§13. Conceptual Design of 10 kA Class MgB_2 Cable for Hybrid Energy Transfer Line

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It is important to understand the mechanical performance of the MgB_2 wire. To suppress the Ic degradation for bending strain, multi-filamentary MgB_2 wires were investigated. The bending property of the 19 filamentary MgB_2 wire was made, and it was tested in comparison with the mono-core MgB_2 wire [1]. Configuration and Ic performances of both wires are summarized in Table 1. A relationship between the normalized Ic and bending strain for MgB2 mono-core wire and multi-filamentary wire is shown in Fig. 1 The bending strain ε is defined as,

$$\varepsilon = d / D \times 100 (\%). \quad (1)$$

Where the d is diameter of the wire, and D is diameter of the bend. The Ic degradation of both wires was observed. However, about 50 % of I_{c0} is remained in the multi-filamentary MgB_2 wire, even if the bending strain exceeds 2 %. This is that about half of the filaments of inside keep the I_{c0} value, whenever the filaments of outside are damaged by the large bending stress [2].

The MgB_2 cable should be robust for the repetition of the bend and stretch of following manufacture process of; the heat treatment, transfer to the reel, twist and bundle, transportation by cable drums and installation on site. As shown in Fig. 2 (a), a diameter of the cable dram has the restriction of the surface transportation. Diameter of the

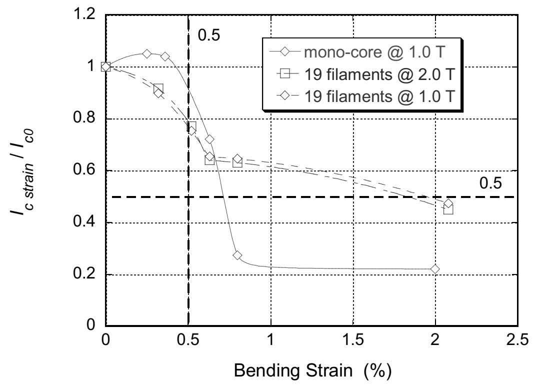

Fig. 1 Normalized Ic vs. bending strain for MgB_2 mono-core wire and 19-filamentary wire.

Table 1 Parameters of mono-core and19-filamentary wires.

Items	Mono core	19 filaments
Diameter of wire (mm)	1.04	1.04
Area of MgB_2 (%)	4.57	5.08
Area of Ta barrier (%)	27.33	34.47
Area of Cu (%)	68.10	57.45
Ic @20K, 1T (A)	76.81	61.56
Ic @20K, 2T (A)		34.31

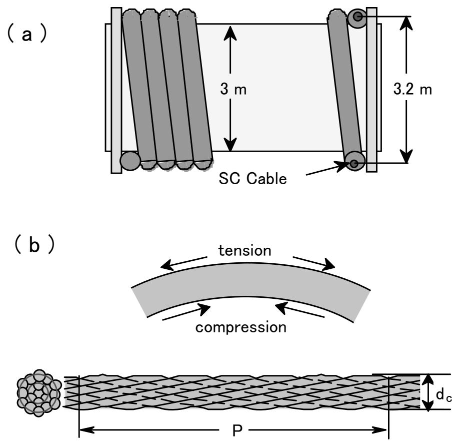

Fig. 2 Cable dram (a) and coaxial twisted MgB2 cable (b).

dram is determined to 3 m. When the cable is wounded to the cable dram, tensile stress and compressive stress are induced to the outside and inside of the bend, as shown in Fig. 2 (b). Structure of a coaxial stranded cable is suitable to relieve the bending stress for the large bore cable. The bending strain of the tight-twisted cable can be explained by the Eq. (1).

In the loose-twisted cable, bending strain will decrease, because the slip among the strands to the axial direction will compensate the outside tensile stress with inside compressive stress. In a coaxial flexible stranded cable, total number of the strands, N, and diameter of the cable, D, can be expressed as

$$N = 3n(1+n)+m(1+n) \quad (2)$$

and

$$D = (k+2n)d \quad (3)$$

where, n is number of layers, m is number of strands of the core, k is constant and value related to m. When m is 3, k becomes 2.155. In the cable design, parameters of m and n are selected to 3 and 12, respectivelly. The diameter of the strand, n, is 1.3 mm as shown in Fig. 2 (a). To decrease the bending strain, a twist ratio (=one pitch length / cable diameter) is also determine to be 30. Main parameters of 10 kA MgB_2 cable are summarized in Table 2.

[1] Y. Hishinuma et al, CSJ Conference , May 13, 2009 1D-a10.
[2] S. Yamada et al, *Journal of Physics: Conference Series* **97** (2008) 012167.

Table 2 Design parameters of 10 kA MgB_2 cable.

Items	Target values
Operation Temperature	17 K – 24 K
Material of the SC wire	MgB_2
Diameter of the SC strand	1.3 mm (0.5 mm)
Operation Current of strand	19.7 A (~100 A/mm^2)
Number of the SC wire	507
Diameter of SC cable and wire	26.5 : 1
Twist ratio (P / d_C)	30 (1035 mm / 34.5 mm)