§17. Experimental Studies on Stabilities of Parallel Configuration of Superconducting Strands

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For a large scale superconducting devices such as fusion devices, superconducting magnets are made by multi-stranded cables to obtain sufficient current capacity. However, the cable has a problem of instability caused by non-uniform current distribution. We have carried out experimental studies on the stability and current distribution of Rutherford cables [1]. We found that it was very hard to clarify the factors that affect to the current distribution and stability of the Rutherford cables. In order to obtain more basic phenomena, the experiments on parallel strands were carried out.

Two arrangements of parallel strands were prepared for the experiments, they consist of two parallel strands with and without insulation on a cylinder with a bifilar winding.

In each experiment, the center point of one strand was heated by a spot heater, that is put at the center of the strand #1. Table I shows the parameters of the strand used in the experiments.

TABLE I

PARAMETERS OF THE SUPERCONDUCTING STRANDS.

Type	NbTi/Cu round wire
Diameter of wire	0.486 mm
Diameter of filament	4.4 - 4.6 mm
Cu/NbTi ratio	1.80 ± 0.08
Twist pitch	23.0 ± 1.8 mm
Ic at 5 T, 4.2K	145 - 157 A
RRR	35 - 50

Figure 1 shows the increasing voltages in the insulated strands. At first the voltage of T1-56 (voltage tap between 5 and 6 on strand #1) increases, where heater is. After that the voltages of the neighboring taps increase, and fianlly voltages of all other taps increase. It is worth to notice the behavior in the first 40 ms of T1-56 and T2-56. By heating, the voltage in T1-56 increases untill 13 ms, and after that decreases. We can say that the decrement of the voltage after 13 ms is caused by current re-distribution between the strands. By the commutated current from strand 1, strand 4 becomes over current, and faster voltage set-up occurs in strand 4. This behavior can be seen during the time between 25 ms and 35 ms. After that the current goes back to strand 1. This current commutation occurs at connections at the ends.

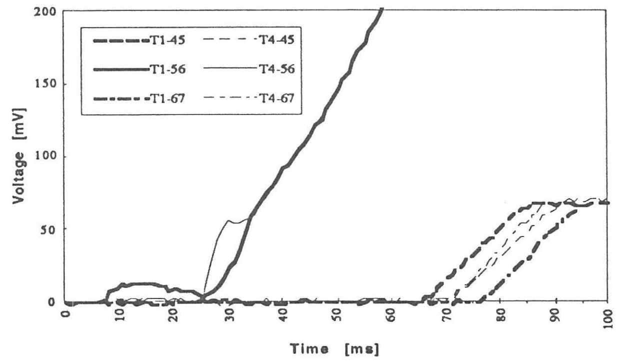

Fig. 1. Voltages measured from taps on the insulated strands. Transport current is 170 A and magnetic field is 5 T. Strand 1 is heated by MQE (5.3 mJ) during 20 ms (0 - 20 ms).

On the contrary, in the case of two strands without insulation, the voltage wave forms do not cross each other as shown in Fig. 2. Also this figure shows that the two voltage wave forms in strands 1 and 2 have very similar behavior of proportional increment. This is because the current can commutate between two strands everywhere.

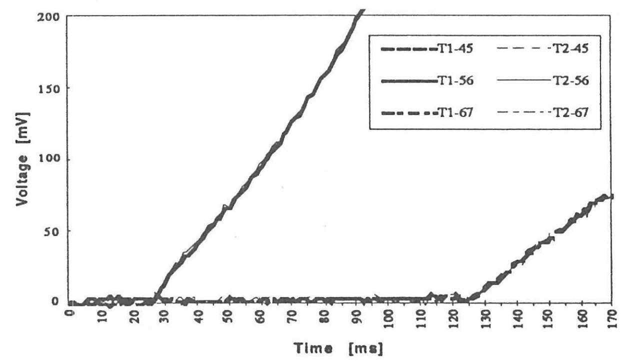

Fig. 3. Voltages measured on the non-insulated strands at transport current of 170 A and magnetic field of 5 T. Strand 1 is heated by MQE (15.1 mJ) during 20 ms.

In the result of the insulated strands, we could distinguish the current commutation and heat transfer and say that the current commutation was faster than heat transfer from the observation that the quench occures at the same location between taps 5 and 6.

In comparison to our previous experiments, the wave forms by current commutation between two adjacent strands in a Rutherford cable are quite similar to those in this insulated two parallel strands. This means that the side-by-side contact resistance at the edges is relatively low in the Rutherford cable and current commutation may occure mainly there.

References

1) S. W. Kim, T. Shintomi, et al., IEEE Trans. Magnetics 32 (1996) 2784.