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Film Boiling Heat Transfer from a Wire to Upward Flow of Liquid Hydrogen and Liquid Nitrogen

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Knowledge of film boiling heat transfer from a heated wire to forced flow of liquid hydrogen or liquid nitrogen in a narrow gap is important for conductor design and quench analysis of superconducting magnets wound with high-Tc cable in conduit conductor (CICC). However there have been few experimental data as far as we know.
Film boiling heat transfer coefficients in liquid hydrogen were measured for 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 8 m/s. Two test wires used were both 1.2 mm in diameter, 120 mm and 200 mm in lengths made of PtCo (0.5 at. %) alloy. The former wire was located at the center of 8 mm diameter conduit and the latter was at the center of 5 mm conduit made of FRP (Fiber Reinforced Plastics). Film boiling heat transfer coefficients in liquid nitrogen were measured only for the 200 mm long wire. Temperature of the test wires were measured by resistance thermometry. The film boiling heat transfer coefficients are higher for higher pressure, higher subcooling, and higher flow velocity. The experimental data were compared with Shiotsu-Hama equation [1] for forced flow film boiling in a wide channel based on numerical analysis and experimental data. The data for 8 mm diameter conduit were about 1.7 times and those for 5 mm conduit were about 1.9 times higher than the predicted values by the equation. A new equation was presented modifying the Shiotsu-Hama equation based on the liquid hydrogen and liquid nitrogen data. The experimental data were expressed well by the equation.

[1] M.Shiotsu and K. Hama, Nuclear Engineering and Design, 200.1, (2000), 23-38.

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