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

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We have proposed a remountable (or demountable) high-temperature superconducting (HTS) magnet as a design of a superconducting magnet in a fusion reactor, especially for a helical reactor which has huge and complex superconducting magnets. The magnet consists of some sections and they can be mounted and demounted repeatedly. In our previous studies, we had studied on mechanical butt joint of a BSCCO conductor for development of joint for the magnet.[1)] However, ReBCO conductors (YBCO, GdBCO and so on) should be used in high magnetic field such as a fusion reactor environment because critical current of a BSCCO conductor decreases significantly at high magnetic field. Therefore, we started to carry out experiments of the mechanical butt joint of a ReBCO conductor as well as a BSCCO conductor in this collaborative research. In addition, we discussed applicability of the remountable magnet to a helical DEMO reactor, FFHR, based on structural analysis.

We carried out experiments of the mechanical butt joint using a 10-layer BSCCO conductor with copper jacket (I_C = 1000 A at 77 K, self field) and a 4-layer GdBCO conductor with copper jacket (I_C = 500 A at 77 K, self field) in liquid nitrogen. Fig. 1 shows relationship between joint stress and joint resistance. The BSCCO conductor could reduce to 140 nΩ whereas the GdBCO conductor just reduced 1.5 μΩ. This is because cross-sectional area of conductive metal layer in the GdBCO conductor is much smaller than that of the BSCCO conductor. The joint resistance of the GdBCO conductor can be reduced by increasing thickness of the conductive metal layer of that or by coating the joint surface with a metal layer.

We also investigated influences of electromagnetic force on joint condition of the remountable magnet using the mechanical butt joint based on two dimensional structural analysis under plane stress condition. Fig. 2 shows a model used in the analysis, whose structure is decided based on design of a induction cooled helical coil.[2)] In this analysis, a circular coil having average radius of curvature of the helical coil was used instead of the actual three dimensional helical coil. Supporting structure of 0.5 m or 1.0 m thick is placed around the coil. Fig. 3 shows relationship between the external joint pressure applied to joint section and the maximum slip distance when the applied current is 100 kA when BSCCO conductors with aluminum alloy jacket or YBCO conductors with stainless steel jacket are used for superconducting conductors. In this figure, dependence of thickness of the support structure on the slip distance also appears. If allowable slip is assumed to be 0.5 mm corresponding to thickness of the insulator, external joint pressures of over 200 MPa is required for all cases. The external joint pressure and the thickness of the supporting structure are difficult to be applied to actual design. We will investigate more realistic design for the remountable magnet by sophisticating joint structure.

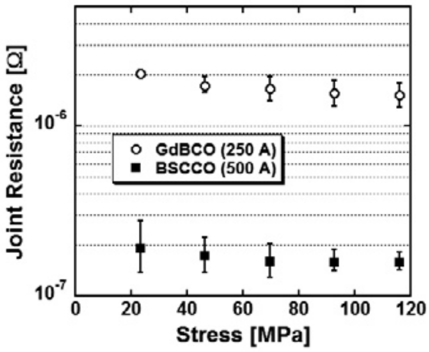

Fig. 1. Relationship joint stress and joint resistnace in mechanical butt joint of a BSCCO conductor and GdBCO conductor.

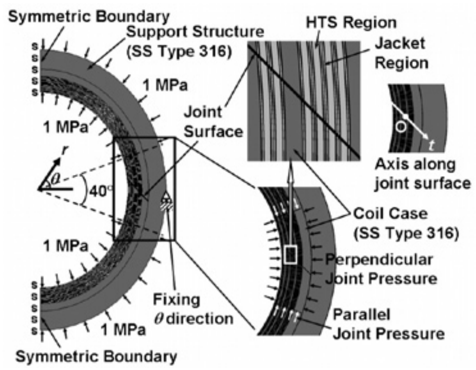

Fig. 2. Two-dimensional analytical model.

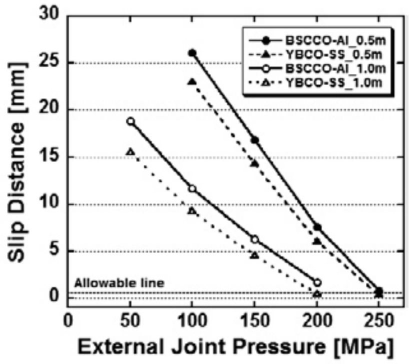

Fig. 3. Allowable slip distance of joint surface.

1) Ito, S., Hashizume, H.: Fusion Eng. Des. **80** (2006) 2527.
2) Tamura, H. et al.: Journal of Physics, Conference Series **97** (2008) 012139.