§17. Study on Stability of Superconducting Cable under He II Cooling

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1. Introduction

Stranded superconductors in copper or aluminum stabilizing materials are required for superconducting coils of fusion devices because of their large current current capacity. Stability of superconducting cables under He II cooling may be controlled by different conditions from those under He I cooling at 4K. Effects of reduction in conductor specific heat, different heat transfer mechanism of He II, and so on, it may be considered . Therefore, it is very important to clarify the stability problems under He II cooling for the superconducting magnets of the fusion devices, which require large current and high magnetic field. The study has been carried out for the experimental stability of the superconducting cables under He II cooling.

2. Heat Transfer in He II

In order to investigate heat transfer characteristics from superconducting cables to a He II bath, we used a Rutherford cable which has 27 strands of Cu-Ni for simulating a practical superconducting cable. The parameters of the cable are as follows: the strand diameter is 0.814mm, cable width 11mm and cable thickness 1.47mm. The cable is lapped with 50% overlap with a 25μm polyimide tape and lapped again with a gap of 2mm with a 50μm polyamide tape on it to make cooling channels. Six cables were stacked together and heated by a current. The temperature rise was measured with tiny thermometer censors imbedded in the cables. From the measured results, the heat transfer was estimated as shown in Fig. 1. The heat conducts from the cables to a He II bath through micro channels composed between the cables and the tapes.

3. Experimental Simulation of Heat Transfer in He II

In order to simulate the magnet stability affected by the obtained heat transfer through micro-channels, an experimental study using a superconducting magnet has been carried out. The magnet, which is a strong focusing quadrupole for the LHC accelerator under development, was cooled with He II and excited with a triangular shape current profile. The cables in the coil are heated by the ac losses. The heat input power into the cables is estimated from the helium gas flow rate by an evacuation pump which is installed to cool down the bath to superfluid temperature. The measurement was carried out at bath temperatures of 1.9 and 2.05K as shown in Fig. 2. In the figure the solid line corresponds to the margins of the magnet against quench measured by the experiment. At the temperature of 2.05K, the magnet quenched at the excitation of 190A/s; however, it did not at 180A/s. The corresponding heat input of 180A/s is the upper limit of the magnet stability. The results agree very well to the values which are obtained by the heat transfer experiment using the dummy cables. We could not reach the upper limit at 1.9K because of the evacuation capacity of the pump.

4. Summary

We have carried out an experimental study on heat transfer and cooling efficiency through the micro-channels on superconducting cables in a He II bath. Such kind of studies on the heat transfer through small channels has not been carried out. The obtained results give us very important information for the construction of very stable superconducting magnets cooled with He II. The studies might be continued for further information.

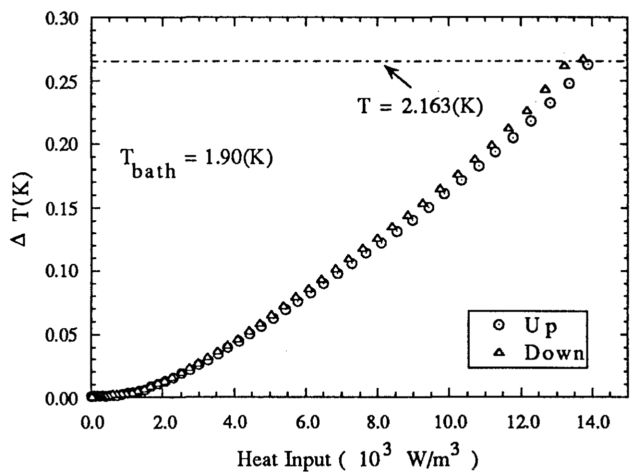

Fig. 1 Cable temperature rise vs. heat input in a He II bath.

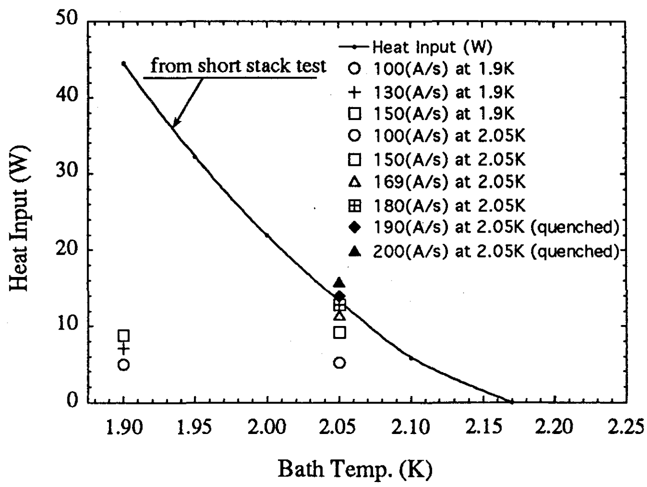

Fig. 2 Allowable heat input in superconducting coil in a He II bath.