§7. Study on Remountable Joint of YBCO Conductor for Remountable High-temperature Superconducting Magnet

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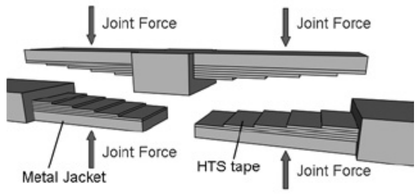
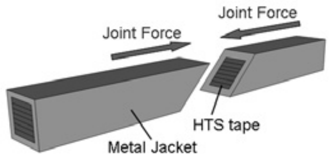
Our research group have been proposed remountable (demountable) high-temperature superconducting (HTS) magnet, segment of which can be mounted and demounted iteratively. [1] This design concept can provide engineering solution for a helical reactor having huge and complex superconducting magnets. In this corroborative study, we are aiming to develop remountable (demountable) joints of a stacked REBCO (YBCO, GdBCO and so on) conductor and design the remountable magnet based on thermal and structural analyses. This year, we mainly investigated two remountable joints, mechanical lap and butt joints shown in Fig. 1. Experimental and numerical results for two joint method are summarized in this report.

At first, we performed experiments for mechanical lap joint. In this experiment, GdBCO tape having layer structure of Ag (20 μm)/GdBCO/buffer layer/Hastelloy substrate (FYSC-S05, Fujikura Ltd.) was used as a sample. Width and thickness of the tape are 5 mm and 0.15 mm, respectively. We evaluated joint resistivity (product of joint resistance and contact area) in bridge-type mechanical lap joint of single layer (single GdBCO tape) and double layer stacked GdBCO conductors. We tested Dry joint (no inserted materials between contact surfaces) and Indium film compliant layer joint (a indium film of 50 μm thick is inserted between contact surfaces) for the single and double layers. Fig. 2 shows relationship between joint stress and joint resistivity obtained by the experiments. In the Dry joint, joint resistivity for the double layer was higher than that for the single layer due to non-uniform contact pressure distribution. On the other hand, the joint resistivities did not increase when the number of layer increased in the Indium film compliant layer joint because the compliant layer can give relatively uniform contact pressure distribution. Though an increase in the number of contact surface and resistance of the indium film cause a rise in joint resistance, the Indium film compliant layer joint is effective to keep joint resistance smaller in the mechanical lap joint of multi-layer REBCO conductors.

We also carried out numerical analysis (current distribution analysis) and joint test to improve conductor structure for the mechanical butt joint of a stacked REBCO conductor. In the mechanical butt joint, thickness of stabilizer layer (copper and silver layers) strongly affects the joint resistance. Therefore, we evaluated a change in joint resistance when thickness of the stabilizer layer changes. Fig. 3 shows relationship between thickness of copper layer and joint resistance for the butt joint of 4-layer stacked GdBCO conductors obtained by the numerical analysis and the joint test. The result shows that joint resistance decreases with an increase in the thickness and experimental results agreed with numerical ones. We also calculated cooling power of the remountable magnet using the butt joint. The calculated cooling power was twice larger than acceptable value when the value was estimated from joint resistance at 77 K. However, joint resistance could be reduced at lower temperature. Therefore the cooling power can become acceptable value at 20 K, that is the first candidate for operation temperature of the remountable magnet.



(a) Mechanical lap joint (bridge-type)



(b) Mechanical butt joint

Fig. 1. Remountable joints of a stacked HTS conductor with metal jacket.

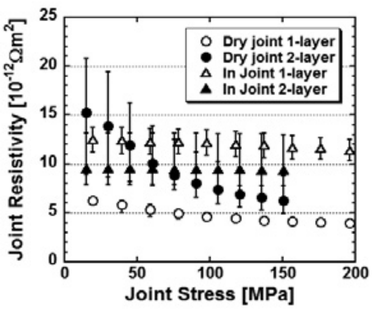


Fig. 2. Experimental results obtained in the mechanical lap joint.

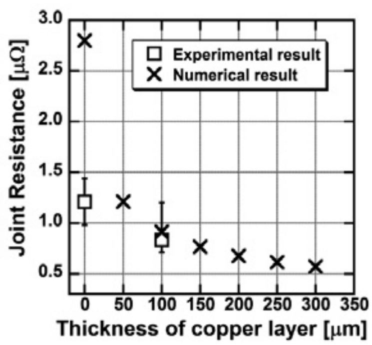


Fig. 3. Relationship between thickness of copper layer and joint resistance in mechanical butt joint of 4-layer stacked REBCO conductor.

1) Ito, S.: Fus. Eng. Des., **81** (2006) 2527.