§23. Research and Development of Oxide Superconducting Cables with a Large Current Capacity

Iwakuma, M., Kajikawa, K., Funaki, K., Matsushita, T. (Kyushu University), Mito, T.

We try to develop oxide superconducting cables with a large current capacity for nuclear fusion system. In the last fiscal year, we made a preliminary investigation of the applicability of oxide superconducting parallel conductors to pancake coils. For the sake of a uniform current distribution and low ac loss, the constituent strands in parallel conductors need to be transposed so as to be inductively equivalent with each other. We adopted an interdisk transposition where the strands are not transposed inside a single-pancake coil but only at the joint between the pancake coils. Then, in the current fiscal year, we investigated the applicability of oxide superconducting parallel conductors to multi-layer solenoidal coils. We adopted an interlayer transposition where the strands are not transposed inside a layer but only between layers, that is the strands are transposed only at the upper and lower ends of layers.

We first searched for the optimum configurations of interlayer transposition in the case of 2-, 3- and 4-strand by the theoretical calculation with a circuit model. As a result, it turned out that at least 8, 12 and 16 layers are required for a uniform current distribution, that is the strands need to be transposed at least 7, 11 and 15 times in the respect case. An example of the optimum arrangement of the strands in the case of 4-strand with 16 layers is shown in Fig.1 and Table I. We can see that the strands need to be regularly transposed.

In order to verify the theoretical investigation, we measured the current sharing in a 1T cryocooler-cooled pulse coil wound with a Bi2223 4-strand parallel conductor in the same way as shown in Fig.1. Rogowski coils were mounted on all the strand to measure the branch current. The total transport current was measured by a non-inductive shunt resistance. The measurement was carried out at LN_2 temperature by applying ac transport current with the amplitude of 28 to 43 A and the frequency of 10 to 50 Hz. The observed wave forms and the branch current ratios in the 4-strand parallel conductor are shown in Figs.2 and 3 respectively. The theoretical prediction is also shown in Fig.3 in comparison to the experimental results. The current distribution was almost independent of frequency. We can see that current flows uniformly, as theoretically predicted, within an error of 10%. We also verified the case that the number of layers deviates from the optimum one.

Consequently it was shown that the interlayer transposition is useful to obtain the uniformity in current distribution in superconducting parallel conductors wound into multi-layer solenoidal coils.

Table I The optimum arrangement of the strands in a 4-strand parallel conductor wound into a 16-layer solenoidal coil.

Strand \ Layer	#1	#2	#3	#4	#5	#6	#7	#8
①(White)	1	2	3	4	4	3	2	1
②(L.Gray)	2	3	4	1	1	4	3	2
③(D.Gray)	3	4	1	2	2	1	4	3
④(Black)	4	1	2	3	3	2	1	4
Strand \ Layer	**#9**	**#10**	**#11**	**#12**	**#13**	**#14**	**#15**	**#16**
①(White)	4	3	2	1	1	2	3	4
②(L.Gray)	3	2	1	4	4	1	2	3
③(D.Gray)	2	1	4	3	3	4	1	2
④(Black)	1	4	3	2	2	3	4	1

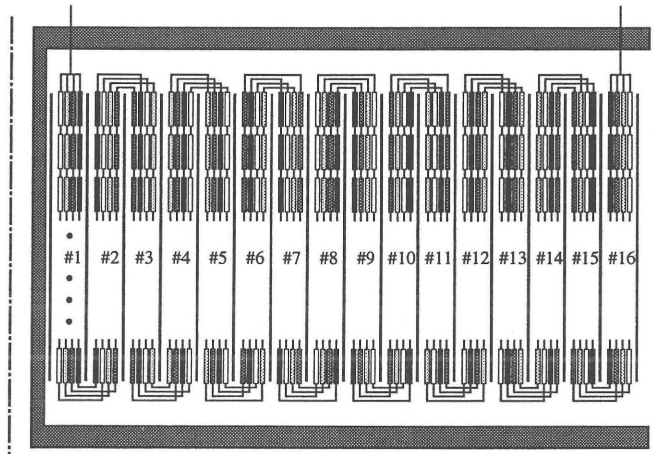

Fig.1 Optimum configuration of interlayer-transposition in the case of a 4-strand parallel conductor.

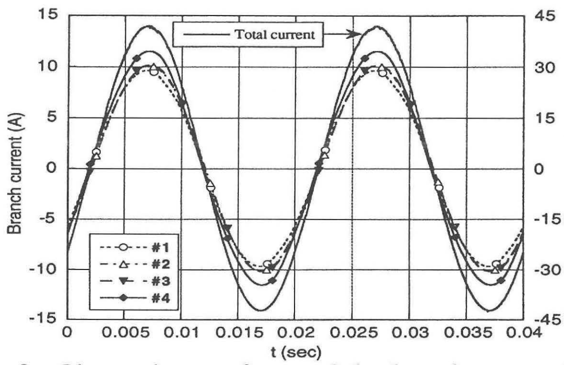

Fig.2 Observed wave forms of the branch current in the 16-layered Bi2223 4-strand parallel conductor.

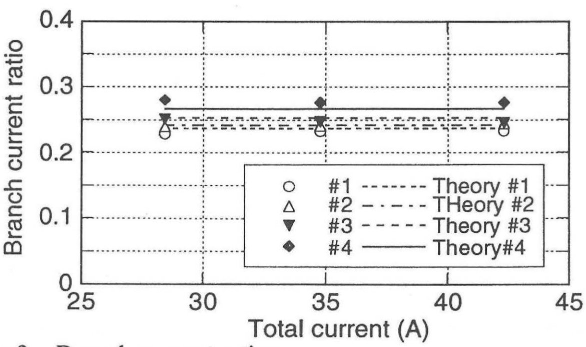

Fig.3 Branch current ratios.