§12. Non-metallic Structural Bobbin and Thermal Stability of Superconducting Coil

Takao, T., Asano, S., Kawahara, Y., Ishikawa, K. (Sophia Univ.),
Nishimura, A.

Heat of a superconductor due to an AC loss and local degradation is one of causes to obstruct thermal stability of a superconducting coil. In the study, we try to increase the thermal stability of the coil from a standpoint of a bobbin material.[1), 2)] We choose a high-thermal-conduction and non-metallic material as a coil bobbin. The material expands with cool-down. Therefore, when the material is used as the bobbin in the coil, the contact between the superconductor and the bobbin becomes good, and the superconductor is cooled effectively.

We fabricated a double-pancake coil whose 3D view was illustrated in Fig. 1. A DFRP described in the figure means a Dyneema fiber reinforced plastic, and has a property of high thermal conduction. Dyneema is a trademark of Toyobo, Japan. We use two kinds of the DFRP which are the DFRP85 and the DFRP45. The expansion of the DFRP85 is larger than that of the DFRP45. To compare the data, we also use the glass fiber reinforced plastic (GFRP) and Aluminum nitride (AlN) as the bobbin materials. The diameter of all bobbins is 55 mm. The superconductor for the coils is a YBCO tape (width = 4 mm, thickness = 0.1 mm), and the number of the winding is 10 turns (5 turns times 2 coils). The winding tensions of the coils are 10 and 20 N.

The double pancake coil is placed on a cold head in a refrigerator and cooled down to 77 K. After being at 77 K, the coil is excited with a constant DC current. And the coil voltage is measured.

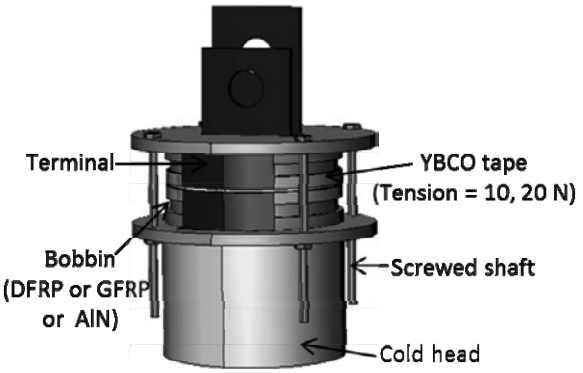

Fig. 1: 3D view of double pancake coil.

Figure 2 shows the typical measured results. From the figure, even if the coil currents are same in the 4 coils, the takeoff times are not same. The difference of those soils is only the bobbin materials. The contraction/ expansion and the thermal conductivity are largely different in the 4 kinds of bobbin materials. The DFRP85 has high expansion property and hence the contact between the superconductor and the DFRP85 bobbin becomes better. And the bobbin is high thermal conduction. From those two reasons, the takeoff f time of the DFRP85 coil is longest in the four coils.

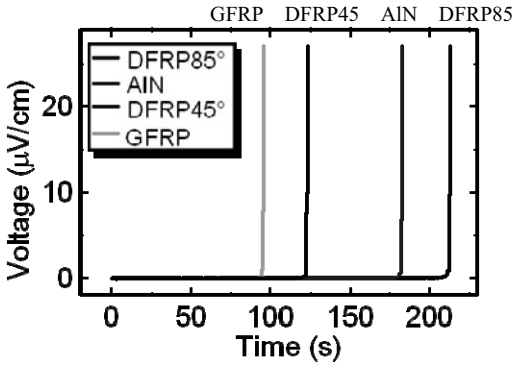

Fig. 2: Takeoff times of 4 coils. (Winding tension and coil current are respectively 10 N and 0.8Ic.)

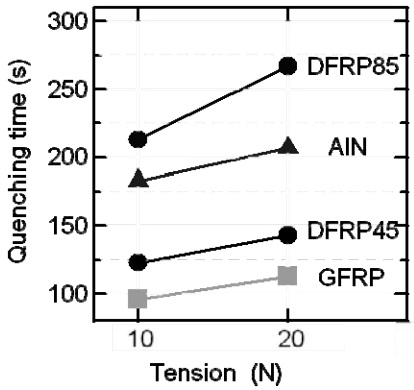

Fig. 3: Dependence of takeoff times on winding tensions.

Figure 3 shows the dependence of the takeoff times on the winding tensions (10 or 20 N). According to the figure, the takeoff times become long with increasing of the winding tensions of the coils. It is easily understood that the heat transfer from the superconductor to the bobbin becomes better due to the increasing of the winding tensions.

From those experimental data, we think the DFRP85 is one of useful bobbin materials to increase thermal stability of a superconducting coil. The study results were published as an academic journal[1)], and were presented at a domestic conference[2)].

1) T. Takao, S. Asano, K. Ishikawa, Y. Kawahara, O. Sakamoto, A. Nishimura, A. Yamanaka, "High thermal conduction bobbin and thermal stability of conduction cooled superconducting pancake coils," IEEE Trans. Appl. Supercond., vol. 23, 2013. (in press)

2) K. Nishimura, S. Sakai, D. Nakayama, T. Takao, T. Goto, S. Fukui, A. Yamanaka, A. Nishimura, "Estimation of coil performance of superconducting coil having negative thermal expansion bobbin," National convention of IEE-J, No. 5-157, Nagoya, March (2013).