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

Shintomi, T., Yamamoto, A., Kimura, N., Haruyama, T. (High Energy Accelerator Research Organization), Mito, T., Iwamoto, A., Maekawa, R.

1. Introduction

Effective heat removal from superconducting coils is a great concern to obtain stable operation of fusion reactor superconducting magnet systems. The heat transfer in pressurized He II has been investigated by focusing on its characteristics through narrow channels around the superconducting coils.

A simplified model experiment has been carried out to investigate the heat transfer characteristics through the well-defined narrow channels with both circular and annular cross-sections.

2. Experimental set-up

To simulate the heat transfer characteristics in He II through the cooling channels in a superconducting magnet, two types of the cross sections with *circular* and *annular* types were prepared for a series of experiments. The cross section of the prepared cooling channels covered the area from 4.34×10^{-9} to 1.71×10^{-5} m^2.

A cutout side view of the specimen is shown in Fig. 1. Each specimen was assembled with a heat bath containing a heater and a thermometer. The heater was used to generate heat input, Q, in the heat bath.

The heat flow through the channel was generated by slowly increasing the heater current under in pressurized He II. When the heater current was increased, a long relaxation time was necessary to keep a steady state condition in the heat bath for each measurement. The data acquisition was started after confirming the steady state condition inside the heat bath and the temperature difference was measured between the heat bath and the outside He II bath. The heat was increased in a stepwise manner and the same procedures were repeated until the temperature in the heat bath reached the λ-transition temperature.

3. Results

To clarify the cross-sectional area dependence, all of the measured peak heat flows by this study and other experiments are plotted as a function of the cross-sectional area at the bath temperatures of 1.90 K as shown in Fig. 2. All of the data were normalized by the cubic root of the channel length to be compared in the same dimension. Within the limit of the cross-sectional area that we have measured, it can be seen from the figure that the peak heat flow depends only on the cross-sectional area without any geometrical dependence.

4. Summary

We have confirmed that the heat transfer characteristics in the narrow channels in pressurized He II can be described by using the *Gorter-Mellink equation*, in either case of the circular and the annular cross-sections and no major geometric dependence was verified. The obtained results are applicable for superconducting magnet design.

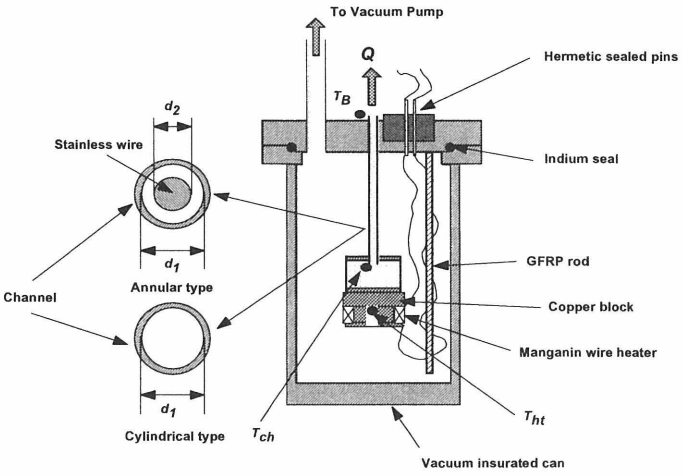

Fig. 1 A cutout side view of specimen along the test channel with the heated section.

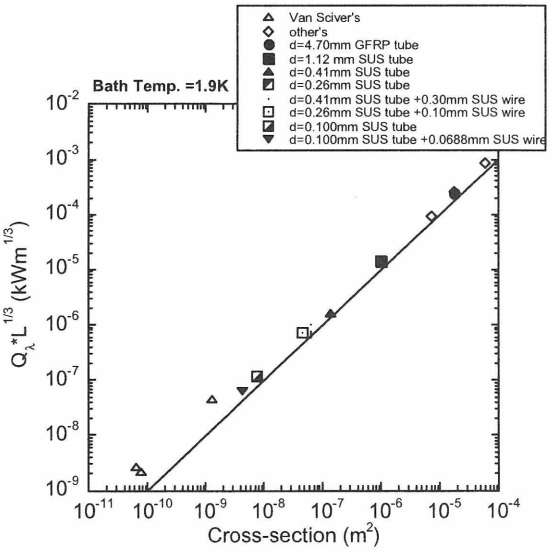

Fig. 2 The measured peak heat rate normalized by the cubic root of the channel length as a function of the cross-sectional area.