§10. Stability of Al-Stabilized Composite Superconductor Cooled by He II

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1. Purpose of study

Al-stabilized composite superconductors cooled by He II will be used for the next phase LHD coil. In this study, stability against a conductor motion of the conductor was studied. Stagnant normal zones and traveling normal zones are some times observed in a composite conductor stabilized with aluminum and cooled by He I to satisfy the cryostatic stability condition, when the conductor is subject to pulse disturbances such as conductor motions. In this study, we investigated the possibility of the stagnant normal zones and traveling normal zones when the conductor was cooled by He II.

2. Results of study

We analyzed stability behaviors of the composite conductor that was used in the present helical coils. The cross sectional view of the helical conductor is shown in Fig.1. The Al-stabilizer is surrounded by the CuNi barrier and inhomogeneity in the resistance between the NbTi superconductor and Al-stabilizer may cause the stagnant normal zones. The Al-stabilizer is very low resistive and there is a delay for the conductor current to fully diffuse into the stabilizer, which may cause the traveling normal zones.

For stability analysis we calculated time evolutions of the temperate distributions of the conductor subject to a pulse heating by numerically solving equations of an electro-circuit for current distribution in the conductor cross section and the heat balance equation. The heat transfer characteristics of He II is assumed as shown in Fig.2. According to the analysis, a stagnant normal zone appears if the contact resistance between the Al-stabilizer and the NbTi superconductor is 30 times higher in the poor contact area than that in the good contact area where only the resistance of the CuNi barrier exists.

To study the effect of the time delay of the current diffusion in to the Al-stabilizer, the resistance of the Al-stabilizer $R_{al}(t)$ is assumed as follows.

$$R_{al}(t)=R_{CuNi}\, e^{-t/\tau}+R_{alo},$$

Where R_{alo} is the steady state resistance of the Al-stabilizer, R_{CuNi} is the resistance of the CuNi part τ= 0.6 sec) is the current diffusion time constant of the Al-stabilizer. Occurrence of the traveling normal zones is shown in Fig.3.

3. Concluding remarks

This time a case that the conductor was cooled by saturated He II was studied. When the conductor is cooled by non-saturated He II(1.8K), it is predicted that no traveling normal zones appear. However, if there is inhomogeneity in the contact resistance between the Al-stabilizer and NbTi superconductor through the CuNi layer, traveling normal zones and stagnant normal zone may appear.

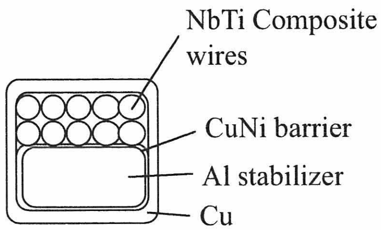


Fig.1 Cross sectional view of the helical conductor

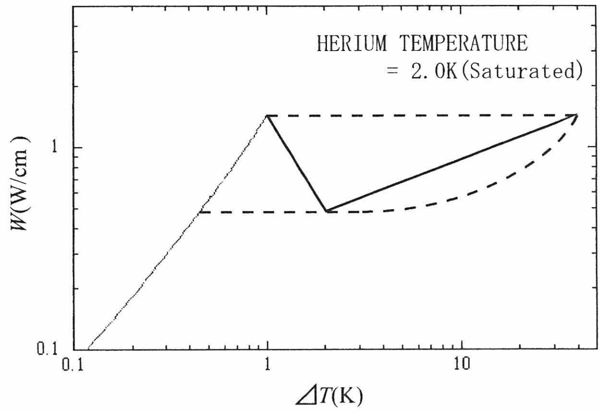
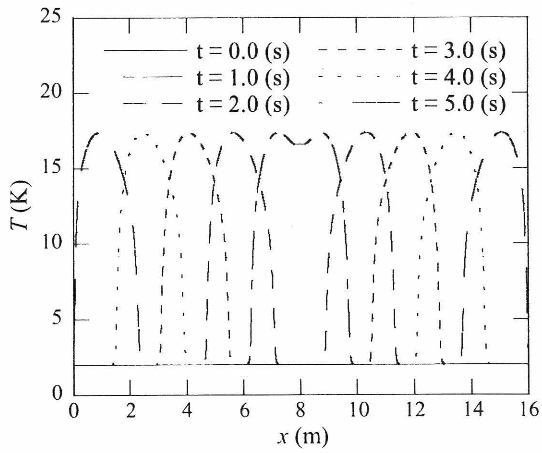


Fig.2 Heat transfer characteristics of He II



Conductor current = 18 [kA]

Fig.3 Traveling normal zones in the helical conductor