily under high heat leakage due to the increasing size. The transit time is dependent on the bubble behavior, which is related to the driving pressure, inlet temperature, and heat leakage. The synergetic effect of inlet temperature and heat flux on the critical pressure shows that the critical pressure is more dependent on the inlet temperature when compared with the heat leakage.

Keywords: cryogenic propellants, phase change, porous structure, critical pressure, phase-field method

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