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§10. Development of a Conductor with Large Capacity for Fusion Devices by Using Superconducting Tapes with High Aspect Ratio of Cross-section

Sumiyoshi, F., Kawabata, S., Kawagoe, A. (Kagoshima Univ.),
Matsushita, T., Otabe, E.S., Kiuchi, M. (Kyushu Institute of Technology),
Tanaka, K., Wakuda, T. (HITACHI),
Yanagi, N., Mito, T.

In order to develop new superconducting conductors for fusion devices, the performance of MgB_2 wires has been improved, and the investigations to assemble tapes and to fabricate the coils have been carried out[1]. In order to simultaneously attain both increase in critical currents and decrease in ac losses of MgB_2 wires, we proposed MgB_2 tapes which aspect ratio of cross-section is high.

The purpose of this study is to clarify design method of large scale conductor composed of MgB_2 tapes for fusion reactors. Our previous study have shown experimentally both effect of increase in critical current densities and decrease in ac losses on short samples of MgB_2 tapes with high aspect ratio made from round wires by rolling process. In order to get the design method for fabrication of conductors assembled plural MgB_2 tapes, electromagnetic properties of a test coil wound with a parallel conductor composed of two tapes have been evaluated experimentally[2].

The MgB_2 tapes have been fabricated from round wires with 0.8 mm in diameter by rolling process before annealing the round wire. The parameters of MgB_2 tapes which are used on the experiments is shown in Table I. The test coil which has been wound with a parallel conductor composed of two MgB_2 tapes insulated each other. The test coil is composed of two small coils that are arranged coaxially and connected in series. The gap between these small coils is 10 mm. Therefore, the test coil is Helmholtz coil. Inner and outer diameters of the test coil are 65 mm and 107 mm, respectively. Whole length of the coil is 53 mm. The layer of the test coil is 15. The total turn number of the test coil is 540 turns. The conductor length is 140 m. The two tapes are transposed at joint point between the two small coils for uniform current distribution between two tapes. Produced magnetic fields in bore of the test coil is 1.31 T at 200 A.

The all experiments were carried out in liquid helium. The critical current of the test coil was measured 360A. The voltage criterion has been defined as 1.4 mV which is a coil voltage when an electric field of 0.1μV/cm is generated whole length of the conductor in the coil. This critical current is close to predicted value from the experimental results on short samples and about twice as large as one of the coil wound with round wires. It indicates our coil is fabricated without degradation. We found as follows: our tape is very effective to improve the performance of MgB_2 coil; MgB_2 conductor composed of insulated strands is not problem in case of slow sweep.

Ac loss measurements have been carried out under following condition; the transport current is superposed ac current on dc current of 100 A, in order to suppress the effect of superconductivity of Nb in tapes. Ac loss measurements are needed to cancel the inductive voltages in terminal voltages across the coil. The loss components of voltages of the test coil were measured. Transformer for cancelling is connected in series to the circuit to measure ac losses in the test coil. Ac losses were calculated from the loss component of the coil voltage and ac current. Measured results are shown in Fig. 1. Horizontal axis is RMS values of transport ac currents, and vertical axis is measured ac loss energy per one cycle of transport ac current. Frequency dependences of ac losses are not observed. This indicates that measured losses are mainly hysteresis losses. In range of low ac currents, ac losses depend on frequency due to eddy current losses in Cu. In order to show the validity of the tape, theoretical values of ac losses are shown by two lines in this figure, solid and dashed lines represent ac losses in a coil wound with round wires and that of this test coil wound with the tapes. It is found that our coil wound with tapes is low losses compared with a coil wound with round wires. The reason of difference between theoretical values and experimental values might be J_c distributions in the filaments or surface pinning of filaments.

In order to validity of the conductor composed of our MgB_2 tapes, the test coil has been designed, fabricated and tested. Consequently, it has been shown that our MgB_2 tapes are very valuable to develop high performance conductor or coil.

1) F. Sumiyoshi, et al., Journal of Physics:Conference Series, Vol. 234, No. 22038, pp. 1-13.
2) A. Kawagoe, et al., IEEE Trans. Appl. Supercond. Vol. 21, No. 3, pp.1612-1615.

Table I Parameters of MgB_2 conductor for winding a test coil

	tapes	conductor
outer dimension	1.05 x 0.504	1.25 x 1.43
filament dimension	0.712 x 0.233	
filament aspect ratio	3.08	

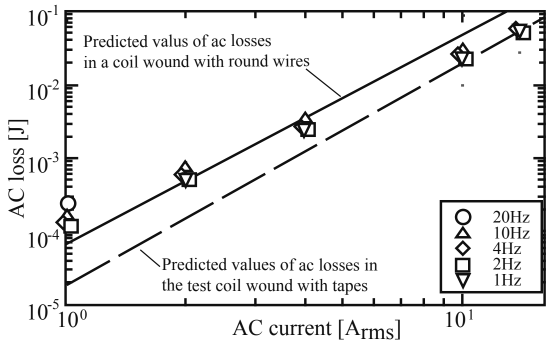

Fig. 1 AC loss properties of MgB_2 test coil wound with a parallel conductor.