§7. Investigation of A15 phase Metallic Superconducting Wires for Fusion Magnets via React and Winding Process

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1. Introduction and Motivation

In the Fusion Engineering Research Project (FERP) of National Institute for Fusion Science (NIFS), various R&D and investigations concerned with the superconducting materials and helical winding process are carried out in order to realize for the Free Force Helical Reactor (FFHR) design activity. Generally, critical current density (J_c) of A15 phase metallic superconducting wire depends on the mechanical strain and is decreased by the bending and tensile 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 mainly 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 uniaxial tensile mechanism applying uniaxial tensile strain quantitatively. We noted to design a simple uniaxial tensile mechanism of the critical current measurement probe. This critical current measurement probe with simple uniaxial mechanism is inserted 18T superconducting magnet in Tsukuba magnet laboratory of National Institute for Materials Science (TML-NIMS).

2. Conceptional design of the uniaxial tensile mechanism on critical current measurement probe

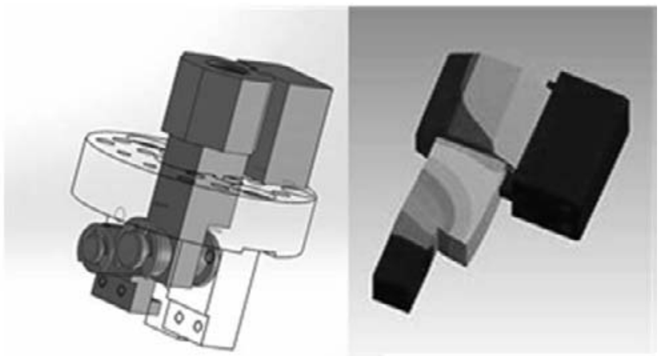
The configuration of the probe and simple uniaxial strain mechanism were restricted by the configuration of 18T superconducting magnet (bore size (52 mm) and the distance between top flange and magnet (about 1800 mm)) and wire length (35 mm). The conceptional design of applied uniaxial tensile strain mechanism on transport I_c measurement probe shown in Fig.1. The uniaxial tensile stress is controlled by the rotation frequency of the liner motion. The liner motion is connected with Cu electrode via link bar. The uniaxial tensile stress of the wire is occurred by the moving of the liner motion. We confirmed that superconducting wire was uniformly pulled for uniaxial direction. The tensile displacement of wire was measured by the clip gauge (four strain gauges). The uniaxial tensile strain is defined by the following formula,

$$\text{Tensile strain } \varepsilon = (l-l_0) / l_0 \text{ ---- (1)}$$

l is the wire length applying the uniaxial tensile stress and l_0 is wire length.

In order to realize the uniaxial tensile mechanism, we carried out the stress analysis of the constructional element using ANSYS system. The configuration design and ANSYS stress analysis of applied uniaxial tensile strain mechanism are shown in Fig.2. We found that the linear force about 550 kgf and torque with 415 kgf・mm were necessary to apply the tensile strain over 1.0 %.

Fig.1 The conceptional design of applied uniaxial tensile strain mechanism on transport I_c measurement at 4.2K under various higher magnetic field.



(a) The configuration of tensile mechanism (b) The ANSYS stress analysis

Fig.2 The configuration design and ANSYS stress analysis of applied uniaxial tensile strain mechanism.