§35. Heat Transfer Characteristics of a Prototype Pool Boiling Superconductor to Liquid Helium

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A pool boiling superconductor is applied to the helical coil[1]. Usually, according to Maddock's equal area theorem, the stability of the large sized superconductor, for example, the helical coil superconductor, have been analyzed. In the analysis, the heat transfer characteristics decides the stability of the superconductor. For the reliable stability analysis, the heat transfer characteristics of a prototype superconductor have to be investigated. In the helical coil, conductor orientation varies according to the winding position. Liquid helium is limited in the coil because of the cooling channel. To analyze the stability of the helical coil, the effects of the sample orientation and the cooling channel must be estimated. In this study, the heat transfer of liquid helium for the stability analyses was measured as a function of surface orientation and channel width.

The prototype superconductor was a polished copper block with 72 mm long and 18 x 18 mm cross section. The schematic illustration is shown in Fig.1. Dependence of the heat transfer on channel width and sample orientation was investigated. The surface roughness was less than 10 μm. The sample orientation was changed form 0° (horizontal) to 90° (vertical). The copper block was surrounded by four stainless steel plates to make up a cooling channel. The channel width was 2, 3 mm or open. Temperature difference between the surface and the liquid helium was measured using AuFe-Chromel thermocouple.

Figure 2 shows the dependence of the critical and the minimum heat fluxes on sample orientation and channel width. The critical heat fluxes depended on the sample orientation and increased as the sample orientation increased from 0° to 45° and decreased from 45° to 90°. The CHFs had a peak at 45°. The CHFs were significantly affected by the channel width and were improved as increasing the channel width. The channel width of more than 3 mm makes the heat transfer be as same as that without a channel. It is assumed that a narrow cooling channel prevented liquid helium from being supplied to the heat transfer surface. On the other hand, the minimum heat fluxes were less dependent on the surface orientation as well as the channel width than the critical heat fluxes. According to these experimental results, it is thought that the stability of a pool boiling superconducting magnet with more than 3 mm channel width is almost as same as that of its superconductor.

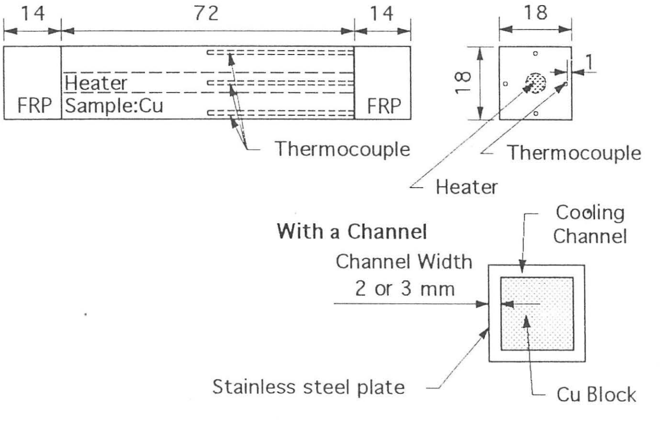

Fig.1 Schematic illustration of the prototype superconductor

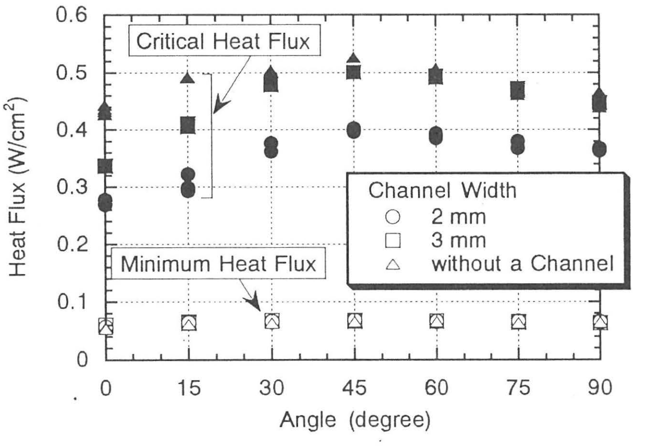

Fig.2 Dependence of the critical and the minimum heat fluxes on sample orientation and cooling channel width

Reference

1) Yanagi, N. et al. : Advances in Cryogenic Engineering 40 (1994) 459-468