§20. Thermal and Mechanical Properties of Composite Materials for Superconducting Coils

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Decreasing of weight of a large-scale superconducting coil such as the coils for nuclear fusion reactor is one of important issues. For one solution we use high strength and high-thermal-conduction non-metallic composites in the coils. In the study, we proposed those materials and experimentally studied to apply the composites to a structural material in the coil.

The proposed material is the Dyneema fiber reinforced plastic (DFRP). To compare the data a glass fiber reinforced plastic (GFRP), and aluminum nitride (AlN) are also used. An experimental setup is that a short Bi-2223 tape is clamped from both sides of the tape faces by the material. That experimental arrangement is cooled down using a GM refrigerator. In the experiments, liquid nitrogen as a coolant has not been used. At a cryogenic temperature, a constant DC current was applied to the Bi tape, and the voltage and temperature rise of the tape were measured.

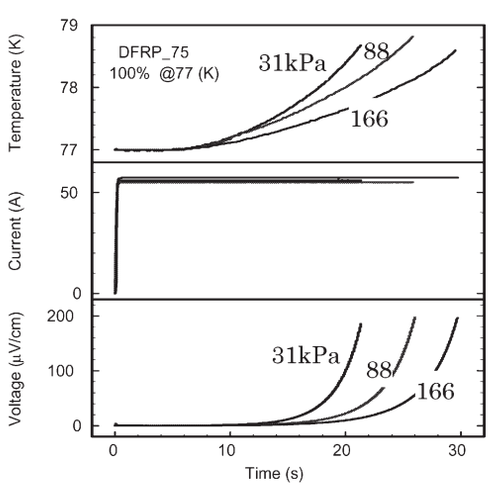

Fig. 1. Dependence of contact stress.

Fig. 1 shows the measured data whose sample material is DFRP. The tape current is approximately 56 A, and the contact stress between the tape and the composite are 31, 88, and 166 kPa. From the figure, increasing of the stress effectively decreased the temperature rise of the tape.

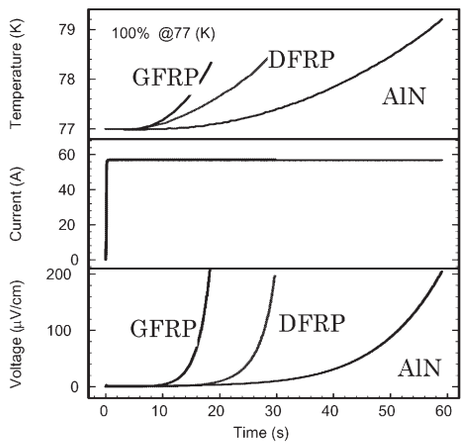

Fig. 2. Comparison of sample materials.

The comparison of the sample materials is shown in Fig. 2. The DFRP was not best in the samples; however the cooling performance increased when a high-thermal-conduction grease was coated on the face of the DFRP (whose data are not shown in the figure). The performance became approximately 10 or 20 percent better than that of the bare DFRP.

From those results, the DFRP's performance does not reach the AlN's performance. But, we think it is possible to apple the DFRP to the coils if the techniques to increase the cooling performance such as increasing of the contact force and coating of the grease and so on are applied.

List of publications and presentations:

(1) K. Nakamura, T. Takao, A. Nishimura, "Electrical and mechanical properties of strands in superconducting bundle conductors," IEEE Trans. on Applied Super., vol.16, No.2, pp.108-110 (2006).

(2) T. Takao, A. Watanabe, Y. Iso, K. Nakamura, A. Nishimura, A. Yamanaka, "Heat drain effects from HTS tapes to high thermal conduction plastics for conduction-cooled magnets," presented at EUCAS, Austria, 2005.

(3) A. Watanabe, K. Nakamura, T. Takao, A. Nishimura, A. Yamanaka, presented at Fall Meeting of Cryogenic Eng., No. 1D-p03, Niigata, 2005.

(4) T. Takiyama, A. Watanabe, K. Nakamura, T. Takao, A. Yamanaka, A. Nishimura, National convention of IEE-J, No. 5-030, Yokohama, 2006.