§10. Electromagnetic and Structural Investigation of Inter-strand Resistance in CIC Conductor for Fusion Magnets

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National Institute for Fusion Science (NIFS) and Japan Atomic Energy Agency (JAEA) have carried out performance test of the cable-in-conduit conductor (CICC) for JT60-SA Equilibrium Field coil(EF coil) in cooperation from 2007[1]. Inter-strand contact resistance is one of the important parameters in terms of the temperature margin and stability of Multi-strand superconducting cable like CICC. The CICC is composed of twisted sub-cables in which the minimum unit is the triplet made of twisted three strands sometimes including Cu strand.

The resistance depends not only on the geometric parameters such as contact length and width but also on the contact pressure at the crossover point and might plays an important roles for the current re-distribution in the conductors.[2] So it is difficult to estimate the contact resistance numerically. In our research, the contact resistance between strands has been experimentally evaluated for three short samples of cable-in-conduit conductor for JT-60SA equilibrium magnets. The samples are a 3×5×5×6 cable with Ni plated Nb_3Ti strands, a 3×6×5×6 cable with Ni plated Nb_3Ti strands that includes a Cu strand in each triplet and a 3^4×6 cable with Ni plated Nb_3Ti strands of which the final sub-cables are wrapped by the stainless steel tape. The contact resistances are measured by the four-probe method in two temperature conditions.
Fig.1 represents the experimental setups for the measurement of inter-strand conductance in LHe. Fig.2 shows the selected strand combinations. The combinations are well selected to categorize the conductance in terms of including sub-cable boundaries along the current path.

Fig.3 shows the result of the contact conductance measurement in liquid helium. In this measurement, the results of pairs of low No. strand of Prototype sample has indicate value of the contact conductance. So it is supposed to be the lower void fraction which leads to the higher contact pressure on the contact surface. But if the contact pressure is uniform inside the conduit, the conductance values of high strand no. pairs in prototype sample would be large compared to those in EF-L and EF-H sample like Fig.3. However, the difference of the value for high strand no. pairs between prototype and EF conductors are much smaller than those of low strand no. pairs in Fig.4. This means that the wrap well suppress the electrical coupling of distant strand pairs which causes the large coupling loss under the condition of high contact pressure between strands. The lowest values of conductance in EF-L indicate that the Cu strands might block out making shortest current path, which might result in more contact resistance in series.

As the future investigation, the actual trajectory of the strand in the CICC samples will be researched and this experimental data will be numerically analyzed by using the data of aquired the actual trajectory.

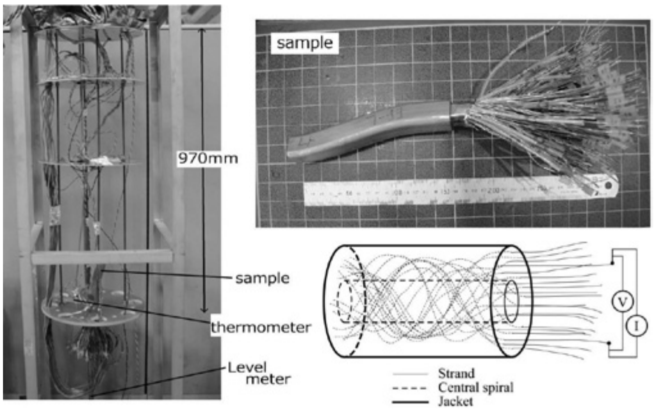

Fig. 1. Pictures of sample CICC and setting for conductance measurement in LHe. The schematic view of conductance measurement is also shown.

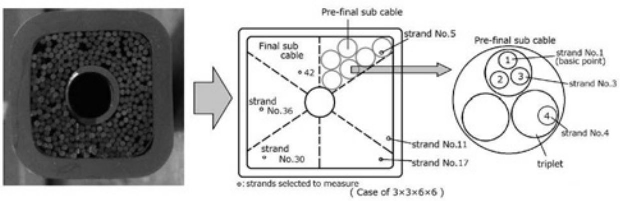

Fig. 2. Schematic of how we selected the strand combinations for inter-strand contact resistance.

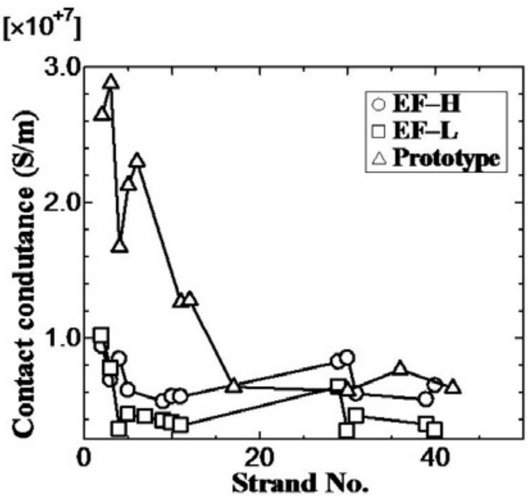

Fig. 3. Inter-strand contact conductance measurement result in liquid helium

1) T. OBANA et al., Abstract of CSSJ Conference, 82, (2010), p. 123, 2B-a09
2) N. Amemiya , Cryogenics 1998 38, p545-546