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Experimental study of enhanced cryogenic cool-down performance in metal pipe with polymer coating on the inside

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Cryogenic fluids such as liquid oxygen, hydrogen and nitrogen are used in rockets and superconducting applications. Boiling heat transfer occurs between the liquid and solid interface during initial cooling from room temperature to cryogenic temperature. Boiling heat transfer performance has a significant impact on the cooling speed. The largest heat flow occurs in nucleate boiling, but has a short range in the cool-down process, while film boiling has a relatively small heat flow due to the vapor film, but has a long range in the cool-down process. Previous research has confirmed that polymer coating on a metal surface increases cooling speed by reducing the film boiling process within pool boiling, but understanding of flow boiling is limited. Flow boiling is a complex effect caused by vapor-liquid flow as well as the liquid-solid interface. Therefore, it is greatly influenced by the pressure, flow rate, and type of two phase flow.
In this paper, liquid nitrogen was used to experimentally analyze the cool-down performance of horizontal stainless steel pipe with polymer coating on the inside according to the coating material, coating thickness, and flow conditions. The polymer coating significantly improved heat transfer efficiency and reduced cool-down time. The proposed pipe with polymer coating on the inside presents a competitive method for accelerating rapid fueling and rapid pipeline cool-down operation for future cryogenic mobility application.

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