A Development of the Lifting Tools for 40° Sector Sub-assembly and ITER Components

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1. Introduction

The ITER Tokamak assembly tools are purpose-built and specially designed to complete the ITER Tokamak machine which includes; Vacuum Vessel (VV), VV Thermal Shield (VVTS) and Cryostat Thermal Shield (CTS), Toroidal Field Coil (TFC) and Poloidal Field (PF) coils, and other components contained in the cryostat. Based on the engineering design and design description documents prepared by the ITER organization (IO) [1,2], Korea Domestic Agency (KODA) has carried out the conceptual and preliminary design of these assembly tools [3-6].

The lifting tools described in this paper are special tools used to lift and transfer the VV, TFC and pre-assembled 40° sectors at sector sub-assembly tool placed in assembly building from the upending tool to the sector sub-assembly tool or to the Tokamak pit. The lifting tools consists of; the sector lifting tool, which is used universally for the major ITER components, and some lifting attachments for connecting components to the sector lifting tool to meet their lifting configurations. The functions, interfaces, features and configurations of the lifting tools are introduced as a result of their preliminary or final design. The results of the structural analysis to verify the stability of the lifting tools are described as well.

The preliminary design of the lifting tools, including the sector lifting tool and associated lifting attachments, have been developed by KODA to satisfy the ITER assembly plan, procedure, environments, interfaces with associated tools or ITER components and technical requirements requested by IO. The structural stability of the lifting tools has been studied using ANSYS with an applied dead weight of the relevant components for example: VV, TFC and 40° sector. For the heaviest load condition, the 40° sector (about 1200 tons), a structural analysis has been carried out and these results are summarized in this paper.

2. Lifting Tool and Attachments

2.1 Configuration of Lifting Tool

The major function of the sector lifting tool, as shown in fig. 1., is to lift the sector components such as VV or TFC of their horizontal and vertical orientations and transfer the completely assembled TFCs/VV/VVTS 40° sector from the sector sub-assembly tool at assembly building to the Tokamak pit.

The sector lifting tool is composed of; balancing beam, inboard cross beam, outboard cross beam and driving systems including longitudinal and transverse driving systems operated by electrical motors and radio control system. The crane lifting lug with 300 mm diameter pin connection is placed on the upper center of balancing beam. Overall size of this tool is 8.9 m(L) x 4.1 m(W) x 2.8 m(H) and weighs about 62 tons.

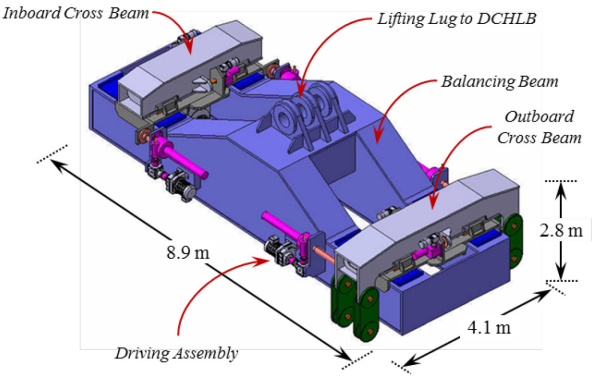

Fig. 1. Configuration, overall dimensions and main components of the sector lifting tool; length 8.9 m, width 4.1 m, height 2.8m and weight about 62 tons.

2.2 Sector Lifting Tool

The sector lifting tool was designed to be compatible with the dual crane heavy lifting beam (DCHLB), as shown in fig. 3., part of the Tokamak building crane so that it is able to accommodate the dead weight of each sector (about 1200 tons) and install and rotate each sector in a particular direction in the Tokamak pit. DCHLB is connected to Tokamak crane hooks and has a pin connection system operated by electrical power.

This lifting tool, as shown in fig. 4, is designed to adjust the position of a sector to minimize the difference between the center of the crane installed in the Tokamak building and the center of gravity (CG) of the sector or each ITER component. The outboard cross beam and inboard cross beam loaded with the sector move the sector by screw jacks and electrical motors to match the center of the balancing beam and that of the sector.

