§18. Study on Testing Methods for Joints of Large-Scale Cable-in-Conduit Conductors

Koizumi, N., Kajitani, H. (JAEA),
Imagawa, S., Obana, T.

Large superconducting magnets are indispensable for magnetic fusion reactors. In order to suppress the voltage at quick discharge for the magnet protection, high current conductors are needed. A cable-in-conduit (CIC) conductor, which comprises a multi-strand cable of superconducting wires within a tube-like conduit, is suitable for them. For example, the 70 kA class CIC conductor is adopted for Toroidal Field (TF) coils of ITER. A joint resistance of superconducting conductors must be sufficient low to assure its cryogenic stability higher than the other parts. In the case of the ITER-TF conductors, the allowable joint resistance is 3 nΩ. The electrical voltage at the joint part is not uniform in a cross-section of CIC conductors because of the currents transfer between the strands.[1] Therefore, researches are necessary for measurement of the joint resistance of CIC conductors with sufficient accuracy. The purpose of this study is to improve the measurement accuracy of joint resistance of a large CIC conductor.

Firstly, published papers for testing methodology of joint resistance and their testing facilities were investigated. Secondly, the subjects for improving the measurement accuracy of joint resistance were discussed. Since Nb in the strands and solder in the joint part are superconducting in the lower field, the external magnetic field about 2 T is needed to measure the actual joint resistance. Moreover, the measurement of temperature dependency of joint resistance is effective for the quality control, because joint resistance changes with temperature in the case that the jointing state is incomplete or uneven.

Based on these discussions, testing methods for the ITER-TF joint samples was studied, and the testing jigs were designed. The plan of set up of the joint sample is shown in Fig. 1 using the 9 T conductor test facility in NIFS. The length of joint part is 675 mm that is longer than the final twisting pitch of the strands. Since the 9 T split coils are bath-cooled, a sample case is needed for changing the temperature of the sample, which is cooled with supercritical helium. In the case that the operating current is 68 kA, the joule heating in a copper busbar of 25 mm thick and 100-150 mm wide exceeds 300 W. Considering the refrigerating power of the facility, the whole heat generation in the sample and busbars should be reduced around 100 W. Therefore, an additional busbar with 35 layers of high temperature superconducting (HTS) tapes is planned. Two of the HTS busbars are attached on one side of the copper busbar by solder as shown in Fig. 2. The critical current of the HTS tape, DI-BSCCO of SUMITOMO Electric Industries, is 200 A at 77 K in the self field. It will increase over 600 A at 4 K in the self field of 1.2 T. The two HTS busbars are expected to carry the current over 40 kA, and the total joule heating of the copper busbar can be reduced below 45 W.

1) Koizumi, N., Matsui, K., and Okuno, K.: Cryogenics 50 (2010) 129–138.

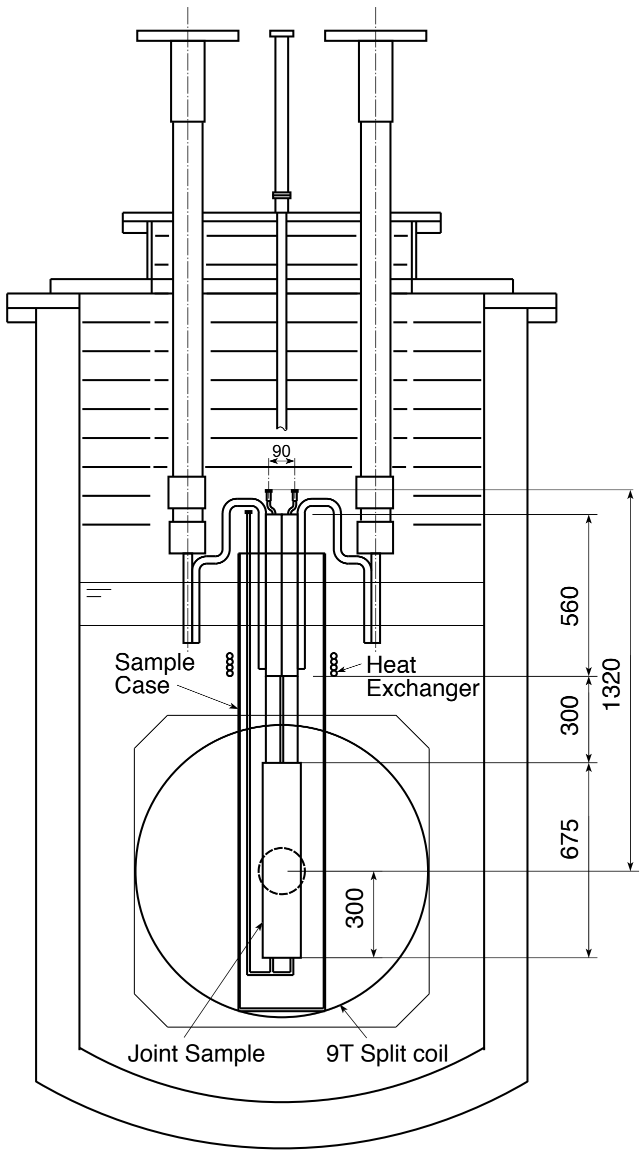

Fig. 1. Set up of an ITER-TF joint sample in the conductor test facility with 9 T split coils.

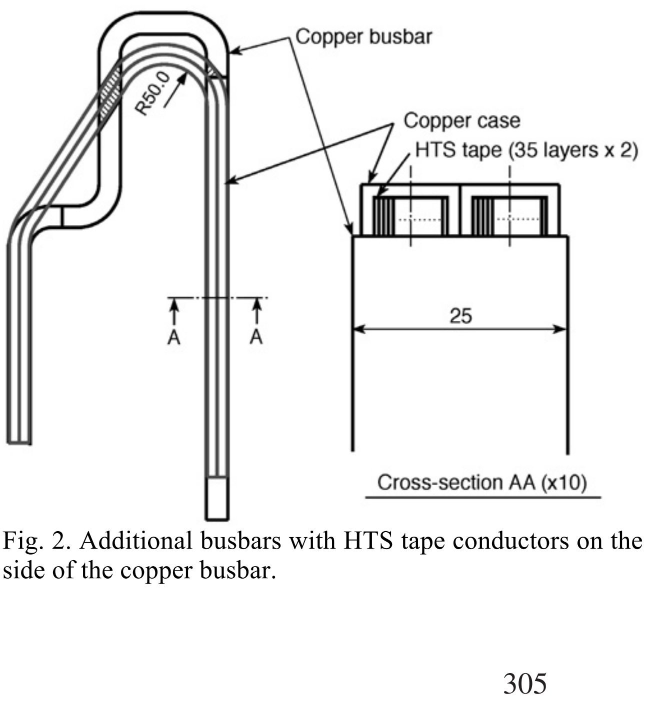

Fig. 2. Additional busbars with HTS tape conductors on the side of the copper busbar.