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Sector Manufacturing and Assembly of the JT-60SA Vacuum Vessel
JT-60SA真空容器のセクター製作と組立

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Manufacturing of JT-60SA Vacuum Vessel (VV) is under the onsite sector assembly, where ten VV sectors are to be welded into a torus. The vessel is described as 10 m diameter, 6.6 m height and a double wall structure with type 316L stainless steel of 18 mm thickness and locally 30 mm, and total dimensional tolerance is designed to avoid any interference due to operational displacements. This report introduces two issues such as sector manufacturing and onsite assembly. The sector manufacturing is accomplished in high precision, and the assembly concept is obtained with combination of the direct butt joint and splice plate joint. Moreover, status of the onsite sector assembly are presented.

1. Introduction

Construction of the JT-60SA tokamak is conducted under both the Broader Approach activities between Europe and Japan and the Japanese domestic program [1,2]. This tokamak assembly [3] is started with placement of the cryostat base in 2013 [1], and the next step is to assemble the vacuum vessel [4,5] manufactured by Japan since 2014. The completion of all assembly is expected in 2019 [1].

The vacuum vessel (VV, 150tons) is a torus, D-shaped poloidal cross section, the maximum diameter of 10.0 m and height of 6.6 m as shown in Fig. 1, and made of low cobalt stainless steel 316L [4]. The double-wall structure [4] composed of inner/outer walls and internal poloidal ribs is adopted to achieve high stiffness structure and high toroidal one-turn resistance. The total dimensional tolerance is designed to avoid any interference with thermal shield [1] due to displacements: the temperature difference in the 473K baking, and the large electromagnetic force during the plasma operation [4].

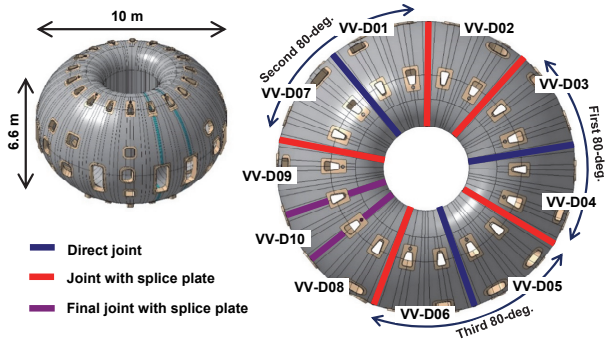

Fig. 1 Vacuum vessel (left) & sector assembly (right).

The VV manufacturing is designed to be ten sectors because of the transport limit [5]. The tolerances of the torus shape are defined by radius of the outer wall surface within ±10 mm in the inboard (IB) and ±20 mm in the outboard (OB). The height of sector installation is defined by the equatorial plane (FL+7998.1 mm) within ±5 mm.

In this report, the sector manufacturing accomplished in May 2014, their assembly concept and status of the onsite are presented.

2. Sector Manufacturing

The sector manufacturing is started with the various welding preparations on its quality and distortion reduction to keep these tolerances [6], consumed by manufacturing and assembly.

Basic size as a 40-degree sector (two port sections) is determined to avoid port stub joint onsite except the final sector. The final 20-degree sector is designed not to interfere with the TFC during its assembly work, and the symmetric port section as well as less number of port bore, closer to the assembly hall, is selected and divided at the section center as shown in Fig. 1 [5].

The IB and OB are manufactured respectively at factory and jointed in Naka site. As a result of the onsite welding joint, the major dimensional precisions of ±2 mm in the IB, ±5 mm in the OB are achieved in every sector.

