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# Assembly Technologies of the Superconducting Tokamak on JT-60SA

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The JT-60SA (JT-60 Super Advanced) project is a combined project of Japan's program for national use and the Japan-EU Satellite Tokamak Program collaboration between Japan and the EU fusion community. The main objectives are to demonstrate steady-state high-beta plasma and to support ITER through the optimization of ITER operation scenario. The JT-60SA tokamak device is designed as a superconducting tokamak, which is about half of ITER. This tokamak assembly must allow for the thermal deformations of the superconducting coils at 4 K and 473 K baking for the vacuum vessel (VV) in addition to withstanding electromagnetic and seismic forces. The rigid support method is not able to absorb the thermal contraction and expansion. On the other hand, a high accuracy, below several millimeters, is required for the positioning of the superconducting coils to achieve a magnetic field error under 10ˆ-4 B_tor. Two types of gravity supports are employed for the superconducting coil system and the VV. Both gravity supports are characterized by their flexibility to absorb thermal deformation while maintaining their symmetry about the toroidal axis. In the onsite assembly work, it is important to install these components with high accuracy and adjust them to their design positions. Installation of the VV and pre-positioning of the lower equilibrium field coils have been achieved with high accuracy of a few millimeters using carefully planned assembly technologies, which are the combination of 3D CAD and real-time 3D position measurement by a laser tracker, customization of the joint structures derived from the measurement, and welding taking account of predicted deformations. The assembly measurement precision due to spatial recognition is 0.5 mm in the tokamak hall of 40 meters square. The sector joints of the VV were completed up to 340-degrees. The shrinkage of each weld was predicted from factory manufacturing results and this prediction was improved by the measurement of the shrinkage of each pass during the welding of the joints between sectors. The complete assembly of JT-60SA is expected to be achieved with high accuracy by applying these assembly technologies. The design and manufacturing of these components have been shared by the EU and Japan, and the assembly of these components started on the Naka site in 2013 aiming at the first plasma in 2019.

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