

Completion of the first TF Coil Structure of ITER

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This paper reports the completion of the first Toroidal Field Coil Structure (TFCS) of ITER of which Japan Domestic Agency (JADA) takes 100% share on procurement responsibility. The major technical challenges of the TFCS of ITER are (i) new material development for high ductility under cryogenic temperature (4K), (ii) application of partial penetration welding (PPW), (iii) welding deformation control, (iv) special ultrasonic test (UT) development considering attenuation by weldment of austenitic stainless steel and (v) fitting of large (16m x 9m) complex D-shape structure for closure welding (CW) within tight tolerance of a range of 0.5mm. Developed solutions for these challenges lead us to the successful completion of the first TF coil structure.

ITER TFCS requires both high strength and high ductility at cryogenic 4K temperature. For this, special austenitic stainless steel was newly developed. This developed material is used at inboard straight leg which supports most severe electro-magnetic force of 600MN. JADA also developed new method to keep fracture toughness requirement finding strong correlation between fracture toughness and Md30.

The PPW is applied to attachments with fracture mechanics assessment using data of crack propagation under cryogenic temperature. JADA developed new UT method to apply for PPW joints, which is to obtain the position of tip of discontinuity with its continuous length and then to assess the area of deviation from nominal position compared with maximum allowable defect area obtained by fracture mechanics.

The mechanical property at cryogenic temperature was checked for fracture toughness as well as yield strength of welded joints. The welding deformation was controlled by special welding process to keep balance of angular distortion.

The attenuation of UT beam in the weld is compensated by transfer correction factor obtained by welding test piece made with actual material and weld metal.

The TFCS was finally machined on its closure welding root that has a range of 0.5mm gap and misalignment tolerance between two welding edges. For this, quite precise control was performed such as temperature control/compensation or setting of the machining position target based on as-machined data of the other parts.

As a result of fitting test, CW roots were fit and the first TFCS of the ITER was successfully completed.

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