§21. Influence of Cold-thermal and Mechanical Fatigues on AC Losses in Superconducting Coil

Takao, T., Nakamura, K., Yamamoto, K. (Sophia Univ.)

A winding in a superconducting coil contracts during cool-down to cryogenic temperature, and is subjected to electromagnetic force. The force becomes zero in the end of excitation, and the winding expands in the warm-up process. The changing of performance in superconductors in the thermal cycle has not yet quantitatively been estimated.

In the report, we apply temperature change between room temperature to cryogenic temperature to the superconducting coil, and discuss dependence of thermal cycle on superconducting performance. In the coil, a Bi-2223 tape was used, and bobbin material was DFRP. A winding angle of fiber in the bobbin is 30 degrees, and hence the bobbin contracts in the cool-down.

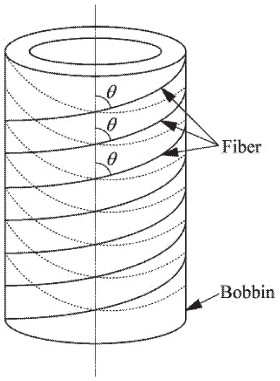

Figure 1. Fiber angle in bobbin.

The coil was immersed in liquid nitrogen, and coil's critical current (Ic) and AC loss were measured. After the measurement, the coil was returned to room temperature, and immersed again. The measuring process was repeated many times.

Figure 2 shows the measured data of Ic. Total numbers of repeating was 100, however degradation of Ic was only approximately 2 A or lower.

The AC loss data were shown in Figure 3; the 30th and 100th cycle data in the thermal cycle were shown. As shown in the figure, the AC loss was not increased from n=30 to 100.

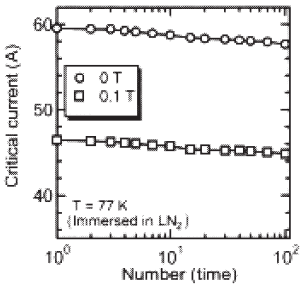

Figure 2. Dependence of thermal cycles on Ic.

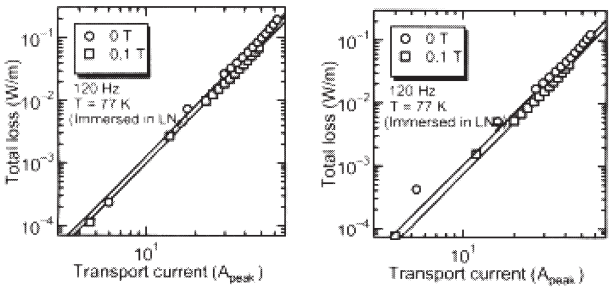

Figure 3. Measured data of AC loss.
(left: n=30, right: n=100)

From those experimental results on the thermal cycles, Ic did not decreased and hence electromagnetic loss did not also increased. And fixing conduction of the winding was not loose and hence mechanical loss did not also increased.

According to the study, the degradation due to thermal cycle can be estimated. In the next step of the study, we will use the bobbin which expands in the cooling process, and relation between thermal stress to the Bi-2223 tape and its degradation will be studied.

Publications

(1) K. Nakamura, T. Takao, A. Nishimura, IEEE Transactions on Applied Superconductivity, vol.16, pp.108-110 (2006).
(2) K. Nakamura, T. Takao, T. Goto, A. Nishimura, presented at ASC2006, no. 3LH05, Seattle, USA (2006), to be published in IEEE Transactions on Applied Superconductivity in 2007.
(3) R. Sakuma, T. Takiyama, K. Nakamura, T. Takao, A. Yamanaka, A. Nishimura, National convention of IEE-J, Toyama (2007).
(4) T. Takao, et al., Dependence of thermal cycles on mechanical loss in superconducting coils having negative thermal expansion bobbins, to be presented at 20th International Conference on Magnet Technology (MT20), USA (August, 2007).