§8. Dependence of Heat Transfer from a Large Cu Plate to Liquid Helium on Surface Treatment and Orientation

Iwamoto, A., Mito, T., Takahata, K., Yanagi, N., Yamamoto, J.

The heat transfer characteristics change according to heat transfer surface orientation, area, and treatment. In the magnets for the fusion application, the surface orientation of the superconductor changes according to the winding position, and the surface treatment of oxidization is applied to the heat transfer surface of the superconductor. The heat transfer characteristics from large surface with some treatment is required to estimate the stability of the large superconductor exactly. The purpose of this study is to measure the heat transfer from a larger copper plate to liquid helium by changing the surface orientation and treatment which is applicable to the cryogenic stability analysis of the large scale superconductors.

Figure 1 shows the dimension of the sample and treatment of the surface. In Fig.1, sample (a), (b), (c) and (d) are polished Cu surface, 100% oxidized Cu surface, two types of 50% oxidized Cu surface, respectively. The surface roughness of the polished surface was less than 10 μm. The surface was heated uniformly by a thermofoil heater attached on the reverse side of the copper plate. The sample was covered with a FRP holder except for the heat transfer surface to insulate liquid helium. Temperature difference between the surface and the liquid helium was measured by AuFe-Chromel thermocouples. They were attached at equal intervals of 17 mm in the longitudinal direction and at 1 mm deep from the surface (Fig.1). The heat surface orientation was varied from 0°(horizontal, heat surface upward), through 90°(vertical), to 180°(horizontal, downward) with the interval of 15°.

Figure 2 shows the dependence of the critical heat flux (denoted by CHF) and the minimum heat flux (MHF) on the heat transfer surface orientation of the sample (a), (b), (c) and (d). We found that the critical heat flux strongly depends on the heat transfer surface orientation. At the angles above 30°, the critical heat flux decreases with the increasing angle. It becomes maximum between 0° and 30° of the surface orientation. On the other hand, the minimum heat flux shows less dependence on the orientation, except for around 180°. As Figure 2 shows, the oxidization of the whole heat transfer surface (sample (b)) improves the critical and the minimum heat fluxes compared with those of the polished surface. The minimum heat fluxes of the sample (c) and (d) agree with that of the sample (b). On the other hand, the critical heat fluxes of the sample (c) and (d) almost agree with that of the sample (a). The difference of the heat transfer characteristics between sample (c) and (d) cannot be found.