A Study on Sector Sub-assembly Tool for Assembly of 40° Sector

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1. Introduction

The ITER tokamak assembly tools are purpose-built tools to complete the ITER tokamak machine which includes the cryostat and the components contained therein. Based on the design description document prepared by the ITER organization [1,2], Korea has carried out the conceptual design of assembly tools [3,4]. Basically, the ITER assembly tools are classified into 5 groups according to machine assembly procedures such as lower cryostat activities, sector sub-assembly, sector assembly, ex-vessel activities and in-vessel activities. The conceptual design of the main tools for lower cryostat activities, sector sub-assembly, sector assembly and ex-vessel activities has been developed to satisfy the ITER basic assembly concept [5,6].

The ITER main vacuum vessel in torus shape consists of 9 sector assemblies. Therefore the sector sub-assembled at assembly hall is a basic unit for ITER device construction. Sector sub-assembly tool is the purpose-built assembly tool in which the vacuum vessel (VV) sector, vacuum vessel thermal shield (VVTS) segments, VVTS port shrouds, and toroidal field coils (TFC) are integrated to form the basic assembly unit (that is 40° sector), on which the in-pit assembly of the tokamak is based. To assemble components as mentioned above, the sector sub-assembly tool should have following functions: supporting sector assembled fully, operating 6 degrees of freedom (DOF) of adjustment part for accuracy assembly, temporary supporting of VV. This paper describes the conceptual design including function and structure of the sector sub-assembly tool. The conceptual design of the tool covers the structural analysis using ANSYS.

2. Sector Sub-assembly Tool

2.1 Function and Structure

The sector sub-assembly tool is the device in which the VV sector, VVTS sectors, and TFCs are integrated to form the assembly unit. This tool might be located in the assembly hall, within the reach of the dual crane system. This tool consists of main structure, horizontal beam, support beam, rotating frames, VV & TFC supports and rails. The main structure of the tool comprises three columns, mounted on a common foundation (the assembly hall floor), and having a triangular footprint as shown in Fig. 1.

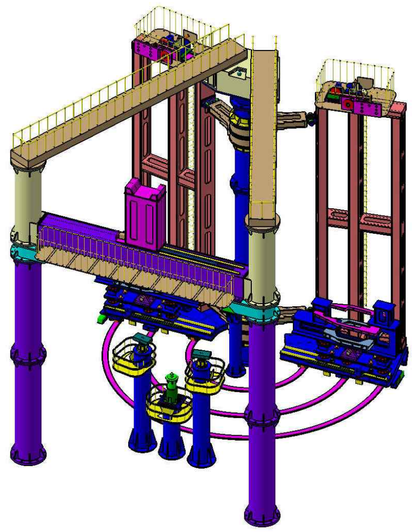

Fig. 1. The Configuration of the Sector Sub-assembly Tool.

The inboard and two outboard columns are connected via a pair of horizontal beams at their upper end. Two outboard columns are connected via a support beam. The support beam is located at the lower elevations of horizontal beams to allow the removal of the completed 40° sector with the limited building height. The installation of the VV sector and the removal of the completed 40° sector require the use of the overhead cranes. In the context of the tokamak assembly, the axis of the inboard column is located at the machine centre, and provides the reference for aligning the components in the tool. The inboard column defines the vertical axis about which the VV thermal shield sectors and TFCs rotate as they are incorporated around the VV sector. To assemble the TFCs and VVTS sectors around the VV sector necessitates their rotation about an axis corresponding to the centre of the tokamak assembly. This kinematic motion must be precise due to the tight clearances between the components. The assembly of the outboard VVTS sectors requires an additional radial movement after the toroidal positioning has been completed. The components are supported, and assembled by utilizing two rotating frames. These frames are attached to the inboard column, around which they are constrained to rotate via a pair of slewing bearings. The base of the frame is provided with roller units, driven by motors, to facilitate movement of the load along floor mounted, circular rails. Hinge-type adjustable supports for the TFCs (and VVTS sector as well) will be incorporated into the base of the rotating frame. These are located between pre-compression flanges and PF5 support plates. The coil is stabilized at its upper extremity by bolting the upper intercoil structure to the rotating frame via upper adjusting unit. Because the VV thermal shield sectors are flexible, they must be supported during handling (including assembly around the VV sector) via external, rigid, handling frame. The handling frames must interface with the rotating frames of the sub-assembly tool, to which they can be attached (bolted). The interfaces with the handling frames for the outboard VVTS sectors shall incorporate linear bearing assemblies, to support and guide the radial movement of the component. Following assembly, the TFCs are supported via four support columns, i.e. two per coil mounted on the common foundation, and positioned to correspond with the lower ledge of the coil nose, inboard, and with the gravity support leg, outboard. Independent height adjustment is provided by hydraulic jacks, mounted on top of each column. The VV sector is supported from above in the sub-assembly tool, via a large radial beam. This beam is positioned on top of the main structure of the sub-assembly tool. The VV sector is secured via an attachment that provides adjustment capability in the vertical direction and horizontal plane. Its lower outboard port is stabilized by a VV temporary support mounted on the assembly hall floor.

2.2 Structural Analysis

The structural analysis of the sector sub-assembly tool was carried out under applied load of dead weight x 4/3 using ANSYS v11.0 and compared with allowable stress. Fig. 2 shows mesh for FE analysis. The main material is AISI 1050. The results are given in Table I. For applied load, the maximum displacement is 24.9 mm at the border points between the slide block and the support. The maximum stress intensity is 360 MPa at the slide block and is well below the allowable stress.

Fig. 2. Mesh of the Sector Sub-assembly Tool for FE Analysis using ANSYS.

Table I: The Result of FE Analysis using ANSYS

Items	Maximum Stress Intensity (MPa)		Allowable Values (MPa)	
	P_m	P_L+P_b	1.0Sm (P_m)	1.5Sm (P_L+P_b)
Support Beam	207	350	276	414
Slide Block	286	360		
Horizontal Beam	53.9	60.6		
Inboard Column	144	168		
Outboard Column	105	173		
Rotating Frame	49.4	97.6		
Rotating Frame Base	22.7	25.6		
Lower Adjust Transfer	< 149	149		
Component Support	< 172	172		
Roller	< 17.9	17.9		

3. Conclusions

The conceptual design of the sector sub-assembly tool to complete sectors has been developed based on ITER assembly procedure. The structural stabilities of assembly tools have been studied using ANSYS with an applied load that is 4/3 times the dead weight and the results of structural analyses for these tools are well within allowable limits. Works continues to develop the preliminary and detailed design of the ITER assembly tools for satisfying ITER assembly schedule and procedure.

Acknowledgement

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