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

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The superconducting coils wound with Cable-In-Conduit Conductors(CICCs) which are composed of several stages of sub-cable has been applied to large devices such as experimental fusion apparatuses because of its high mechanical and dielectric strength. In order to reduce ac losses, strand surface is coated by the high resistance layer such as CuNi. On the other hand, the layer would prevent the current transposition which contributes the stability of the conductor. In terms of studying on the stability of the conductor, the evaluation of the contact resistance must be important.

In this work, we measured the contact resistances between strands in both LN2 and room temperature. The strands are assembled for the conductor for JT60SA equilibrium field (EF) coil. The resistance measurement have done for many combinations categorized by the sub-cable boundaries across which the coupling current flows.

The conductor constructions are $3^4\times6$ and $3\times5^2\times6$ for EF prototype and type H, respectively. The NbTi strands are coated by Ni layer with 2μm in thickness. As for the prototype conductor, the last sub-cables (each has 81 strands) are wrapped by stainless steel thin tapes, which would be prevent current sharing between last sub-cables in order to reduce the coupling current losses.

Figure. 1 shows the schematic of EF conductor and the experimental setup for the measurement of the contact resistance between strands. The selected strands for measurement are random but can be covered all cases of combinations of sub-cable boundaries. The resistance might be different when the current crossing boundary is different, e.g. strand 1-2 (in identical triplet) and strand 1-36 (in different 4th sub-cables) because the contact length depends on the sub-cable boundary[1].

Figure 2 indicates the measured contact resistances for strand combinations categorized by sub-cable boundaries. The values are normalized by the nearby strands inside the same triplet. It is cleared that these are within the 7% range in spite of including the resistance of stainless steel wrap around last sub-cables for prototype conductor. This indicates that the current paths are considered to be complex in which they have Cu and Ni and many contact points and stainless steel with wide cross section.

In order to simulate the complex current paths with the almost same whole resistance, we introduce the lattice-shaped resistance network and calculate the parallel current paths based on the minimum energy theorem. The result indicates that the Ni resistance with two order larger than that of Cu and stainless steel assumed the surface is well oxide would be needed. Since conductors are exposed for a long time in the air, the assumption seems reasonable for accounting the calculation result.

As a next phase, we will measure the resistances in LHe temperature. We anticipate the high resistance effect of the stainless steel wrap would be observed due to the drastic reduction of resistances along the strand, i.e. the NbTi filaments along strands translates to the superconducting state.

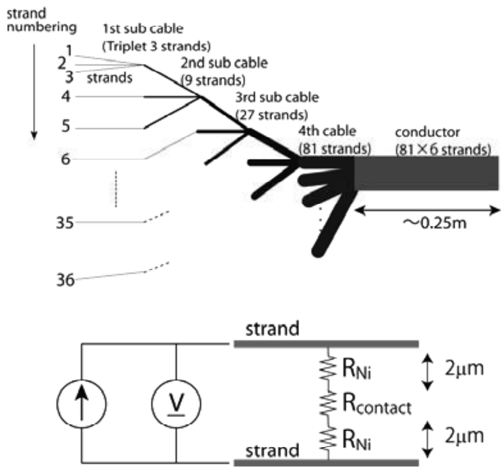

Fig. 1: Schematics of sample conductor and experimental setup

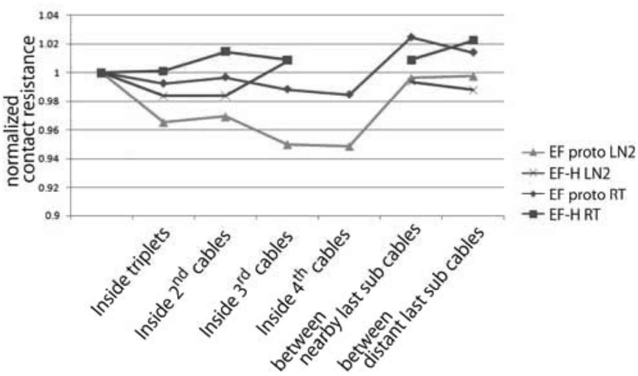

Fig. 2: Measured contact resistance for strand combinations categorized by sub-cable boundaries.

1) Yagai, T., et al.: IEEE transaction on Applied Superconductivity, **17** (2007) 2470.