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C1Po1A-03: Enhanced cryogenic boiling heat transfer by surface coating of metal

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Boiling heat transfer of cryogenic fluid is strongly related with various industrial field such as liquefied natural gas (LNG), superconducting electromagnet, and hydrogen plant, which have recently been in the spotlight as eco-friendly energy. To reach the operation temperature, initial cooldown process of the cryogenic system is an important issue in terms of coolant consumption and the corresponding cost. When the cryogenic fluid directly starts to contact the surface of a metal object at room temperature in the initial cooling, a film boiling heat transfer occurs due to a large temperature difference and the heat transfer rate is limited by vapor film between the cryogenic fluid and solid surface. It is known that a thin surface coating of solid surface with low thermal conductivity material can increase the cooling speed by increasing the Leidenfrost temperature and the peak nucleate boiling. In this paper, Stainless Steel 316L, Copper, and Aluminum 6061 test specimens coated with Teflon, Epoxy, and Polyimide tape are prepared and cooldown experiments are conducted in a bath of liquid nitrogen to investigate the enhanced boiling heat transfer. By applying a thin surface coating of less than 200 μm, it is possible to reduce the initial cooldown time by about 50%. The boiling curve is obtained using the Inverse Heat Conduction Method (IHCM). As a result, it is verified that an appropriate surface coating increases the effective Leidenfrost temperature through the thin, low thermal conductive coating layer, as well as the peak nucleate heat transfer rate due to the modified surface condition. The results of this study are expected to be used to improve the initial cooldown rate of metals used in cryogenic systems.

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