§21. One Dimensional Simulation of Normal-state Propagation in Superconducting Conductor

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Abstract

Using one dimensional model, the propagation of the normal state has been studied.

Introduction

The motivation of this simulation study is inspired to explain the results of experiments of the superconducting short sample test[1]. These results are summarized as below; 1) the normal zone was observed to stagnate in a short high field region, 2) the resistance of the conductor was larger than the calculated value of the parallel circuit model, and 3) the distribution of the voltage was not uniform along the conductor. These phenomena could not be expected in larger scale experiment, and therefore, we propose the new physical process to understand; Hall effect is induced and caused the enlargement of the resistance by the different sign of Hall efficient of Cu and Al, and the magnetic field profile is not uniform. The distribution of the temperature along the conductor might not be uniform, and it might generate thermoelectric voltage. In order to confirm these physical picture, we use the one-dimensional simulation at first.

Model

The profiles of the magnetic field and the temperature of the conductor along the current direction are essentially one dimensional, however Hall effect is two dimensional effect. In order to embed Hall effect into the model practically, the resistance obtained in the actual experiment was used to evaluate the resistance of the conductor, and it is proportional to the magnetic field strength. Therefore, the conductivity is calculated by Wiedmann-Frantz law to use the above resistance. The specific heat was calculated by

$$C = \gamma T + \beta T^3 \tag{1}$$

where γ and β depend on materials of conductor, and T is absolute temperature

To study the dependence of the magnetic distribution, two models of magnetic distribution, a long-scale model and a short-scale model, are used. The long-scale model is applied to the uniform distribution of the magnetic field, while the short model is the same magnetic distribution as the profile of the actual experiment.

Results

The results of the simulations are following; 1)Figure 1 shows the propagation boundary between the superconducting and the normal states. The long-scale model has short stagnation window against the magnitude of current. The window of the long-scale model is 0.1kA at most, while short-scale model's is about 0.3kA. 2) The recovery current depends on the initial temperature in the long-scale model. On the other hand, the recovery current of the short-scale model has nothing to do with the initial temperature.

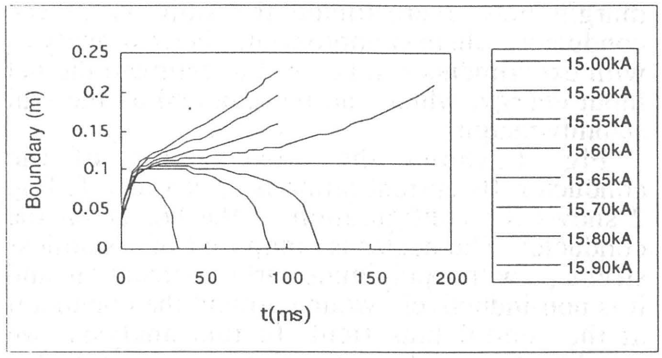

Fig.1 the propagation of normal-state in long-scale model.

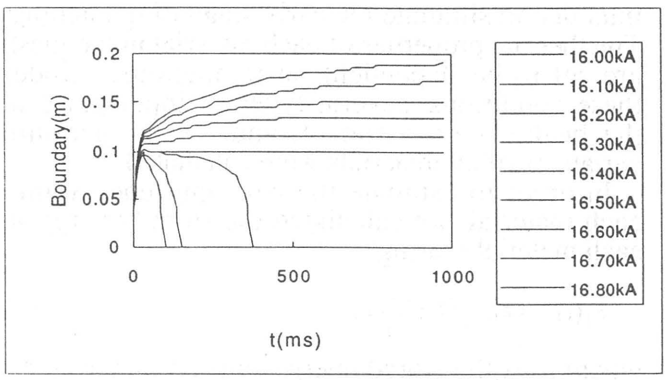

Fig.2 the propagation of normal-state in short-scale model.

Reference

[1]T. Mito, K. Takahata, N. Yanagi, et al., "Short sample tests of aluminum-stabilized superconductors for Large Helical Device", Fusion Eng. Des. 20 (1993) 233.