§69. Experiment of Current Imbalance Correction Using Iron Core

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Superconducting conductors are used in nuclear fusion experiments and superconducting magnetic energy storage (SMES). These conductors which are composed of many superconducting strands have a problem of current imbalance. This may cause the conductors to quench at a current level below its design value. We proposed the iron core method to fix the current imbalance problem[1]. The iron core method is the one in which two insulated strands are passed through an iron core with electric currents circulating in opposite directions as shown in Figure 1. In this review we investigated the current imbalance by using Ag sheathed Bi-2223 high temperature superconducting (HTS) wire (45 A at 77 K, 0 T) and also observed that the current imbalance was corrected by using H5A ferrite iron core (saturation fulux density 0.65 T, coercive force 74.0 A/m at 77 K) in liquid nitrogen.

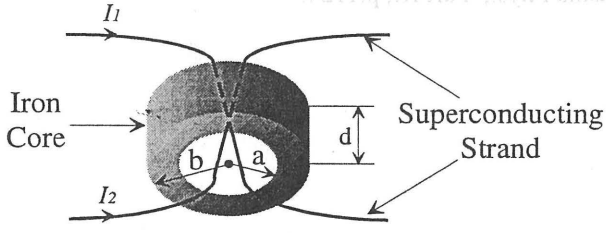
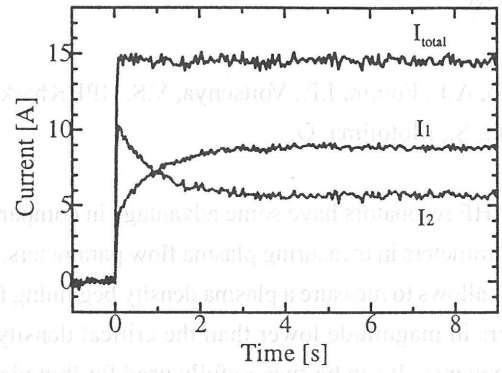
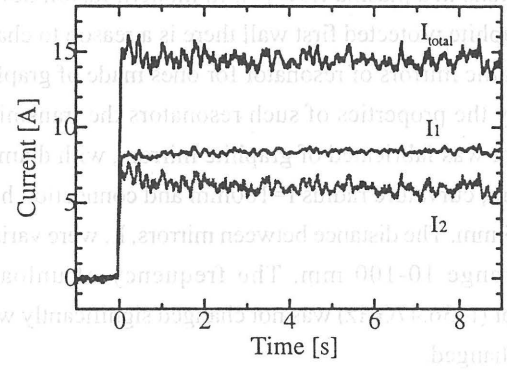


Fig.1 Configuration of iron core method.

The ratio of current imbalance is decided by the ratio of leakage inductance (L – M) between strands. The variation of the leakage inductance is in the range of 1~10 μH even in a large superconducting magnet. So we use two different length HTS wires connected in parallel. The diffrence of leakage inductance is 1.54 μH. The ratio of current imbalance is about 2. The experiment was made applying a step signal of DC 15 A. Figure 2 shows experimental results. We used Hall elements for current measurement. As shown in Fig.2-(a), the current imbalance appears in a transient state. The current ratio is about 2. In this case, the conductor is quenched at 75 % of its critical current. As shown in Fig.2-(b), the imbalance is reduced within 1 A by using iron core.



(a) Current imbalance.



(b) Effect of iron core.

Fig.2 Experimental results.

Recently a high temperature superconducting transformer (500 kVA at 77 K) whose winding cable is Ag-sheathed Bi-2223 wires was developed[2]. In this transformer, in order to correct the current imbalance, those wires that are connected in parallel are transposed several times. The difference in self inductance of each wire is about 20 μH. When several iron cores with diameter of 25 mm and 110 mm length are used can be easily corrected the current imbalance without transposition of superconducting wires. Moreover with insulated wires AC losses are minimized in addition to the benefit of current imbalance correction with iron cores.

Reference

1) S. Yamaguchi : "An iron core circuit to balance the current of insulated strands in superconducting cables", Applied Superconductivity Conference '96

2) K. Funaki : "Superconducting Transformers" The Journal of the IEEJ, Special Issue, Application of Superconducting Technology to Electric Power Apparatuses, Apr. 1997, Vol.117, No.4, pp227-230