§30. Study of Stress/strain Problem in Fusion Reactor Oriented Superconducting Strand and Conductor by Means of Quantum Beam Techniques

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On the basis of the progress in the LHD project, a conceptual design of FFHR has been developed as the upgraded thermal fusion reactor in the coming decades. The superconducting conductor and coil shall be used as indispensable key components. Therefore it is important to investigate their mechanical and electromagnetic properties and to establish their diagnostic technology. With respect to this subject, some typical results in this fiscal year are reported here.

Mechanical-electromagnetic properties of Nb_3Sn strand have been assessed. The residual strain exerted on Nb_3Sn component was evaluated by means of neutron diffraction technique at 9.3 K as shown in Fig. 1. The whole value of local strain consists of thermally -induced and lattice strains. The thermally-induced strain was compressive. The lattice strain increased linearly with increasing applied tensile load. The force-free strain (A_{ff}) was evaluated to be 0.12%, at which the residual stress on the Nb_3Sn component becomes zero. The strain dependence of critical current was investigated at 4.2 K. The critical current maximum was observed at nearly A_{ff}. This coincidence between the critical current maximum and the force free strain has been theoretically expected for long time before the present experimental verification.

The stress/strain behavior of the surround Cu stabilized YBCO coated conductors and its influence on critical current were precisely investigated[1,2,3]. The internal strain exerted on the superconducting YBCO layer was determined at 77K by using neutron diffraction technique at JAEA as shown in Fig. 2. The initial compressive strain decreased during tensile loading and changed tensile component at A_{ff}, where the internal uniaxial stress becomes zero in the YBCO layer. The A_{ff} was evaluated to be 0.19 – 0.21 % at 77 K. The critical current measurements were carried out under uniaxial tensile load at 77 K. The strain dependence revealed a characteristic behavior, where a maximum was observed at 0.035%. Thus it was made clear that the strain at critical current maximum does not correlate with A_{ff} for YBCO coated conductors.

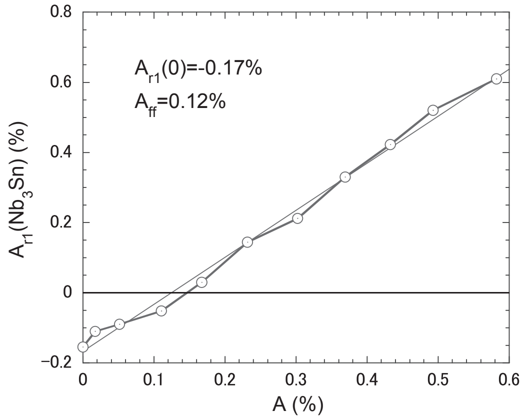

Fig. 1 Applied strain dependence of total local strain exerted on Nb3Sn component at 9.3 K

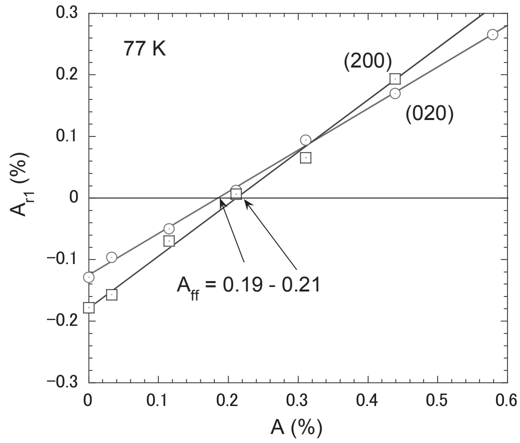

Fig. 2 Applied strain dependence of total local strain exerted on YBCO layer at 77 K.

It is highly demanded to assess the local strain in the conductor like CICC because nobody could measure the information on strain from the so thick sample. We succeeded to measure the local strain as a function of interior position for the CICC by means of pulsed neutron diffraction technique. It is expected to use as a diagnostic technique measuring local strain in the conductor.

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2) K. Osamura, S. Machiya, Y. Tsuchiya, H. Suzuki, IEEE Trans. on Applied Supercond. .20 (2010) 1532-1536.
3) K. Osamura, S. Machiya, Y. Tsuchiya, H. Suzuki, Supercond. Sci. Technol. 23 (2010) 045020-045026