§17. 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, critical currents and coupling losses of test conductors, which are stacked and transposed five MgB_2 tapes, are measured in order to clarify electromagnetic properties of transposed MgB_2 conductors[1].

Table1 shows parameters of the experimental transposed conductors, which are fabricated from five stacked 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.

Firstly, critical current measurements were carried out at 4.2K and around 20K. Critical currents of the samples were measured under eternal magnetic fields of edge on orientation to the tapes, EO direction, 2-7T. Voltage criterion was 1 μV/cm. Distance of the voltage taps were 30 mm. Measured magnetic field dependences of the critical currents are shown by Fig. 1. At 4.2K, critical currents of both of insulated and non-insulated samples are agreed well. Around 20K, temperature distributions in the samples were observed, so measurements were carried out at several temperatures. In the Fig.1, difference between measured data of insulated and the non-insulated samples were observed due to difference of distributions of temperatures in the holders. At 4.2K, measured data were coincident with predicted values from data of short samples. In addition, measured data around 20K and fitting curves, which use temperatures as fitting parameters, are also agreed. These indicate that the test conductors were fabricated without any degradation.

Next, preliminary experiments of stability measurements were carried out on the insulated sample. The samples exposed to bias magnetic fields of 2.5-5 T in EO direction and dc transport currents of 80% of critical currents. Voltages of the samples were measured, after just one tape in the samples was heated for 5 sec by a carbon heater. From experimental results, it was found that stability depends on temperature margins, which are decided by identical temperature rises of five tapes.

Finally, inter-strand coupling losses in the non-insulated samples were measured. AC losses in the samples applied transverse magnetic fields which are ac ripple fields in amplitudes of about 10 Gauss superimposed on the dc bias fields of 0.5 T were measured by pick-up coil method. Frequencies of the ac fields were 10Hz-318Hz. As a result, it was found that coupling time constant of the sample is about 1.5 msec when EO fields applied to the samples. Comparison between the measured results and data from numerical analysis clarifies that inter-strand contact resistances are about 10^{-10} Ωm^2, which are same level as that of conductors composed of NbTi/Cu strands.

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

Table1 Parameters 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

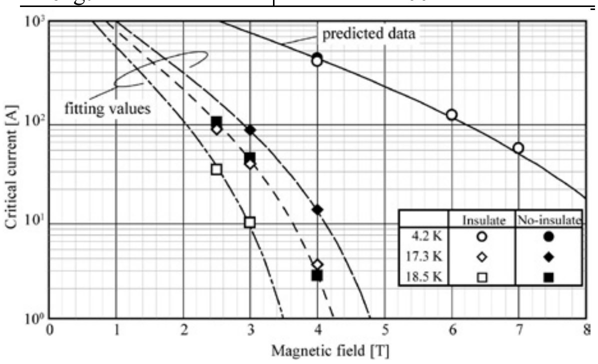

Fig. 1 Critical currents of MgB_2 transposed conductors