§3. Study on Stability of Superconducting Cables under Cooling with He II

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1. Introduction

Superconducting magnets for nuclear fusion systems require large currents and high magnetic field. For these requirements, superconducting magnets need to be cooled with He II. Under the condition of He II cooling, superconducting magnets may behave with different stabilities caused by the reduced specific heat, heat conduction, etc. of helium in comparison with cooling at 4.2 K. Therefore, it is considerably important for superconducting magnets of fusion systems to obtain information on stabilities of superconducting cables under the He II cooling. We have studied these problems under the He II cooling condition.

2. Heat conduction of He II

We have carried out experimental studies of heat conduction in He II depending on the shapes of micro-channels using a equipment which has a cavity and a micro-channel as shown in Fig. 1(a). The different shapes of the micro-channels are two types, round and rectangular, whose cross-sections are three different areas for each shape. The heat from the heater inside the cavity is transported through the channel, and finally the temperature increases beyond the λ point by increasing the input heat power. The critical heat flux at the λ temperature obtained by the experiment is plotted for the bath temperatures in Fig. 1(b). For the comparison, the data from other experiments are shown in the same figure. From this experiment, we can say that there is no shape dependence on the critical heat flux and an one-dimensional model in the region of turbulence of superfluid helium can be applied to estimation of heat conduction through micro-channels of a few tens of microns. This means that we can calculate heat conduction through complicated shape micro-channels consisting of insulation tapes of cables and then estimate their stabilities in He II.

3. Development of pressurized superfluid helium test equipment

We have developed test equipment which is designed to perform various studies in pressurized superfluid helium. We also plan to install an 1-m long dipole magnet with an aperture of 50 mm ϕ in order to test performance of cables in a magnetic field of 7 T. It will be very useful for R&D of the phase II program of LHD. We have carried out the performance test and obtained a cooling capacity of 19 W at 1.8 K and 8 W at 1.7 K. The lowest temperature reached was 1.63 K.

4. Summary

We have carried out the experiment of heat conduction through micro-channels apparently 50 μm in pressurized He II. From the results obtained, we showed that the critical heat flux does not depend on the shape of the micro-channels and an one-dimensional model in the turbulence region can be applied to calculate the heat conduction. The data obtained by this experiment gives us important information to estimate stabilities of superconducting magnets under pressurized He II cooling.

Moreover, we have developed the test equipment for pressurized He II and confirmed the cooling capacity of 19 W at 1.8 K.

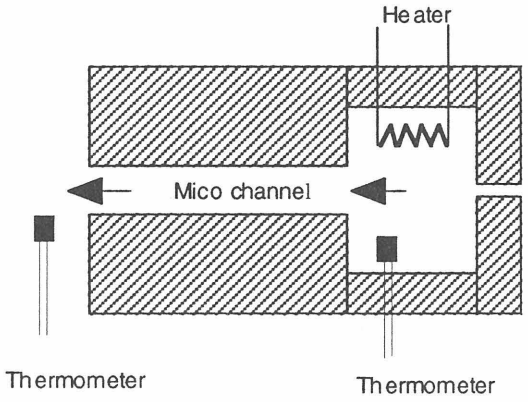

Fig. 1(a) Equipment to measure the critical heat fluxes.

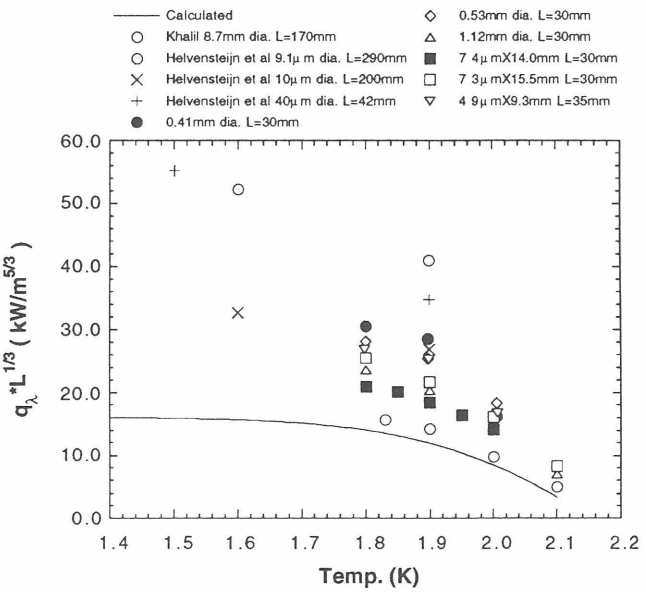

Fig. 1(b) The measured critical heat fluxes in comparison with other data and calculated one.