Contribution ID: **158** Type: **not specified**

Magnet development for national project (JA DEMO)

Tuesday 10 June 2025 11:10 (40 minutes)

Hiroyasu Utoh

National Institutes for Quantum Science and Technology,
Rokkasho, Aomori 039-3212, Japan

ABSTRACT

A fusion demonstration (DEMO) reactor requires toroidal field (TF) coils larger than those used in ITER and can withstand higher electromagnetic forces. This creates significant challenges regarding the manufacturability of the TF coils, the increased electromagnetic forces on the TF inner leg case, and increased fabrication costs. This means that new winding pack designs and superconducting conductors must be designed to meet these requirements, and high-strength cryogenic steel for the coil case must be developed to withstand electromagnetic forces. This paper describes these possible solutions based on the Japanese DEMO (JA DEMO) design. In the layered winding of rectangular conductors, it was found that a new conductor geometry called the hybrid R-shape conductor can significantly reduce the stress on the turn insulation while reducing the superconducting wire to less than half. In addition, a guideline for designing the conductor strand structure was provided for a superconducting conductor subjected to electromagnetic forces 1.5 times greater than those of ITER. Furthermore, the effect of composition on strength was evaluated using several prototype materials based on high-Cr austenitic steels, and the feasibility of increasing the strength of cryogenic steels was confirmed. When considering options for layer winding of rectangular conductors, we found that adopting a hybrid R-shape conductor would alleviate stress and make it possible to design an optional TF coil that could rationalize costs by optimizing the amount of Nb_3Sn. The rectangular conductor layer winding method is considered a promising option for TF coils for JA DEMO, and we plan to refine the design, including manufacturability, further. Regarding conductor design compatible with high electromagnetic force and large current, it was found that it was not easy to adopt the same twist pitch as ITER for the ITER CS grade wire for the DEMO conductor. Therefore, reviewing the strand structure with a focus on the twist pitch and developing high-strength strands will be necessary. Regarding the development of high-strength structural materials, we started development with the goals of yield strength YS > 1,600 MPa and fracture toughness KIC(J): 120 MPa$\sqrt{m}$. We confirmed that our policy of increasing strength by increasing the amount of N was correct. We plan to create and evaluate materials with new compositions in the future.

Country or International Organisation

Affiliation

Speaker's email address

Presenter: UTOH, Hiroyasu (National Institutes for Quantum and Radiological Science and Technology)

Session Classification: Magnets