§13. A Study on Current Equalization of Twisted Parallel Superconductors

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Many strands having the composition such as compacted stranded conductors, multiple layer spiral conductors, CICC's, etc. are connected in parallel in order to provide a large current carrying capacity and act as one conductor. However, they have a problem of unequal current flows among strands due to the parallel connection of strands having different values of resistance and inductance, thus causing an anxiety of the increase of ac loss and the reduction of superconducting stability.

This study is on the strands current equalization by the action of transformer coupling, though there is a method which copes with it by a conductor itself in the idea of varying stranded pitch. The proposed method of currents equalization is effective for large current conductors as well as magnets wound with parallel conductors and parallel connected magnets.

Fig. 1 illustrates the test circuit of current equalization based on the idea of transformer coupling. As for the circuit composition, two strands of a cable are represented by the Bi base high temperature superconducting coil of L_1 and L_2 of whose inductance is different each other. Two coils are kept at 77 K with liquid nitrogen.

Two power transformers are needed in this case and the 1st windings of transformers are connected in series with each coil, whereas the 2nd windings are connected in series each other and shorted. A winding ratio of transformers can be selected properly as required.

As for an experiment, the power supply voltage of 40 V is employed and the inductance of Bi base superconducting coil is L1=1.35 mH and L2=6.15 mH, respectively. In the case of the transformer coupling, the current of I (L1) =2 A and I (L2) =1.93 A, exhibiting almost the equal current distribution, however it becomes I (L2) =0.41 A and I (L1) =2 A with no measures.

Fig. 2 shows the simulation result at transformers coupling, indicating almost the identical current waves form like the experiment. The effectiveness of currents equalization by transformers coupling was confirmed. Fig. 3 is the one without transformers coupling. It is clear that currents do not flow equally but they are mainly governed by the difference of the coil inductance.

It was confirmed by the experiment as well as the simulation that the current equalization for strands having different impedance is possible by the adoption of the idea of transformers coupling.

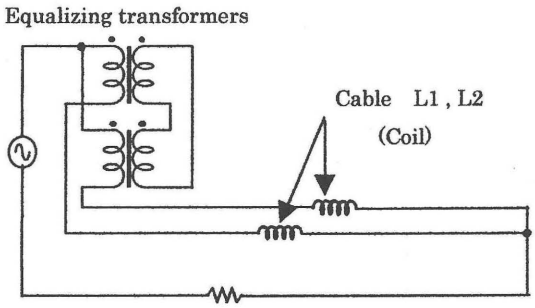

Fig. 1. Currents equalization with transformers coupling.

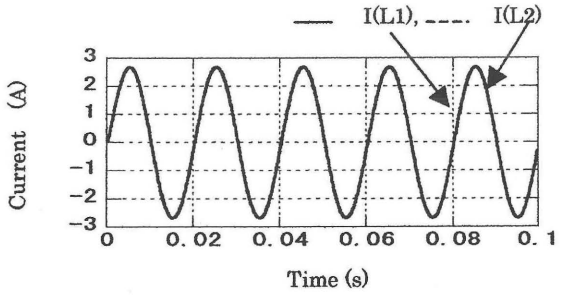

Fig. 2. Simulation result at transformers coupling.

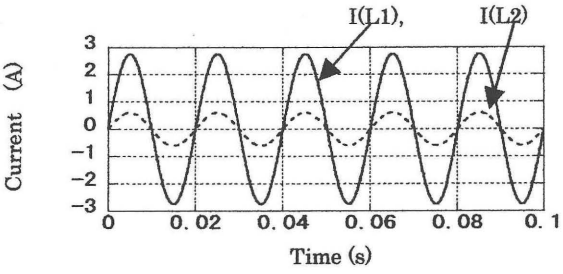

Fig. 3. Simulation result without transformers coupling.

Reference

1) Nagasawa T., Fukui S., Yamaguchi M., Satoh T., et al., 62nd Spring Cryogenic and Superconductivity Conference (2000)86