§21. Development of Advanced Superconducting Conductors for Fusion Devices

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In order to develop new superconducting conductors for fusion devices, the performance of MgB_2 wires has been improved, and the investigations to assemble conductors and to fabricate the coils have been carried out as well. 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 proposed MgB_2 tapes are obtained by rolling the twisted MgB_2 multifilamentary round wires. In this time, measurements of both critical currents and magnetizations have been carried out on fine single filament wires and tapes, to clarify the effects of deformation into tape shape on the electromagnetic properties of MgB_2 filaments. In addition, a test coil has been fabricated and tested. The test coil is wound with a parallel conductor composed of two insulated tapes from each other.

Fig. 1 shows the critical current improvements due to deformation under external magnetic field of 7 T. Measured samples are straight samples with 60 mm in length. The horizontal and vertical axes represent the aspect ratio of a filament and the ratios of critical current densities, J_c of tapes to that of original wires, respectively. It is found that J_c of our tapes increase when a filament is made flatter. The effect of deformations on J_c doesn't depend on the diameter of original round wires. In addition, SiC addition doesn't have influence to improvement of J_c. In case of the tape with the aspect ratio of a filament of 15, its J_c for parallel field increase to 7 times as one of the original round wire. One of the possible reasons for the increase in J_c due to deformation from round shape into tape shape is the increase in electrical connectivity in the tapes. Moreover, increase in upper critical magnetic field, B_{c2} has been observed. The increase in B_{c2} is one of the reasons for increase in J_c.

An effective thickness, t_{eff} which is defined by $t_{eff} = 2\Delta M/ J_c$, has been measured. The effective thickness, t_{eff} corresponds to magnitudes of hysteresis losses. Our measured result showed that hysteresis losses decrease with increase in aspect ratio of filaments. In case of the tape with the aspect ratio of 9.2, hysteresis losses decrease to 1/4 of the original round wire. In addition, measured data are closely to the theoretical line.

As an example of a superconducting conductor with large capacity of transport currents using our tapes, a parallel conductor composed of insulated tapes has been proposed. In this case, the inter-strand coupling losses are not produced. A test coil wound with the conductor has been fabricated and tested. The tapes as winding conductor for the test coil have non-doped MgB_2 tapes with aspect ratio of 2. The test coil is composed of two coils arranged coaxially and connected in series. The winding conductor is a parallel conductor composed of two insulated tapes from each other. The two tapes are transposed at joint point between the two coils. Inner and outer diameters of the coil are 65 mm and 104mm. The designed value of a center magnetic field produced in the coil is 1.31T at 200A. The designed critical current of the coil is 340A which is twice as large as one of the coil wound with a conductor with round wires. The critical current measurement of the coil has been carried out at 4.2K. The measured critical current is defined the transported current when the voltage of the coil is 1.4 mV which is voltage in case that the electric field of 0.1μV/cm is produced whole the all length of the conductor in the test coil. The measured critical current of the test coil was 360A. This value is close to the designed value of 340A. It is shown that both the coil have been wound with the conductor with no damage and the transport current has been flowed without unbalanced current by transposition of the conductor. AC losses measurements were carried out. The measured data is shown in Fig. 2. In case of that bias current was flowed, frequency dependence of the losses was not observed. This shows that hysteresis losses are dominant.

Consequently, it has been shown that the good electromagnetic properties of MgB_2 tapes are gotten by rolling process and the tapes have validity for MgB_2 conductors and coils.

1) Kawagoe, A. et al.,: IEEE Trans. Appl. Supercond., **20** (2010) 1601
2) Sumiyoshi, F. et al.: Journal of Physics Conference Series **12** to

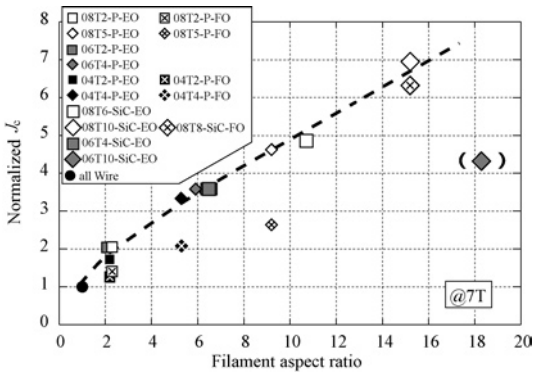

Fig. 1 Increase in critical current densities, J_c.

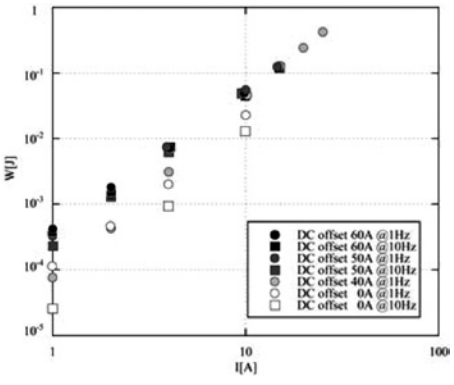

Fig. 2 Measured ac losses in the test coil wound with a parallel conductor composed two MgB_2 tapes.