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

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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 cycles has not yet quantitatively been estimated.

In the report, we apply temperature change to the superconducting coil between room temperature and cryogenic temperature, and discuss dependence of thermal cycle on superconducting performance. In the coil, a Bi-2223 tape was used, and bobbin materials were DFRP and DGFRP. A winding angle of fibers in the DFRP bobbin is 30 degrees, and hence the bobbin contracts in the cool-down. On the other hand, the angle in the DGFRP bobbin is 60 degrees, so the bobbin expends in the cool-down.

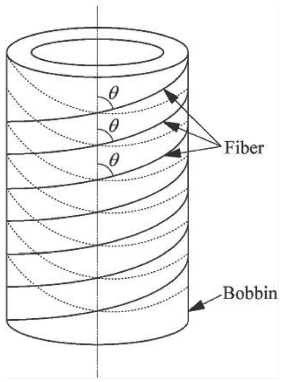

Fig 1. Fiber winding angle in bobbin.

We immersed those coils in liquid nitrogen, measured critical currents and AC losses of the coils, and returned the coils to room temperature. 100 times of this procedure has been repeated.

The measured results of the critical currents are shown in Fig. 2. When the bobbin material was DFRP, critical currants decreased only 3 % from the initial value, and degradation hardly occurred. In case of the DGFRP coil, large degradation occurred due to excessive expansion of the DGFRP bobbin.

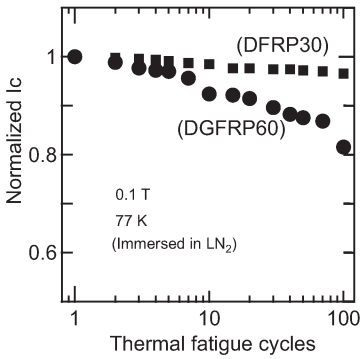

Fig 2. Influence of thermal cycles on critical current.

We also measured the AC losses during 100-time thermal fatigues. Those data are shown in Fig. 3. From the figure, the AC loss of the DFRP coil was almost constant. However, the loss of the DGFRP coil increased because the critical currents decreased and a load ratio increased.

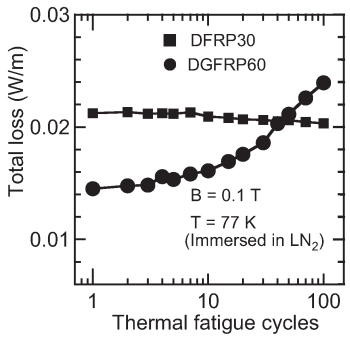

Fig 3. Measured results of AC loss (I=30A).

From the study, the measuring method of the degradation of the superconductors due to thermal and mechanical fatigues was established. And it was experimentally shown that excessive expansion of the bobbin caused degradation of the conductors.

(1) T. Takao, et al., Dependence of thermal cycles on mechanical loss in superconducting coils having negative thermal expansion bobbins, IEEE Trans. on ASC (in press).
(2) T. Takao, et al., presented at ASC, No. 5X10, USA, August 2007.
(3) Y. Yamada, T. Takao, et al., Technical meeting of IEE of Japan, ASC-08-10, Tokyo, January 2008.