§22. Thermal Strain Exerted on Superconductive Filaments in Practical Nb_3Sn and Nb_3Al Strands

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In order to design the upgraded thermal fusion reactor, FFHR, the superconducting conductor and coil shall be used as indispensable key components. In practice, those superconducting devices will be exposed under a huge magnetic force field. Therefore it is important to investigate their mechanical and electromagnetic properties and to establish their diagnostic technology [1),2)]. Here, the results of the precise measurements of thermal strain in the practical SC strands are reported.

Two types of SC strands were examined. Nb_3Sn strand was fabricated for ITER project, in which 11,000 SC filaments are embedded in the bronze matrix and surrounded by Nb barrier and Cu stabilizer. Nb_3Al strand was fabricated by means of Jerry Roll method, in which 90 SC filaments were embedded in Cu matrix.

The diffraction measurements were carried out at TAKUMI of J-PARC. In order to measure the thermal strain at elevated temperatures, the bundle of short samples was put in the evacuated electric furnace, which was equipped at the center of goniometer.

The temperature dependence of thermal stains exerted on SC filaments was measured along both axial and transverse directions as shown in Fig. 1. Here the room temperature data are added in the figures. The axial thermal strain near room temperature was negative, that means compressive strain. It decreased with increasing temperature and became zero. Then the sign of thermal strain turned to positive, it means tensile. It tended to saturate at high temperature. On the other hand, the transverse thermal strain was compressive in the whole temperature range and gradually decreased with increasing temperature for Nb_3Sn strand. In the case of Nb_3Al strand, the behavior of axial thermal strain was similar to the change for Nb_3Sn. At room temperature, the axial strain was compressive. With increasing temperature, the thermal strain became tensile and saturated. The transverse thermal strains at room temperature were scattered, but their average was compressive. It increased and turned to tensile with increasing temperature.

Their temperature dependence was numerically evaluated by means of iteration method as shown in Fig. 2. As a whole, it has been established that the temperature dependence of thermal strain can be well reproduced by the numerical calculation proposed here. It was pointed out that the thermal strain on SC filaments is affected by the creep phenomenon at high temperatures above a threshold temperature.

In conclusion, it could be suggested that the evaluation method of local strain exerted on SC filaments has been established experimentally as well as theoretically for such complicated SC strands.

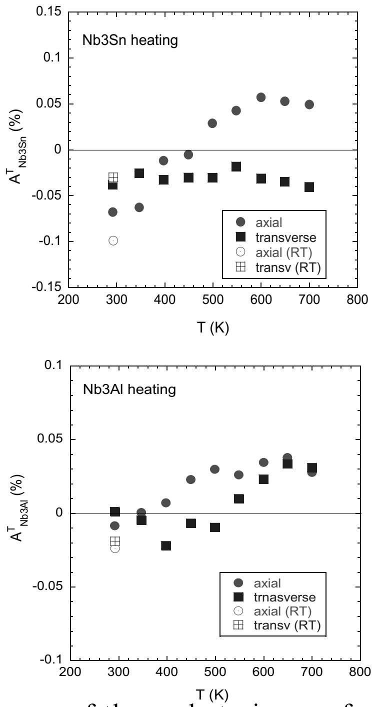

Fig. 1 Change of thermal strain as a function of temperature for Nb_3Sn and Nb_3Al strands.

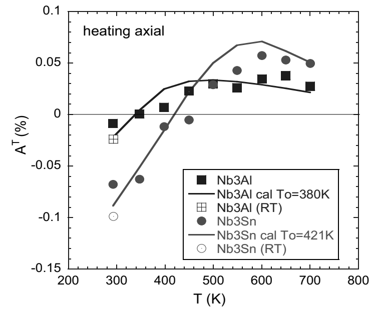

Fig. 2 Comparison of the calculated results with the experiments for Nb_3Sn and Nb_3Al strands.

1) K. Osamura, S. Machiya, S. Ochiai, G. Osabe, K. Yamazaki and J. Fujikami: Supercond. Sci. Technol. 26 (2013) 045012 (5pp).
2) K. Osamura, S. Machiya, Y. Tsuchiya, H. Suzuki, T Shobu, M Sato, S. Harjo, K. Miyashita, Y. Wadayama, S. Ochiai and A. Nishimura: Supercond. Sci. Technol. 26 (2013) in press [CSSJ Conf., 87(2013) 49].