ABSTRACT

- Thermal insulation devices such as the thermal shield (TS) and the cryostat for the JT-60SA Tokamak were developed by the design activities through the collaboration between Japan & the EU.
- Design, manufacturing & acceptance tests on these devices were successfully completed by 2019 and these devices were completely installed into the Tokamak by the end of March 2020.
- Technique & knowledge to realize high accuracy manufacturing & short time installation of these devices will contribute to the ITER construction & DEMO design.

BACKGROUND

- JT-60SA as a superconducting tokamak was constructed in the Naka Fusion Institute of QST and the tokamak assembly had started since January 2013.
- The superconducting coils were installed into the tokamak in early 2018 and then TS & Cryostat were installed to insulate these coils from the thermal radiation.
- Thermal insulation devices procured by Japan, such as TS & Cryostat Top Lid, are reported here in detail.
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- Thermal insulation devices procured by Japan, such as TS & Cryostat Top Lid, are reported here in detail.
- The TS structure as the double wall with the 80K pipe set inside between the walls was designed to reduce the eddy current during the operation.
- The TS surface facing to the cryostat vessel is entirely covered with low emissivity sheets to insulate these coils from the thermal radiation.
- The TS is supported at the horizontal port TS (HPTS) from the base of each TF coil.
- The TS was designed as the VV TS (VVTS), Cryostat TS (CTS) & Port TS (PTS).
- The thermal shield was designed to insulate superconducting coils in the cryostat vacuum region of the TS & Cryostat were assembled on the TF coils.
- The design requirements are to endure forces due to the operational electromagnetics & seismic events, and to absorb the thermal displacement with the clearance to the other surrounding devices.

Manufacturing of the Thermal Shield

Manufacturing of TS

- The thermal shield was designed to insulate superconducting coils in the cryostat vacuum environment from the radiation heat intrusion of the vacuum vessel (VV) and cryostat.
- TS structure as the double wall with the 80K pipe set inside between the walls was designed to the conditions of the high-pressure gas law, and the double wall is composed of thinner stainless steels and electrically insulated in every 20-degree toroidal sector to reduce the eddy current during the operation.
- TS was designed as the VV TS (VVT’s), Cryostat TS (CTS) & Port TS (PTS).
- The TS is supported at the horizontal port TS (HPTS) from the base of each TF coil.
- The TS surface facing to the cryostat vessel is entirely covered with low emissivity sheets layered as multilayer thermal insulation (MLI), and the TS is kept at the cryogenic temperature with 80K helium gas flow during the operations.
- The 20-degree TS sectors were manufactured in the geometrical tolerance of ±5mm to keep the over 30mm clearance between TS and each other component.

Manufacturing of the Cryostat Top Lid

Manufacturing of Cryostat

- Cryostat is designed to provide vacuum environment of 10⁻⁵ Pa to insulate superconducting coils thermally from the ambient.
- Cryostat was divided mainly in three parts, such as base (CB), cylindrical section (CVB&C) & lid (CTL), and the manufacturing size is limited by the Japanese domestic transportation.
- The CB & CVB&C were manufactured in the EU and the CB was installed into the tokamak in early 2013 & the CVB&C in 2019.

Manufacturing of Cryostat Top Lid

- Cryostat Top Lid (CTL) was manufactured in Japan.
- The CTL was manufactured as the two half-pieces, and these pieces were weld-jointed as one onsite in February 2020.
- Dimensional tolerances were: spherical radius 8m±8mm, & outer diameter 11.5m±5mm to join these two pieces as one lid onsite.

CONCLUSION

- The 20-degree TS sectors were successfully manufactured within the tolerance and the clearance between TS and other devices were kept in onsite assembly.
- CTL half pieces were manufactured within tolerance and successfully jointed as one lid onsite.
- The thermal insulation devices on the JT-60SA & its manufacturing were developed and top region of the TS & Cryostat were assembled on-schedule.