§7. Structural Design of the Remountable Magnet and Development of Joint Section of a High-temperature Superconducting Conductor

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Segment-fabrication of high-temperature superconducting (HTS) magnets has been proposed for helical reactor, FFHR-d1. [1)-4)] The magnet is constructed by assembling short conductors (joint-winding of the helical coils, shown in Fig. 1) or segments (remountable helical coils) with resistive joints. HTS materials can allow the resistive joint because they have high thermal stability and achieve low electric power to run cryoplant. Objectives of this corroborative study are 1) investigation of mechanical strength of the joint by means of tensile shear test of joint samples and 2) development of mechanical joints of large-scale HTS conductors to be used for the magnet

For the first objective, we carried out tensile shear tests of soldered and mechanical lap joints of Gadolinium Barium Copper Oxide (GdBCO) tapes to obtain mechanical strength and investigate fracture mechanism of those joints.[5), 6)] The soldered joint was made by soldering the GdBCO tapes with PbSn solder whereas the mechanical lap joint was made by pressing the joint section of GdBCO tapes where a 100-μm-thick indium foil was inserted between joint surfaces. Fig. 2 shows the results of the tensile shear test; maximum tensile load (tensile strength of joint) as a function of contact conductance (the reciprocal of the contact resistance). The soldered lap joint shows relatively low mechanical strength due to fracture of the GdBCO tape induced by stress concentration at the edge of soldered joint. On the other hand, the joint slid at the maximum tensile load in the case of the mechanical lap joint. For the mechanical joint, there are two mechanisms of fracture of the joint. One is slide of interface (contact surface) between GdBCO tape and indium surfaces at contact conductance up to a certain value. The other is shear fracture of the indium at contact conductance above the certain value where the shear strength becomes constant.

For the second objective, we achieved a current of 100 kA and a joint resistance of 2 nΩ at 4.2 K using a bridge-type mechanical lap joint of a prototype stacked tape assembled in Rigid Structure (STARS) conductor developed by the corroborative study.[7)] However the joint resistance was larger than expected value based on mechanical lap joint of GdBCO tapes. That could be caused by non-uniform contact pressure distribution in the case of large-scale conductors. To solve the problem, we proposed to introduce heat treatment during fabrication of the mechanical joint.[8)] Fig. 3 shows the reduction of joint resistivity (the product of joint resistance by joint area) by the heat treatment. The joint resistance was reduced by 60% with the heat treatment. In our future task, we plan to apply the heat treatment to a large scale conductor joint.

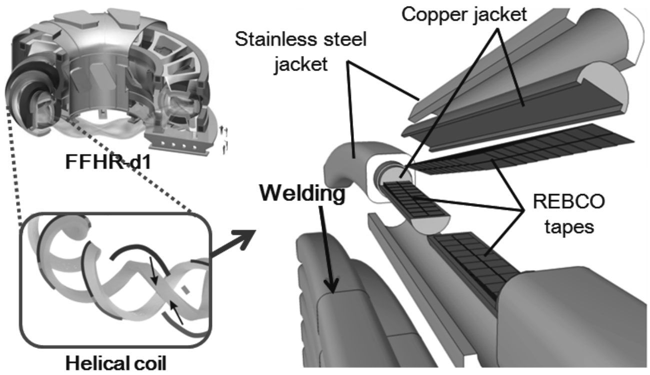

Fig. 1. Schematic illustration of joint-winding of the helical coils in FFHR-d1.

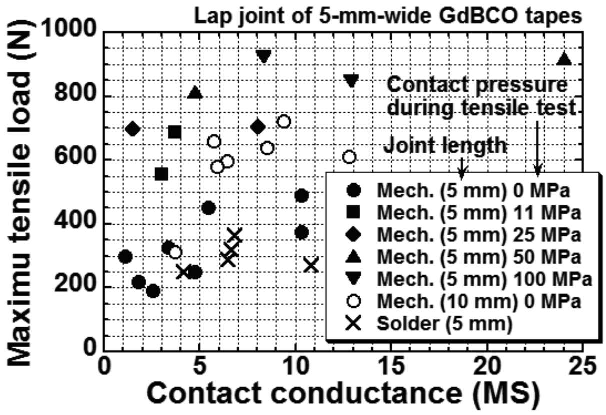

Fig. 2. Results of the tensile shear test.

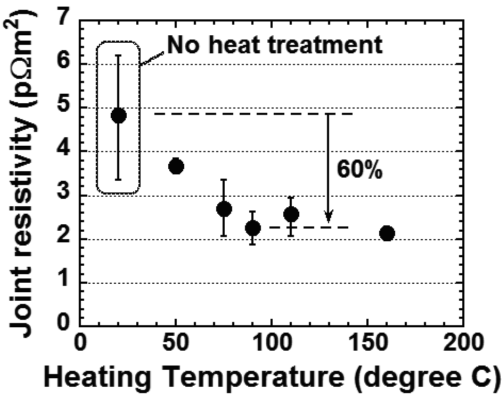

Fig. 3. Reduction of joint resistance by heat treatment during fabrication of the joint.

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