# §21. Investigation of A15 Phase Metallic Superconducting Wires for Fusion Magnets via React and Winding Process

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In the Fusion Engineering Research Project (FERP) of National Institute for Fusion Science (NIFS), various R&D and investigations about superconducting materials and helical winding process base on the Free Force Helical Reactor (FFHR) design activity are carried out in order to realize the Large Helical superconducting coils. Generally, critical current density ($J_c$) of A15 phase metallic superconducting wire is remarkably decreased by the tensile and compressive strains which are caused by hoop stress and electromagnetic force. Consequently, making $Nb_3Sn$ superconducting coil, it is adopted "Wind & React" process which is heated the coil in a vacuum after the coil winding. In the International Themonuclear Experimental Reactor (ITER) project, Toroidal Field (TF) and Center Solenoid (CS) coils are made by the Bronzed processed $Nb_3Sn$ wire, these coils are universally adopted to "Wind & React" process. In the case of DEMO and fusion power plant, there will be limit in the "Wind & React" process to construct larger superconducting coil. In order to investigate the $J_c$ degradation of A15 phase superconducting wire based on the "React &Wind" process, we carried out the conceptual design activity of critical current measurement probe with bending mechanism applying bending strain quantitatively.

The critical current measurement probe with bending mechanism was inserted into the 18T superconducting magnet at Tsukuba Magnet Laboratory (TML) of NIMS. The probe dimension and bending strain mechanism were restricted by the configuration of 18T superconducting magnet (bore size and the distance between top flange and magnet). We set out the basic concept of applied bending strain mechanism on transport $J_c$ measurement probe shown in Fig.1. The wire attachment deformed concavo-convex side with moving the bending shaft up and down. The bending shaft was moved by the bellows type linear feed through. Generally, bending strain of superconducting wire was estimated by the following formula (1);

$$\text{Bending strain } \varepsilon = (D/2R) \times 100 \text{ ----(1)}$$

D: diameter of wire (mm), R: bending radius (mm)

This bending mechanism was able to apply 20 mm of bending radius, and maximum bending strain was obtained to be about 3% when superconducting wire which had 1.04 mm diameter was used. The Be-Cu alloy is one of the candidate metal materials for the wire attachment. Because Be-Cu alloy has larger elasticity limit at 4.2 K compared with the other metal materials. Furthermore, we fabricated the wire attachment made by Be-Cu alloy shown in Fig.2. The both ends of grooves were to fit the superconducting wire. After that, the fixation of the sample was carried out by the Pb-Sn soldering.

The relationship between the bending radius of Be-Cu wire attachment and bending shaft displacement is shown in Fig.3. The bending radius was defined by the CCD image analysis. We found that the bending radius was related exponentially against the shaft displacement. The detail design and construction of this probe including current lead, strain gauge and voltage detection are going on.

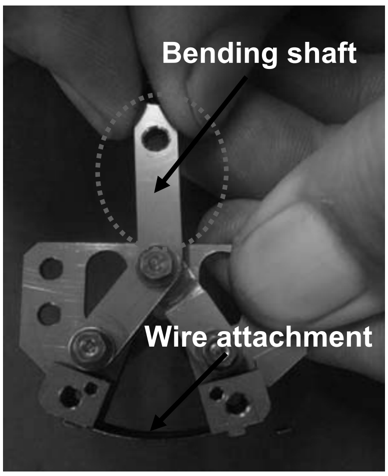


Fig.1 The basic concept of applied bending strain mechanism on transport $I_c$ measurement at 4.2K under various higher magnetic field.

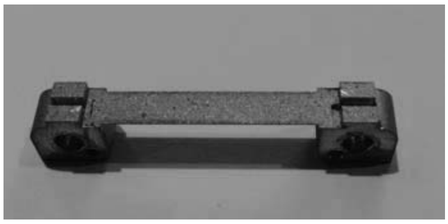

Fig.2 The photograph of wire attachment made by Be-Cu alloy

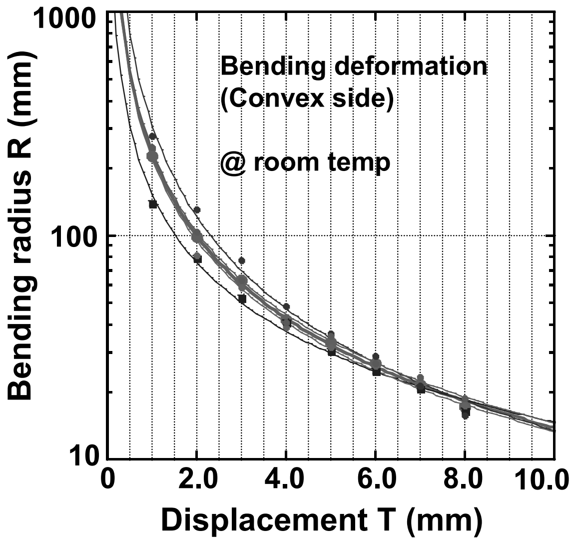


Fig. 3 The relationship between the bending radius of Be-Cu wire attachment and bending shaft displacement