§23. Minimum Propagation Currents of LTS/HTS Hybrid Conductors

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Increases of minimum propagation currents (MPC) or cryogenic stability of low temperature superconducting (LTS) NbTi/Cu conductors have been observed when high temperature superconducting (HTS) tapes are used as stabilizers in place of metals such as pure aluminum [1, 2]. This kind of superconductor is being called LTS/HTS hybrid conductor. The objective of the LTS/HTS hybrid conductor concept is to extend the basic research on cryogenic stability of LTS conductors such as stabilized with pure aluminum. In addition to the big hybrid conductor samples having more than 10 kA operation current, which were tested separately [3], small-scaled samples of an NbTi/Cu conductor, an NbTi/Cu/Al composite conductor, and the NbTi/Cu/HTS hybrid conductors have been prepared and MPC of these conductors have been measured and compared. The cross-sectional views of the tested conductors are shown in Fig 1.

First, the NbTi/Cu conductor was wound onto a bakelite bobbin with 1 layer, 9 turns and tested. Then, an aluminum-stabilized and HTS-stabilized hybrid conductors were made by attaching the pure aluminum tape (RRR: ~7000) and Bi-2223/Ag HTS tapes onto the NbTi/Cu conductors. They were wound onto the same bobbin to form closed loops (diameter: 66 mm, height: 90 mm, self inductance: ~3.6 μH, joint resistance: ~2 nΩ) and placed in the bore of a 9 T bias magnet. The sample coils were inductively charged by changing the current of the bias magnet itself. For MPC measurements, a thin film resistive heater was used to initiate a normal-zone in the conductor. Voltage taps attached to the sample coil at the heater location (V2) and 4 cm away from V2 in both directions (V2R and V2L) provide information of normal-zone growth in the cable.

Fig 2 shows an example of the propagation velocities in a hybrid conductor along (VPR) and opposite (VPL) to the transport current at 7 T bias field.

The MPC at different bias fields for all the conductors are shown in Fig. 3. Here, we should note that, for the hybrid conductors, the average values of the extrapolated currents with zero velocities in both sides of normal-zone propagation are taken as the minimum propagation currents. As shown in Fig. 3, the MPC of the NbTi/Cu conductor increases significantly when it is stabilized with HTS tapes. The high-purity aluminum-stabilized NbTi/Cu conductor also showed high MPC comparable with hybrid conductors stabilized with 3 HTS tapes. But the current density in the aluminum-stabilized conductor was much smaller than that of the hybrid conductor due to the size difference of the conductors as shown in Fig 1. Hence, from the experimental results, we can conclude that for the same current density, the minimum propagation currents or cryogenic stability might be significantly higher in hybrid conductors as compared with pure aluminum stabilized conductors.

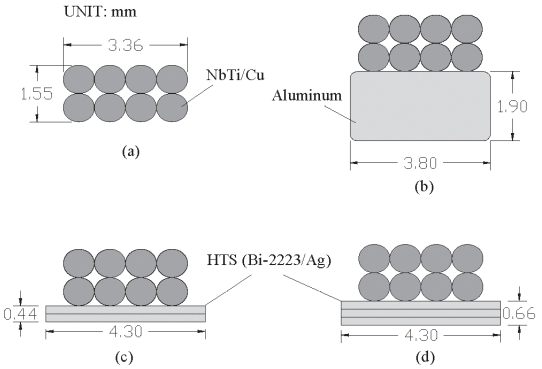

Fig 1: Cross-sectional views of (a) an NbTi/Cu conductor; (b) NbTi/Cu conductor stabilized with pure aluminum; (c) NbTi/Cu conductor stabilized with two HTS tapes; (d) NbTi/Cu conductor stabilized with three HTS tapes.

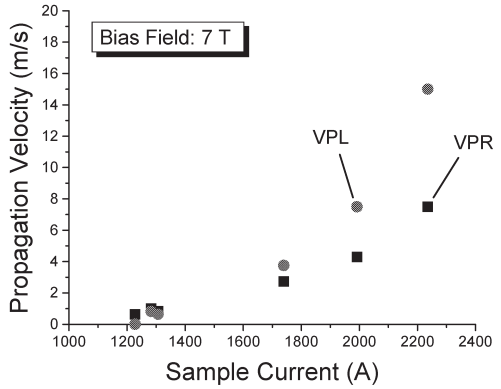

Fig 2: Propagation velocities evaluated in the hybrid conductor (NbTi/Cu conductor stabilized with 2 HTS Bi-2223/Ag tapes).

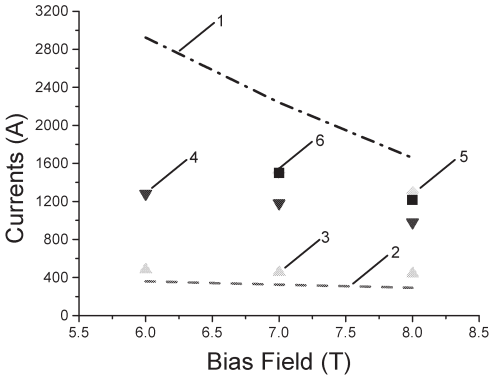

Fig. 3. (1) Critical currents of NbTi/Cu conductor expected at 4.2 K; (2) Calculated MPC of NbTi/Cu conductor; (3) Measured MPC of NbTi/Cu conductor; (4) Measured MPC hybrid conductor (NbTi/Cu stabilized with 2 HTS tapes); (5) Measured MPC of hybrid conductor (NbTi/Cu stabilized with 3 HTS tapes); (6) Measured MPC of pure aluminum stabilized NbTi/Cu conductor.

References:

[1] Bansal, G. et al., Fusion Eng. and Des. 81 (2006) 2485.

[2] Bansal, G. et al., to be published in IEEE Trans. on Applied Superconductivity, 2007.

[3] Yanagi, N. et al., to be published in IEEE Trans. on Applied Superconductivity, 2007.