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The Design of the Major Assembly Tools for the ITER Tokamak

Kihak Im

ITER Cadarache Joint Work Site CEA Cadarache 13108 St. Paul lez Durance France

The ITER tokamak is assembled from 9 machine sectors, each with a toroidal angle of 40°, and comprising a sector of vacuum vessel (VV), two toroidal field coils (TFCs), the associated VV thermal shield (VVTS), and a pair of intermediate outer intercoil structure (IOIS) friction joints, which connect the outboard regions of the two TF coils. The components are delivered to the site individually, and sub-assembled to form the machine sectors using purpose-built jigs and fixtures in a large assembly hall.

The machine sectors are transferred to the cryostat pit sequentially. The TFCs and VVTS sectors are connected sequentially, immediately following transfer, whereas the VV sectors are joined (welded) to form large, 120° grouped sectors, which are later connected by simultaneous welding of the 3 open joints, according to a plan which aims to minimise deformations, and the associated technical risk.

Detailed design concepts have been developed for the massive jigs, fixtures and lifting tools that will perform the component manipulations, alignment, support and immobilization functions defined by the assembly procedure. The specification for these tools is exacting. They must have the capability of maintaining the position of the major ITER components, each with linear dimensions ~ 20 m, and mass in excess of 300 tonne, within a tolerance in the low mm range, whilst facilitating the assembly operations, and assuring worker safety, throughout the entire sub-assembly and assembly process.

This paper describes the design, and operation of the 5 large assembly tools: the Upending Tool, used to rotate the components from the horizontal orientation in which they are delivered, to the vertical orientation for assembly; the Sector Lifting Tool, which transfers the major components between the different assembly tools, and the 1200 tonne machine sector to the cryostat pit; the Sub-Assembly Tool, in which the major components are integrated to form the machine sector; the support and bracing tools for the VV sector; and the in-pit tools which support, adjust and align the TFCs, and Vacuum Vessel during final installation in the cryostat.

The structural stability of the tools has been evaluated using the ANSYS code, and the results of the analyses will be reported in the paper.