§9. Stability Analysis of He II Cooled Aluminum Stabilized Superconductor Subject to Conductor Motion

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1. Purpose of study

In the next phase of the LHD experiment, it is planned to cool the helical coil by superfluid helium (He II) to enhance the magnetic field. The conductor for the helical coil is stabilized by aluminum to obtain cryostatic condition. However, it is often observed that there appears "a stagnant moral zone" in such an aluminum stabilized conductor. Aluminum which has much lower resistivity than copper at cryogenic temperature is added to the composite superconductor to improve the stability. However, non-uniformity of contact resistance between the aluminum and composite superconductor may cause the stagnant normal zone together with slow diffusion of current into the aluminum stabilizer. The purpose of the study is to investigate behavior of a normal zone caused by a mechanical disturbance in an aluminum stabilized helical coil conductor cooled by He II. As a preliminary work, we studied a condition that the stagnant normal zone appeared in the helical coil conductor due to the non-uniformity of the contact resistance between the aluminum stabilizer and the composite superconductor.

2. Stagnant normal zone caused by non-uniform contact resistance

A cross sectional view of the helical superconductor with aluminum stabilizer is illustrated in Fig.1. To suppress heating effect caused by the hole effect, a CuNi barrier layer is inserted between the composite superconductor and the aluminum stabilizer as shown in Fig.1. The composite superconductor, aluminum stabilizer and CuNi barrier are placed together in a copper conduit and fixed by soldering. There is a possibility that quality of the soldering is not uniform along the conductor, which causes non-uniformity in the contact resistivity between the aluminum stabilizer and composite superconductor. Fig.2 is an equivalent circuit to calculate current sharing in the aluminum stabilizer, cooper conduit and composite superconductors.

Behavior of a normal zone caused by a disturbance due to a conductor motion in the conductor was investigated using the equivalent circuit shown in Fig.2 and the one dimensional thermal equilibrium equation. It was found that a stagnant normal zone did not appear when the contact resistant was uniform. However, it was shown that, if there were local low contact resistance areas, a stagnant normal zone appeared as shown in Fig.3.

3. Future Plan

In the present analysis, coolant of the conductor was assumed to be normal liquid helium and we plan to investigate behavior of a normal zone in the conductor cooled by He II. To investigate a normal zone caused by a conductor motion, data on transient heat transfer of He II are necessary because duration time of a disturbance due to a conductor motion is less than 1msec. Therefore, we investigate the transient heat transfer of He II in a narrow channel as in gaps between the coil conductors.

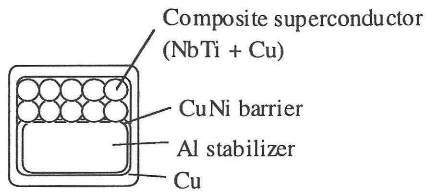
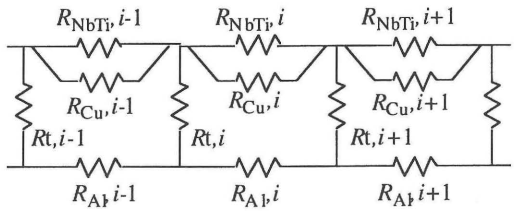


Fig.1. Cross sectional view of helical coil conductor



R_{Al} : Resistance of Al stabilizer

Rt : Contact resistance

R_{Cu} : Resistance of copper part

R_{NbTi} : Resistance of superconductor in flux flow and normal states

Fig.2. Circuit model of conductor

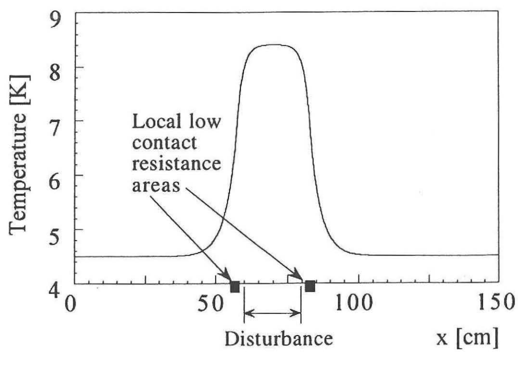


Fig.3. Temperature profile of stagnant normal zone