24P-5F-11 日本におけるITER TFコイル一体化製作技術の確立

Establishment of ITER TF coil Winding Pack integration techniques in Japan

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1. Introduction

QST is responsible for the procurement of 9 Toroidal Field (TF) coils for ITER as the domestic agency of Japan. In the last stage of a TF coil fabrication, a conductor winding (Winding Pack : WP) is integrated into a coil case. Due to its massive size of 9 m wide and 16.5 m high, weighing 310 tons (Fig.1), the fabrication of a TF coil involved some technical challenges. In January 2020, our first ITER TF coil was completed overcoming those challenges. Now, the TF coil fabrication has been routinized and 6 TF coils have been completed in Japan. In this presentation, established WP integration techniques are introduced along with the fabrication results of the completed TF coils.

2. WP integration procedure

WP is composed of 7 double pancakes (DP) which are two-layer windings of Nb_3Sn superconductors impregnated in stainless-steel plates. Coil case is fabricated into 4 main components; straight portion facing the center of Tokamak, called Inboard, curved portion facing the cryostat shell, called Outboard, and their inner covers (Fig.1).

The magnetic property of each TF coil is assured by determining Current Center Line (CCL) positions. CCL of a coil can be calculated as the barycenter of all 134 turns of superconductor in a WP. In WP fabrication, the CCL positions are evaluated at 8 cross sections for each WP.

In WP integration, WP is inserted into coil case by optimizing the CCL positions. After assembling the coil case components together by welding, the WP and the coil case are united by filling the gap with filler-charged resin. Then, the TF coil fabrication is completed by machining the coil case surfaces to the final shape.

3. Technical challenges in WP integration

In WP integration, the major technical challenges are a) optimization of CCL positions, b) welding deformation control, and c) gap-filling process control. Among those, the optimization of CCL positions is the most critical. A cylindrical tolerance of φ2.6 mm is defined at Inboard while somewhat more relaxed tolerance of ±3.0 mm in toroidal direction is defined for Outboard.

CCL positions are optimized by pre-determination of target CCL positions, fine adjustment to best align to the target positions, and monitoring the CCL positions accurately throughout the WP integration.

4. Summary

With the established techniques, fabrication of 6 TF coils have been completed. In Fig.2, the CCL deviations for those 6 TF coils are shown along with the tolerance ranges. It shows that the CCL tolerances are met for all 6 TF coils. It is concluded that the established techniques are appropriate for properly applied for manufacturing.

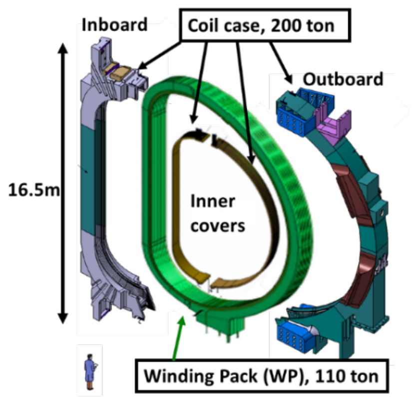

Fig.1 TF coil composition

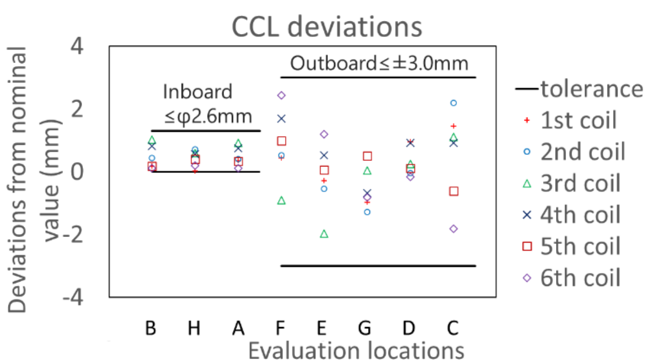

Fig.2 TF coil fabrication results