§13. Conceptual Design of 10 kA Class MgB₂ Cable for Hybrid Energy Transfer Line

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It is important to understand the mechanical performance of the MgB₂ wire. To suppress the Ic degradation for bending strain, multi-filamentary MgB₂ wires were investigated. The bending property of the 19 filamentary MgB₂ wire was made, and it was tested in comparison with the mono-core MgB₂ 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,

\[ \varepsilon = \frac{d}{D} \times 100 \, (\%) \]  

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 Ic₀ is remained in the multi-filamentary MgB₂ wire, even if the bending strain exceeds 2 %. This is that about half of the filaments of inside keep the Ic₀ value, whenever the filaments of outside are damaged by the large bending stress [2].

The MgB₂ 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 dram is determined to 3 m. When the cable is wound 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

\[ N = 3n(1+n)+m(1+n) \]  \hspace{1cm} (2)

and

\[ D = (k+2n)d \]  \hspace{1cm} (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, respectively. 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 MgB₂ cable are summarized in Table 2.