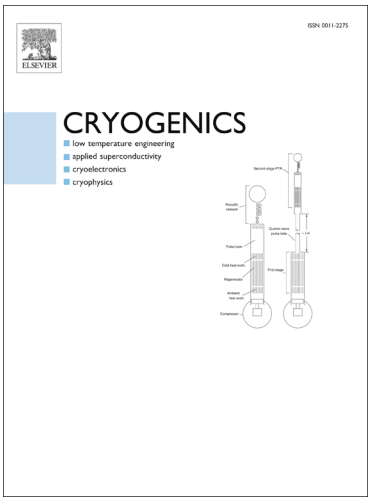

Research paper

The influence of cavitation on the flow characteristics of liquid nitrogen through spray nozzles: a CFD study

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The influence of cavitation on the flow characteristics of liquid nitrogen through spray nozzles: a CFD study

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Abstract

Spray cooling with cryogen could achieve lower temperature level than refrigerant spray. The internal flow conditions within spray nozzles have crucial impacts on the mass flow rate, particle size, spray angle and spray penetration, thereby influencing the cooling performance. In this paper, CFD simulations based on mixture model are performed to study the cavitating flow of liquid nitrogen in spray nozzles. The cavitation model is verified using the experimental results of liquid nitrogen flow over hydrofoil. The numerical models of spray nozzle are validated against the experimental data of the mass flow rate of liquid nitrogen flow through different types of nozzles including the pressure swirl nozzle and the simple convergent nozzle. The numerical studies are performed under a wide range of pressure difference and inflow temperature, and the vapor volume fraction distribution, outlet vapor quality, mass flow rate and discharge coefficient are obtained. The results show that the outlet diameter, the pressure difference, and the inflow temperature significantly influence the mass flow rate of spray nozzles. The increase of the inflow temperature leads to higher saturation pressure, higher cavitation intensity, and more vapor at nozzle outlet, which can significantly reduce mass flow rate. While the discharge coefficient is mainly determined by the inflow temperature and has little dependence on the pressure difference and outlet diameter. Based on the numerical results, correlations of discharge coefficient are proposed for pressure swirl nozzle and simple convergent nozzles, respectively, and the deviation is less than 20% for 93% of data.