§11. Critical Currents of Aluminum-Alloy Jacketed Nb_3Sn Superconductor Fabricated by React-and-Jacket Process

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We have studied a conceptual design of superconducting coils for fusion reactors[1]. One option is to use an aluminum-alloy jacketed Nb_3Sn superconductor. The use of an aluminum-alloy jacketed superconductor is novel because the melting point of aluminum (933 K) is a little lower than the heat treatment temperature of Nb_3Sn wires (~1000 K). Therefore the jacketing must be performed after the heat treatment of the wires. We call this the "react-and-jacket (R&J) process." The R&J process has the advantage in terms of strain-induced changes in critical current. In the case of a stainless-steel jacketed Nb_3Sn superconductor with the jacket-and-react (J&R) process, Nb_3Sn filaments are finally subjected to a compressive strain due to the difference in thermal contraction (1000 - 4 K) between stainless steel and Nb_3Sn. This compressive strain causes the significant degradation of critical current[2]. On the other hand, the R&J process can reduce a strain in Nb_3Sn.

We developed the R&J process using a recently developed friction stir welding (FSW) technique. Fig. 1 shows a conductor for demonstrating the new process and the performance of the conductor. Table 1 indicates the specifications of the conductor. The 18-strand Rutherford cable was heat-treated and embedded into the U-shaped jacket. Finally the cover of the jacket was welded to the U-shaped jacket by FSW. The dimension is 17 mm x 4.9 mm. After a conditioning process, 1-m-long superconductors were fabricated and tested in an 8-T split magnet. We succeeded in carrying 9 kA at 8T. Fig. 2 shows the experimental results of current-carrying capacity tests. Open circles indicate the critical currents (*Ic*) of the test conductor at 4.26 K and the bias field. The criterion for the *Ic* definition was 100 μV/m. Filled circles indicate the product of 18 (the strand number) and *Ic* of the strand. The experiments indicate that the degradation of the critical current was approximately 8%. This degradation is much smaller than that in a conventional conductor fabricated by the J&R process. The R&J process is thus an attractive candidate for a fabrication method.

In order to demonstrate a coil fabrication, the conductor must be bent. We then investigate the effect of bending. Open triangles indicate *Ic* of the samples that were bent with a curvature radius of 150 mm and straightened. The direction of bending was different between the sample SA and SB. Open squares indicate *Ic* of the sample that was bent twice on both sides and straightened. The experiments show that *Ic* slightly increased after bending. The pre-bending effect probably affects the increase of *Ic*[3]. These results confirm that we can wind a coil by using the aluminum-alloy jacketed Nb_3Sn superconductor.

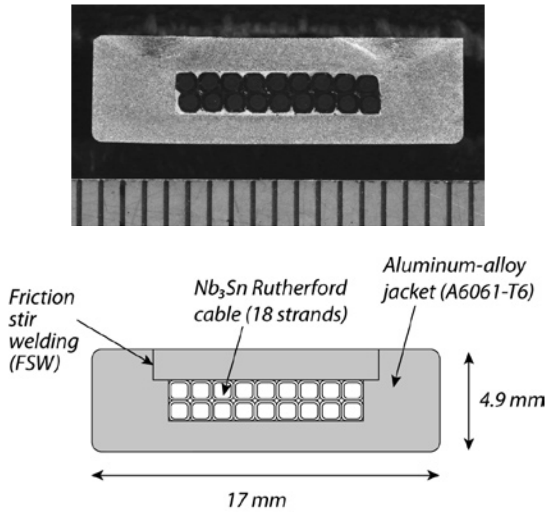

Fig. 1. Photograph and configuration of the aluminum-alloy jacketed Nb_3Sn superconductor.

Table 1 Specifications of the conductor

Conductor dimension (mm)	17.0 × 4.9
Cable space (mm)	9.5 × 2.0
Cable dimension (mm)	9.2 × 1.8
Strand diameter (mm)	1.0
Number of strands	18
Filled material in cable space	Indium
Jacket material	A6061-T6
Welding method of jacket	FSW
Critical current	5 kA @ 12 T
	10 kA @ 8 T

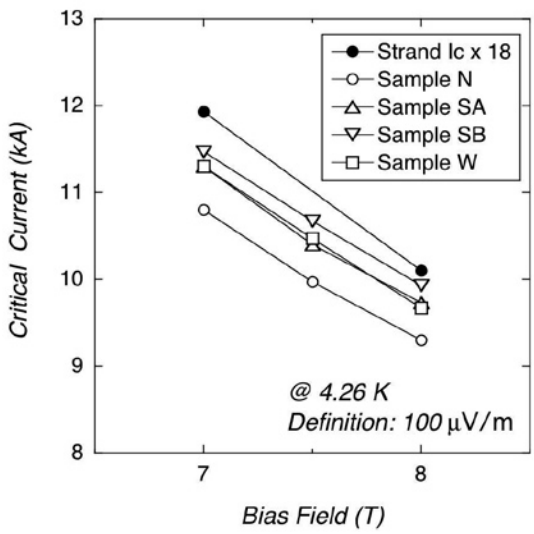

Fig. 2. Measured critical currents of the sample conductors.

1) Takahata, K. et al.: Fusion Eng. Des. **82** (2007) 1487
2) Ciazynski, D.: Fusion Eng. Des. **82** (2007) 488
3) Awaji, S. et al.: Fusion Eng. Des. **81** (2006) 2473