§12. Development of a Transposed Conductor with Large Capacity using Superconducting Tapes with High Aspect Ratio of Cross-section

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MgB_2 is a metallic superconducting material with high critical temperature, about 39K. Material costs of the MgB_2 are lower than that of NbTi or Nb_3Sn. These advantages of MgB_2 are not only valuable to significant cut down of costs of large-scale devices, but also drastically improvement of stability. We have been investigating to improve performance of MgB_2 wires and clearly design methods of large scale conductors composed of the MgB_2 wires for fusion reactors. We have been experimentally clarified that critical currents increase and ac losses decrease by forming into tape shape from round wires with circular cross-section, by experiments using short samples and coils.

In this study, stability of a test conductor composed of five MgB_2 tapes has been evaluated to clarify the electromagnetic properties of the conductor. Table1 shows parameters of the test conductors, which are stacked and transposed five MgB_2 tapes. The tapes rolled from an in-situ wire with circular cross-section. The wire is composed of MgB_2 /Nb/Cu. The tapes were assembled to the transposed conductors, and heat treatments were carried out after the conductor assembling.

In order to clarify the effects of inter-strand resistances among the tapes on electromagnetic properties of the test conductors, we have prepared two samples, one sample is composed of insulated tapes and another one is composed of non-insulated tapes. Positions of the tapes in the cross-section of the test conductors were changed in turns every 50 mm in direction of the conductor axis. Samples are straight with length of 400mm. These samples are put in side of FRP holder, and impregnated epoxy reign as to be filled up gaps in the holder. The samples were simulated conduction-cooling conditions by immersing the sample holder in liquid helium. In addition, temperatures of the samples were controlled by heat power into stainless steel heater in the sample holder.

It has been already confirmed that measured critical currents of the test conductors agreed well with predicted values from short samples of the MgB_2 tapes [1]. This indicates that the test conductors have been fabricated without any degradation of superconducting properties. In this study, stability measurements of the insulated conductor have been carried out.

The external dc transverse magnetic field of 2.5-5 T applied to the sample with transport currents. The sample was heated locally by a carbon heater put on one tape at the center of the sample. The heating time is 5 msec. After the heating, the voltages of the sample were measured. Minimum quench energy (MQE) was defined as minimum input heater energy required in order to generate the electric field of 1 μV/cm. Measured conditions are as follows; at 4.2 K, 5 T, ratio of transport current, I_t to critical current, I_C were 0.8 (I_t = 172 A) and 0.6 (I_t = 108 A), at 20 K, 2.5 T, the ratio was 0.8 (I_t = 81 A).

Fig. 1 shows measured results at 4.2 K. For comparison, measured MQE on a Rutherford cable composed of 18 NbTi/CuNi/Cu strands, and calculated ones on the single strand are shown by solid triangles and broken line, respectively. These data are compensated by volume ratio. The Rutherford cable is high stability type in which between strands are connected with low resistances by heat treatments. MQE of the test conductor are more than 10 times as large as that of NbTi strands and are equal or more than MQE of the Rutherford cable with high stability. That indicates that our conductor has high stability in spite of insulated strand. In addition, a solid line is represented by the heat capacity of the five tapes in the figure. These values are obtained from temperature margins. Measured values are near the line. The same trend is observed on experimental results at 20 K. These show that stability is decided from temperature margin at 4.2 K and 20 K.

1) Y. Kitamura, et al, Abstracts of CSSJ Conference, Vol.85 (2011), p. 110.

Table1 Parameter of test conductors composed of MgB_2 tapes

Strand	
Dimension	1.051 mm x 0.504 mm
Filament dimension	0.712 mm x 0.233 mm
Aspect ratio	2.08
Conductor	
Type	Transposed conductor
Shape	Straight
Number of strand	5
Transposition pitch	50 mm
Length	400 mm

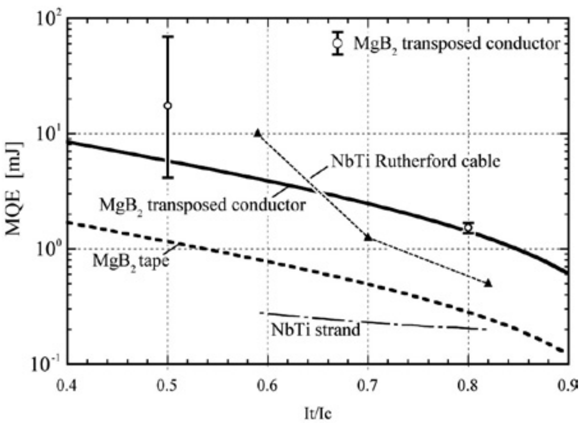

Fig. 1 MQE of MgB_2 transposed conductor.