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Film Boiling Heat Transfer from a Round Wire to Liquid Hydrogen Flowing upwards in a Concentric Annulus

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Knowledge of film boiling heat transfer from a heated wire to forced flow of liquid hydrogen in a narrow gap is important for conductor design and quench analysis of superconducting magnets cooled by liquid hydrogen. However there have been few experimental data as far as we know. Film boiling heat transfer coefficients were measured for when the heater surface superheats up to 400 K under pressures from 0.4 to 1.1 MPa, liquid subcoolings from 0 to 11 K and flow velocities up to 7 m/s. The test wire used was 1.2 mm in diameter and 120 mm in length made of PtCo (0.5 at. %) alloy, which was located at the center of 8 mm diameter conduit made of FRP (Fiber Reinforced Plastics). Temperature of the test wire was measured by resistance thermometry. The heating current was first gradually increased for a low flow rate up to the DNB heat flux. Flow rate was increased to a desired value and heating current was increased to the heater temperature around 400 K, after a jump to film boiling. Then the heating current was gradually decreased and film boiling heat transfer coefficients were measured. The film boiling heat transfer coefficients are higher for higher pressure, higher subcooling, and higher flow velocity. The film boiling heat transfer coefficients were compared with Shiotsu-Hama equation [1] for forced flow film boiling in a wide channel based on numerical analysis and experimental data. The film boiling heat transfer coefficients obtained were about 1.6 times higher than the predicted values by the equation, although the tendency of dependence on flow rate was similar. Discussions were made on the mechanism of difference between them.
[1] M.Shiotsu and K. Hama, Nuclear Engineering and Design, 200.1, (2000), 23-38.

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