§18. Cooling Owing to High Thermal Conduction Non-metallic Material and Stability of Superconducting Coil

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Temperature rise due to AC losses in superconducting coils is one of large origins of instability of the coils. This work is increase the stability from a viewpoint of thermal conductivity in coil bobbin material. [1,2] We changed the bobbin material to a high-thermal-conduction and non-metallic material. The name of the material is the Dyneema fiber reinforced plastic (DFRP) which is the trademark of Toyobo Co. Ltd.

We fabricated a small superconducting coil as shown in Fig. 1. A winding in the coil is a double pancake, and each pancake has 5 turns. A superconducting tape is a typical Bi2223 tape whose width and thickness are 2.3 mm and 0.24 mm respectively. As is written before, the bobbin material is DFRP. To compare the measured results, we made a GFRP-bobbin coil. GFRP is a glass fiber reinforced plastic and is one of typical non-metallic materials.

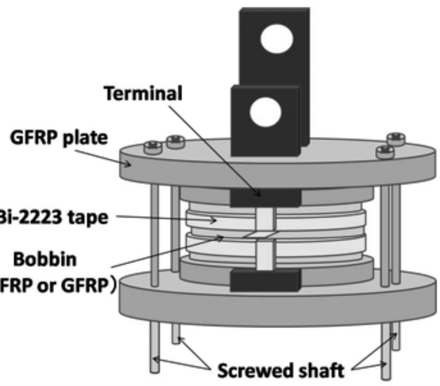

Fig. 1: Sample coil.

The coils were cooled down using a refrigerator. At a cryogenic temperature, we gave a constant DC current to the coil and measured voltage of the pancake.

Figure 2 is an example of measured data. The horizontal axis means the time from the DC current started. When the DC current equaled to the coil Ic, the coil voltage easily took off at the time of approximately 200 s. And the take-off time increased with decreasing to coil currents.

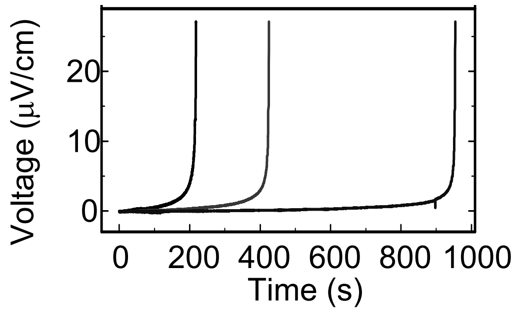

Fig. 2: Take-off of coil voltage. Coil currents are 100, 95, and 90 % of Ic from left to right curves.

We also experimentally studied dependence of a take-off time on the bobbin materials. The measured results are shown in Fig. 3. The coil configuration such as the size, the winding tension, the superconducting tape, and so on is same in those coils shown in the figure. The only deference is the bobbin materials; the take-off time strongly depended on the bobbin materials. DFRP 1, 2, and 3 are deference of thermal conductivity of DFRP. The thermal conductivity of DFRP 3 is best and that of DFRP 1 is worst in three bobbins.

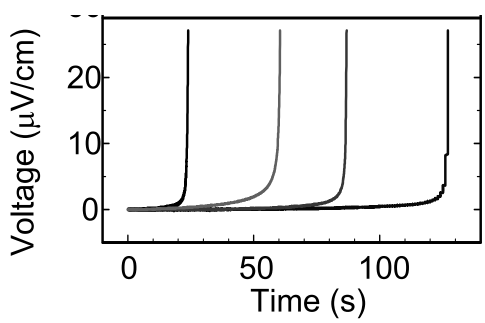

Fig. 3: Dependence of take-off time on bobbin materials. Materials are GFRP, DFRP 1, DFRP 2, and DFRP 3 from left to right.

From those results, increase of thermal stability of the coil is experimentally shown using DFRP which is the high thermal conduction and non-metallic plastic.

1) T. Takao, et al., Estimation of cooling performance in contacting between Bi2223 tape and high thermal conduction composite in conduction- cooled superconducting coil, presented at ASC2010, Washington D.C., August, 2010.
2) S. Asano, T. Takao, et al., Estimation of cooling performance of high thermal conduction composite in conduction-cooled double-pancake HTS coil –part 2-, National convention of IEE-J, No. 5-145, Osaka, March, 2011.