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Fri-Af-Po.04-01: Shear strength evaluation of REBCO tape lap joint with indium using double bridge joint

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Bridge-type mechanical lap joint with indium insertion between REBCO tapes is planned to be utilized for joint-winding of high-temperature superconducting (HTS) helical coils in heliotron-type fusion reactors, such as FFHR-d1 [1]. Shear strength evaluation of single lap joints using tensile shear testing at 77 K, self-field has been conducted to discuss if the joints can keep their performance under large electromagnetic forces [2-5]. According to [4], the shear strength seems to depend on both contact conductivity at joint interface and applied pressure to joint section during the tensile shear testing. However, which factor strongly affect the shear strength is still not clarified due to the limitation of data. In addition, bending moment prevents pure shear strength evaluation in the tensile shear testing of the single lap joint [3,4]. Furthermore, temperature dependence of the shear strength must be also clarified to evaluate structural integrity of joints at fabrication, cooling and operation phases.

In this study, double bridge joint configuration was introduced to avoid the bending moment during tensile shear testing. In this configuration, two bridge-type mechanical lap joint with indium insertion were attached to jigs so that they were arranged symmetrically with respect to the tensile axis. Joint samples were fabricated utilizing REBCO tapes provided by two manufacturers, SuperPower and Fujikura. In addition, two groups of joint sample with different contact conductivity at the joint interface (<600 S/m² and >1500 S/m² at 77 K) were prepared utilizing different joining process. Applied pressure to joint section and temperature (room temperature in air and 77 K in liquid nitrogen) during tensile shear testing were parameters for the shear strength evaluation. During the tensile shear testing, tensile force and joint resistivity (product of joint resistance and joint area) were monitored, where current terminal and voltage taps were attached to the joint samples. The shear strength in Pa was evaluated based on the maximum tensile force and joint area. The contact conductivity was evaluated based on the joint resistivity and resistance factors of joint such as resistance of inserted indium, resistance of stabilizers and interfacial resistance inside REBCO tapes. Some samples were also used for comparison between single lap joint and double bridge joint configurations.

Shear strength evaluated with double bridge configuration was a slightly higher than that with single lap joint configuration, which could be caused by the presence or absence of bending moment. The shear strength increased with an increase in the contact conductivity at <600 S/m² and was constant at >1500 S/m², but was not influenced by applied pressure during the tensile testing. This indicated that the contact conductivity is main factor to determine the shear strength. The shear strength at >1500 S/m² was ˜5 MPa and ˜30 MPa at room temperature and 77 K, respectively for SuperPower's samples. The tensile shear testing of Fujikura's samples is now under preparation. Temperature dependence of the shear strength was also discussed based on the experimental results of tensile shear testing and literature for temperature dependence of yield stress of indium. Detail of the remained experiments and discussion are also presented at the conference.

References

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