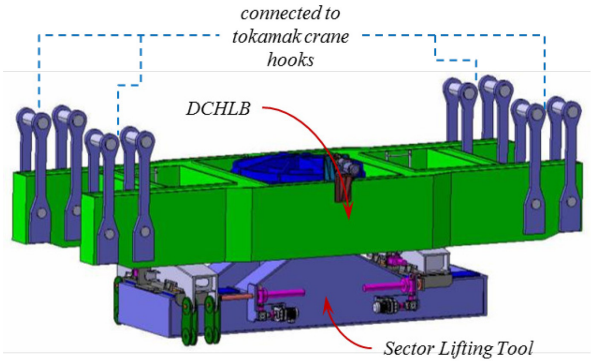

Fig. 2. Configuration of the sector lifting tool and DCHLB connected to the Tokamak 4 crane hooks.

2.3 Structural Analysis

The structural analysis of the sector lifting tool was carried out using ANSYS considering its dead weight and external load which, for one sector including one VV, two TFC and VVTS, is about 1200 tons.

The material applied to all structures is SM490YB, steel for general structure; yield, tensile strength and allowable stress intensity are 325, 490 and 216.7 MPa respectively. The results of stress intensity have been evaluated according to ASME Section VIII, Division II. The results of the analysis are given in table 1. In stress results, S_m, P_L and P_b mean allowable, primary local and bending stress respectively.

Table I: Analysis results of the lifting tool in condition of 1200 tons load, using ANSYS code according to ASME Section VIII, Division II

Load	Maximum stress intensity (MPa)		Allowable values (MPa)	
	P_L	P_L+P_b	$1.5S_m$ (P_L)	$1.5S_m$ (P_L+P_b)
1200 tons	282	282	325	325

For the applied dead weight and external load of 1200 tons, the maximum vertical displacement is 8.8 mm at the end of the outboard cross and the maximum local and bending stress intensities at the lifting lug of the inboard cross beam are 282 MPa as shown in (a) and (b) of fig. 3 and these stress values are below the allowable stress 325 MPa of the applied material.

The vertical displacement 8.8 mm, showed at the end of the outboard cross beam, is compensated by the slot of TFC lifting attachment plates at each side respectively. TFC lifting attachment plates have slot of 30 mm so that it is possible to lay down TFC on the TF gravity supports before radial beam is contacted on the its supports and central column.

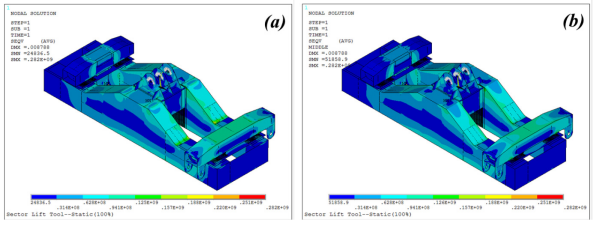

Fig. 3. Deflection and stress intensity results of sector lifting tool considering about 1200 tons of one sector and tool dead weight; (a) 282 MPa, P_L+P_b, (b) 282 MPa, P_L.

3. Conclusions

Based on the conceptual design proposed by the IO, the preliminary design of the sector lifting tool and associated lifting attachments have been developed to satisfy ITER assembly procedure, technical and functional requirements by KODA. Conclusions are summarized as following.

Firstly, the sector lifting tool and associated lifting attachments have been developed by KODA to meet requirements of each lifting configuration for VV, TFC and VV/VVTS/TFC 40° sector in their horizontal and vertical state.

And for common use for the lifting of major components like VV and TFC, inboard and outboard cross beams were designed to be adjusted to align the CG between tool and each component including the 40° sector.

Lastly, the structural stabilities of the sector lifting tool have been studied using ANSYS codes for verifying structural strength for this tool. The results of the analysis show that; for the structural stability of the sector lifting tool considering its dead weight and 1200 tons of sector, all stress intensities of the sector lifting tool are less than allowable stress..

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