§10. Large Current Transport Test of the RHQT-processed Nb_3Al Rutherford Cable

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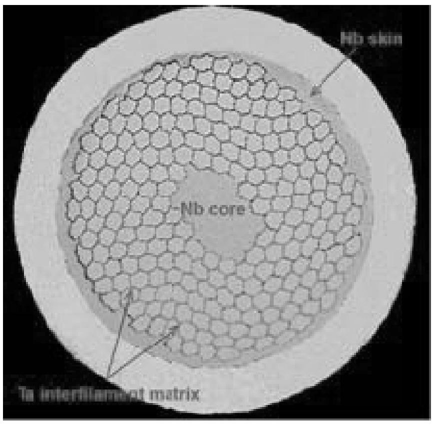
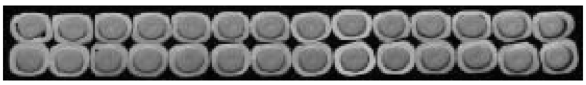
For the DEMO fusion reactor beyond ITER, the ground design and investigation of the large high magnetic field superconducting magnet system have been accelerated in the world. At the present stage, high J_c Nb_3Sn is the first candidate material for the future fusion reactor due to the established industrial mass production and the actual achievement of the ITER project. However, it is well known that the J_c of the commercial bronze and Internal Tin processed Nb_3Sn wires degrade by the mechanical and/or thermal strains, and the Nb_3Al wires have higher mechanical and thermal strain tolerances on the J_c properties compared to the Nb_3Sn wires. At present, there are two major fabrication processes of the Nb_3Al wires, the diffusion process and the Rapid heating, quenching and transformation (RHQT)-process. N. Koizumi et al. had fabricated the diffusion processed Nb_3Al wires and carried out the critical current test of the cable-in-conduit conductor and the excitation test of the coil[1,2]. On the other hand, the RQHT-processed Nb_3Al wires, which have remarkably higher J_c-B properties than those of the diffusion processed wires, have been developed mainly at NIMS. In this study, we have fabricated the large Rutherford cable made of the RHQT-processed Nb_3Al wires, and the current transport test has been carried out in order to investigate the properties of the RHQT-processed Nb_3Al.

The RHQT-processed Nb_3Al precursor wire was manufactured by the jelly-roll Nb/Al process. The precursor wire was then subjected to the RHQ treatment and drawn down to the final size of the wire. Next, stabilizing copper was electroplated on the surface of the wires, and the Rutherford cable was fabricated. The jelly-roll Nb/Al filaments were embedded in a Ta-matrix. The Ta-matrix acts as the barrier material between Nb_3Al filaments to resolve the magnetic instability due to the filament coupling. Typical optical image of the cross-section of the Nb_3Al/Cu wire having 1.0 mm in diameter was shown in Fig.1 (a). The total number of the filaments was 222, and the Cu to non-Cu ratio was about 1.0. Typical cross-section of the 27-strand Rutherford cable was also shown in Fig.1 (b).

The heat treatment of the cable was performed as follows: The Rutherford cable was inserted in a stainless steel case shown in Fig.2. Then the case was installed in a vacuum pipe shown in Fig. 3. In order to check the heat treatment conditions, several witness wires were also installed into the vacuum pipe. By the end of the fiscal year 2015, the heat treatment of the cable and the critical current measurement of the witness sample were completed. And a first trial of the large current transport test of the cable has been performed.



(a) Strand



(b) Rutherford cable

Fig. 1 Optical images of the cross-section of RHQT-processed Nb_3Al/Cu strand and Rutherford cable: (a) strand and (b) Rutherford cable.

1) Koizumi, N. et al.: Cryogenics, **42** (2002) 675.
2) Koizumi, N. et al.: Nucl. Fusion, **45**, (2005), 431

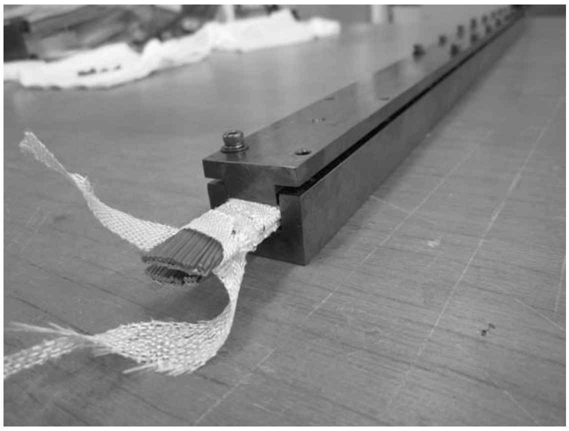


Fig. 2 Rutherford cable inserted in a stainless-steel case for the heat treatment.

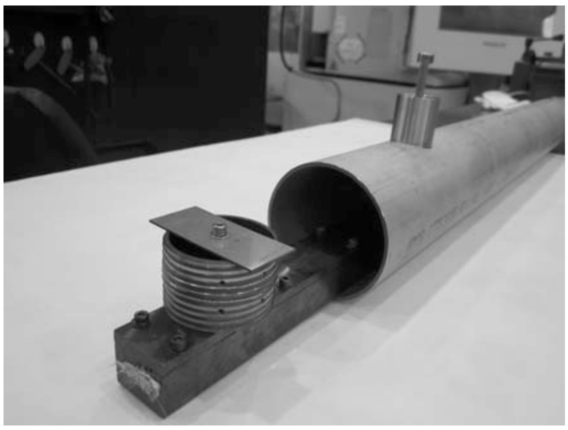


Fig. 3 Witness wire sample and Rutherford cable installing into the vacuum pipe for the heat treatment.