§23. Quench Characteristics and Structural Materials in Superconducting Coil

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Aim of the study is to increase stability of a superconducting coil from a standpoint of a structural material of the coil. The structural material has a remarkable property that is the material expands with cool down. The name of the material is Dyneema fiber reinforced plastic (DFRP). In the study, we made small superconducting coils whose bobbins were DFRP, and measured an AC loss of the coil. In the experiments, glass fiber reinforce plastic (GFRP) was also used as a bobbin material for compare the measured data.

Figure 1 shows a schematic illustration of the sample coil. The diameter and height of the bobbin are 55 and 50 mm respectively. The Bi-2223 tape (width = 4.2 mm) are wound in approximately 4 turns. Winding tension is 5 N for the DFRP-bobbin coil, and that is 10 and 1 N for the GFRP-bobbin coil. Those coils were immersed in liquid nitrogen, placed in a split coil whose magnetic field was 42.5 mT, and supplied AC current (frequency = 61.1 Hz).

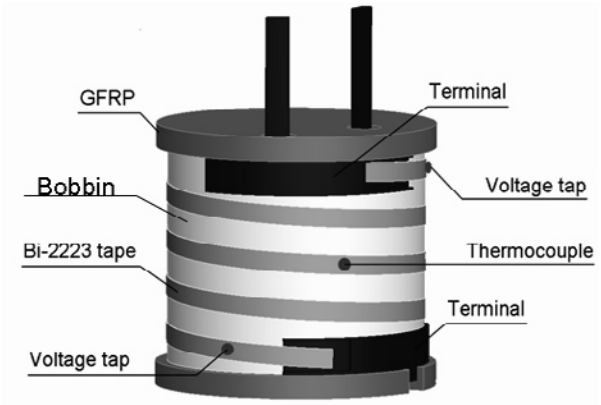

Fig. 1: Schematic illustration of sample coil. The bobbin is made of DFRP or GFRP.

We measured the coil current and the voltage. The same phase component as the coil current in the voltage signal was detected by a lock-in amplifier, and an AC loss was estimated from the component and the current.

Figure 2 shows the measured results. In the figure, the horizontal axis is the peak value of the coil current normalized by the critical current, and the vertical axis is the AC loss. There are three kinds of plotted data (GFRP-1 N coil, GFRP-10 N coil, and DFRP-5 N coil); we subtracted the data on the GFRP-1 and 10 N coils from the DFRP-5 N coil.

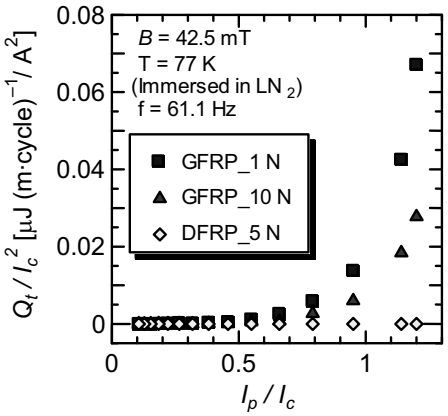

Fig. 2: Measured data of AC loss. The data on DFRP-5 N coil are criterion, and the data on GFRP-10 and 1 N coils are increased loss from the criterion.

From the figure, the AC loss decreases with increasing the winding tension. When the tension increases, the winding is tightly fixed and the vibration of the winding becomes small. And the DFRP-5 N coil is the smallest loss in the three kinds of data. As described before, the DFRP expands during cool down, and hence the coil winding also fixed.

The DFRP-5 N coil showed the good performance rather than the GFRP coils. We think that the DFRP is a useful structural material for increasing the stability of the coils.

Publication lists:

(1) T. Takao, T. Masuda, R. Sakabe, K. Nishimura, T. Goto, S. Fukui, A. Yamanaka, A. Nishimura, Reduction of mechanical losses due to frictional heat in Bi-2223 tapes using structural materials of various thermal expansion properties, presented at MT21 No. 3IP-09, Hofei in China, October (2009).

(2) Takagi, T. Takao, et al., Cooling performance evaluation in contact condition of Bi-2223 tape and high-thermal-conduction composite (part VII), IEEJ 2010 Annual Meeting, Tokyo, March (2010).