§10. Critical Heat Flux on a Flat Plate in Subcooled Liquid Helium

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Knowledge of the critical heat flux (CHF) in a pool of liquid helium is important as a database for the design of superconducting magnets cooled by liquid helium. However, little is known on the effect of subcooling and inclination of a flat plate upon CHF for liquid temperatures down to below λ temperature.

The purposes of this work are first to clarify the effect of the inclination angle systematically from that facing upward to that facing downward in subcooled He I down to below λ temperature, and second to present a correlation of critical heat flux in He I that can describe the effects of subcooling and the inclination based on the experimental data. Third is to clarify the effect of surface oxidation. The results of the first and second purposes were already attained and reported last year.

In this work, the CHFs were measured for the one-side insulated flat plates for bulk liquid temperatures from saturated ones down to 2.0 K at pressures of 101 and 130 kPa. The test plates were made of Manganin, 10 mm in width and 40 mm in a length and 0.1 mm in thickness. The test plates with normal surface and with an artificially oxidized black surface were used. The latter one was oxidized by using a liquid named "Ebonol C Special" produced by Meltex Co., Ltd.. Processing temperature and time in the agent were 80 °C and 5 minutes. They were heated by direct current. The temperature of the test plate was measured by resistance thermometry using the test heater as a thermometer. Effect of inclination of the test plate was systematically studied from the horizontal one facing upward $(\theta = 0)$ to that facing downward $(\theta = \pi)$.

Figure 1 shows relationship between the critical heat fluxes on the normal surface and those on the oxidized surface on the graph of q_{cr} versus T_b at the pressure of 101.3 kPa. Solid symbols show the results for the oxidized surface test plate and open symbols show those for the normal surface test plate. As shown in the figurte, the values of q_{cr} for the oxidized surface facing upward are about 20 % higher than those for the normal surface at the same bulk liquid temperature in He I region, although this effect already observed in saturated He I by Iwamoto (1996). This increase becomes smaller with the increase of angle, and it is seldom effective in θ=π. It should be noted that the effects of the inclination angle and surface condition are the characteristics peculiar to the He I region. The critical heat fluxes in He II region are almost the same regardless of the inclination angle and surface oxidation.

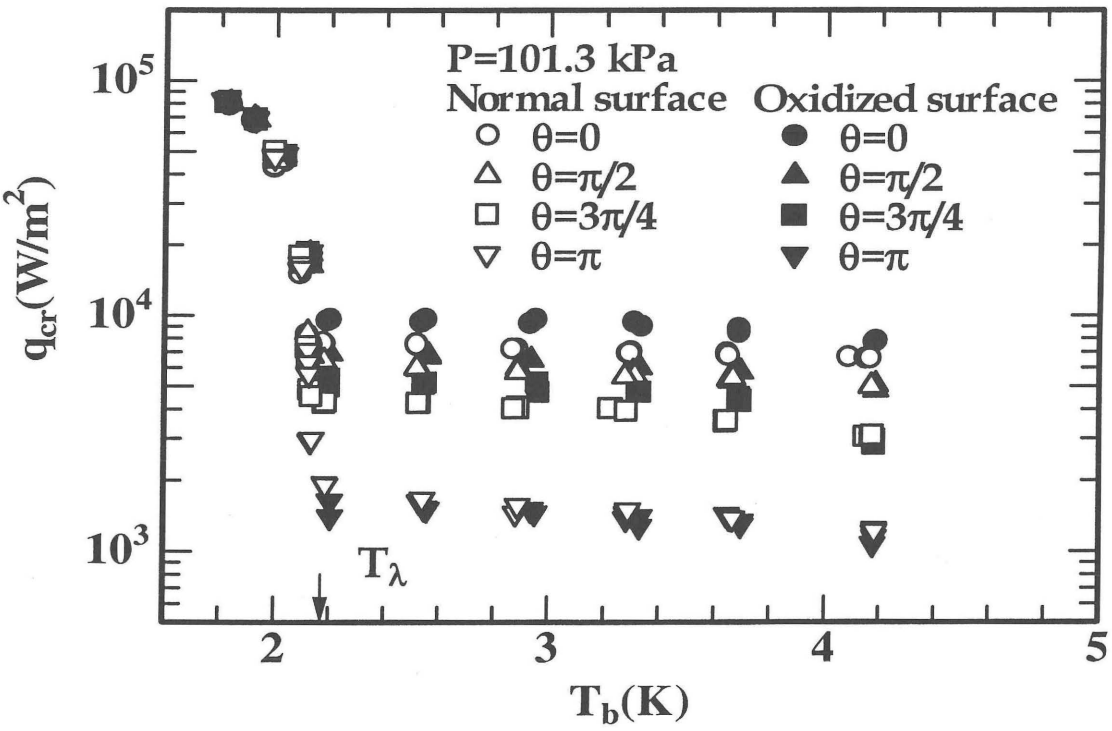

Fig.1 Relation between critical heat flux and bulk liquid temperature on oxidized surface.