§11. Experimental Investigation on Current Imbalance of Stranded Conductor

Ninomiya, A. (Seikei University)
Yamaguchi, S.

Superconducting cable conductors with high current capacity for many large-scale superconducting devices have a fundamental configuration of symmetrically assembled stranded structure. These conductors often experience a heavy current imbalance in the cable. So, we have experimentally investigated about the current imbalance problem using 12 types of experimental solenoid coils with different sizes but the same shape. The conductors used for these coils are cables with 27 insulated copper strands and with 9 insulated copper strands. The cabling formation of them are triple-twisted (3×3×3) and double-twisted (3× 3) respectively.

The inductance measurement was carried out using high accuracy LCR meter with the accuracy of four digits, which is enough to estimate the current distribution. The experiment was carried out at 77K to reduce the resistance component of each strand. And, the used frequency is 1kHz. The current distribution between these strands is estimated through the calculation of the inverse matrix of the measured inductance matrix neglecting the resistance components of each strand.

Table 1 shows the obtained results in the triple-twisted conductors, where L_{disp} and M_{disp} are the quantities of dispersion from the average value L_{ave} as shown in eq. (1).

$$L_{disp} = \left(\frac{L_{max} - L_{min}}{L_{ave}} \right) \times 100 \qquad (1)$$

In addition, I_{max}/I_{min} is the current imbalance ratio between the maximum current (I_{max}) and the minimum current (I_{min}) in the 27 stranded conductors. The obtained results are shown as follows:

- For the value of coupling factor (k) higher than 0.99, the dispersion of the inductance distribution is very small. However, the current flowing exists opposite and current imbalance among the strands becomes very large.
- For the value of k in the range from 0.98 to 0.99 as shown in coil-5 & coil-7, the current imbalance depends on the dispersion of inductance distributions.
- For the value of k of 0.936, current imbalance ratio settles down to at most three.

Fig.2 shows the relation between the direction of twisting and the coupling factor using the second stage cable conductors consist of 9 strands, where Coil A is wound by S×S twisted , Coil C is wound by S×Z and Coil B is non-twisted cable conductor. It is conclude that the coupling factor is affected by the cabling formation and S×Z is good one for the lower value of coupling factor.

Table 1. The Relation between current imbalance and dispersion of inductance distributions

Coils	K_{ave}	L_{disp} (%)	M_{disp} (%)	Current ratio I_{max}/I_{min}	L_{ave} (mH)
coil-1	0.9358	2.0751	2.5861	3.5239	0.1022
coil-2	0.9620	1.0941	1.5678	3.2239	0.2038
coil-4	0.9636	0.7069	1.8068	1.7163	0.2971
coil-3	0.9676	0.9754	1.2406	4.3872	0.2440
coil-7	0.9798	0.1964	1.2159	5.3309	0.9166
coil-5	0.9875	0.1204	0.6703	1.6968	1.5787
coil-6	0.9896	0.1273	0.5703	2.5767	1.8850
coil-9	0.9926	0.0478	0.4381	−2.2720	5.4402
coil-8	0.9999	0.0722	0.4573	−4.8224	5.5385

K_{ave}, L_{ave} : averaged value of coupling factor and self-inductance

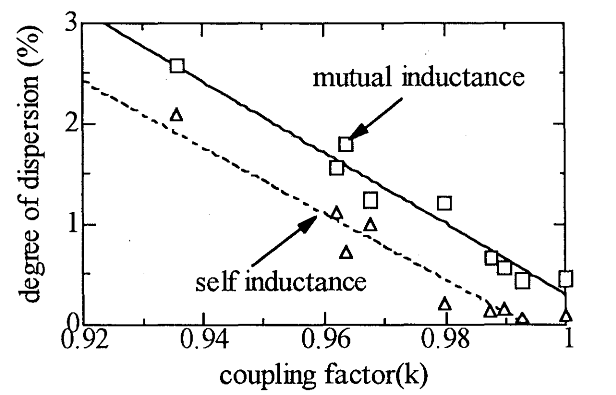

Fig.1 Relation between coupling factor (k) and the degree of dispersion in the inductance

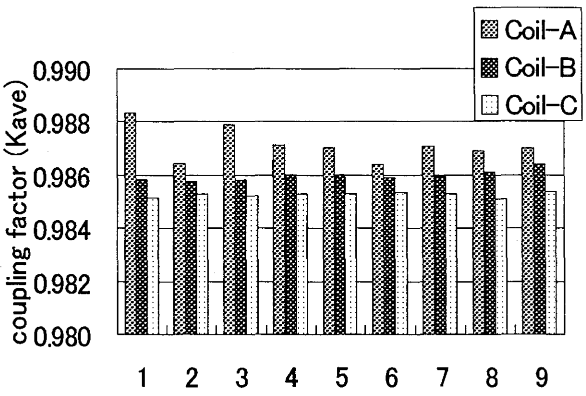

Fig 2 Coupling factor distributions of second stage cable conductors

Reference
1) A. Ninomiya et,al, : ASC-98 LIA-09,1998
2) S.Yamaguchi et al : MT-15,OD1-7, 1997