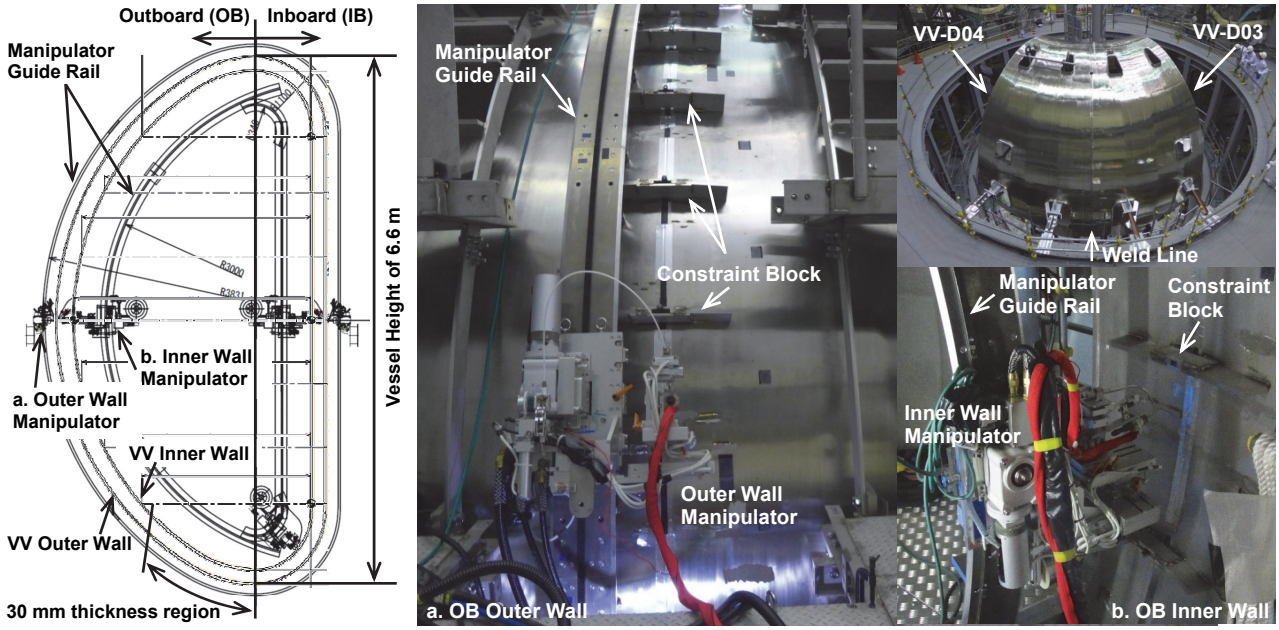

Fig. 2 Simultaneous automatic welding manipulation in both walls of the IB and OB are planned to improve the welding efficiency and reduction of the welding distortion (left). Two 40-degree sectors are placed on the cryostat base (right top) and adjusted for direct butt welding by constraint block: the outer wall welding preparation (middle) and inner wall (right bottom).

3. Assembly Concept

The assembly is expected to achieve the efficient assembly work and the high precision as a large torus vacuum vessel with adjusting errors caused by sector manufacturing. As shown in Fig. 1, the onsite assembly concept is designed with two bases: direct butt joint and splice plate joint.

Application of the direct butt joint is limited due to error accumulated and unknown behavior by welding deformation, three weld lines between 40-degree sectors are designed by direct butt joint. Those errors are distributed equally in 360-degree torus, and sectors over 80-degree are welded with the splice plates. For the final and adjacent two 30-degree sectors, both sector sides are welded by splice plates to adapt the final sector assembly and to adjust any error caused by the assembly of the rest 280-degree sector.

4. Onsite Assembly

The first 80-degree of VV-D03 and D04 is under assembly in the tokamak hall. Welding shrinkage in the toroidal direction is estimated as 4 mm with reference to the factory manufacturing, and the sectors are positioned with the outward 5.9 mm in the radial direction.

Edges of sectors are corrected for sector welding beforehand and then these sectors are transported on the cryostat base. The IB straight and the OB local 30 mm thickness regions are aligned first, and the linear misalignment of the welding chamfer between two sectors is entirely adjusted to less than 1 mm with constraint block.

Although this first direct welding conditions are being confirmed carefully, simultaneous welding manipulation in both walls of the IB and OB are prepared to improve the welding efficiency as well as reduction of the welding distortion as shown in Fig. 2. These welding integrity are examined by the radiographic test for the inner wall, and the ultrasonic for the outer wall. This 80-degree sector is monitored before and after the sector welding and the displacement offset value is improved with this result.

5. Summary

Sector manufacturing of the JT-60SA Vacuum Vessel is completed with good precision, within the design tolerance, and the sector assembly concept is optimized with direct butt joint and splice plate joint to achieve efficient assembly and high precision. Based on these contrivances, VV onsite assembly is started.

Acknowledgments

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