§24. Joint Resistance Measurements of the Butt Joint for JT-60SA CS Coils

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In superconducting fusion magnets, many joints exist between superconducting conductors. Therefore, the performance of joints has a significant impact on fusion magnets. A butt joint is one of the joint types used in the magnets. The butt joint is suitable for situations where conductors are joined in a narrow space. The butt joint is very attractive for central solenoid (CS) coils of tokamak machines because it allows embedding of the joint into a winding pack that provides maximum magnetic flux at a given peak field in the winding [1]. The butt joint was adopted for JT-60 Super Advanced (JT-60SA) CS coils composed of Nb3Sn cable-in-conduit (CIC) conductors [1,2]. To evaluate the fabrication technology of the joint used in the JT-60SA CS coil, joint resistance was measured at NIFS test facility [3,4].

The joint sample is composed of Nb3Sn CIC conductors [1,2] used in the JT-60SA CS coil. The conductor consists of 216 Nb3Sn strands plated with chromium and 108 copper wires. The conductor is equipped with a central spiral made of SUS316L. The conductor conduit is composed of SUS316LN. The joint sample is illustrated in Fig. 1. The sample is hairpin shaped and consists of two butt joints. The total length of the sample is 1,835 mm. Figs. 2 and 3 illustrate the cross-section of the sample at the butt joint and the configuration of the butt joint without conduit, respectively.

Joint resistances of the joint sample were measured at the NIFS test facility [3,4]. As illustrated in Fig. 1, the sample was equipped with thermometers and voltage taps attached to the conduit. To accurately measure the joint resistance, two pairs of voltage taps were utilized for the butt joint. The pairs V2–V5 and V3–V4 were used for joint (−) and the pairs V6–V9 and V7–V8 were used for joint (+). For the measurement, SHe temperature was controlled using a film heater and thermometer (T1) attached to the inlet pipe.

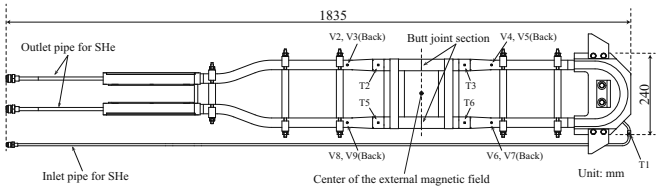

Fig. 1. Schematic view of the joint sample.

Fig.4 shows the joint resistance measurements. The measurements indicated that the performance of the butt joint fulfilled the design requirement in which the joint resistance was less than 5 nΩ at 2 T [2, 5]. In addition, to investigate stable operating conditions of the butt joint, a stability test was performed using the joint sample. In this test, the quench current was measured under several conditions. The measurements indicated that the butt joint has a temperature margin of 4 K for real operating conditions as follows: transport current, 20 kA; external magnetic field, 2 T; operating temperature, 7 K [5].

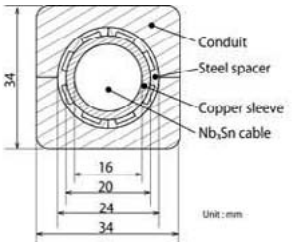

Fig. 2. Cross-section of the joint sample at the butt joint.

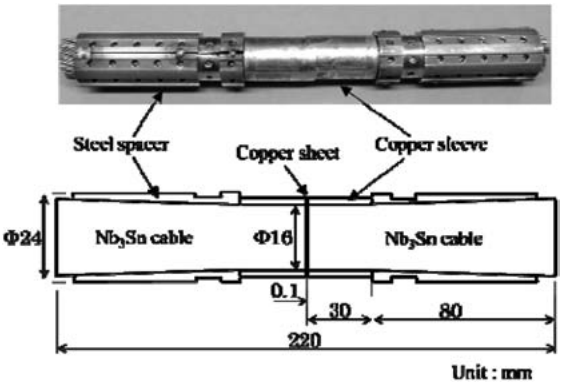

Fig. 3. Photograph and configuration of the butt joint without conduit.

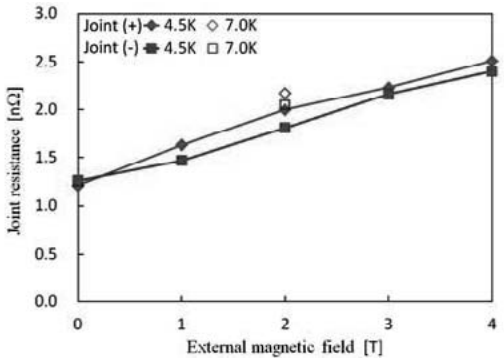

Fig. 4. Joint resistance of the joint samples.

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