22P-4F-15

中核構造組立過程を考慮した核融合DEMO炉の真空容器構造の概念設計
Conceptual design of vacuum vessel structure for fusion DEMO considering assembly process of core components

西村　新

核融合研、理化技研(中科院)
NIFS, TIPC (CAS)

Rough estimation of size and weight of DEMO

The JA DEMO and EU DEMO are published in 2018 [1,2]. The major radius, the fusion output, and the magnetic field on plasma axis of the ITER, JA DEMO and EU DEMO are 6.2, 8.5 and 9.0 m, and 0.5, 1.46 and 2.0 GW, and 5.3, 5.94 and 5.9 T, respectively. Therefore, when the size of the fusion DEMO is focused, the DEMO will be about 1.5 times larger than the ITER. When the global density of the fusion reactor is assumed as the same as the ITER, the total weight of the DEMO is 3.4 times larger than the ITER, which means about 78,000 tons, for the ITER is estimated about 23,000 tons. This is a basic assumption to carry out the conceptual design of the fusion DEMO.

Global requirements

The boundary conditions for the construction which must be respected during the design activities must be considered and fixed first, then the conceptual design activities must start.

- Hard bedrock is essential. The total weight of DEMO, the building and others will be supported by the 45 to 50 m diameter area. The average load per unit area increases by about 1.5 times.
- Capacity of overhead crane must be optimized and reduced. ITER equips a 1200 tons ceiling crane, but a 4000 tons crane will be needed for DEMO. It must be considered that how many times it lifts a product of the maximum weight, for example, for ten years. Co-hanging of heavy products by two ceiling cranes will be useful. Therefore, two ceiling cranes with the each capacity of 1200 tons are assumed here. The maximum will be 2300 tons excluding a special equip to carry out co-hanging.

Core component

The core component was assumed to consist of 18 TF coils and 9 vacuum vessel (VV) sectors. This was considered taking account of the ITER design. The VV must have the thermal shield with super insulations (SI). The weight of one TF coil will be about 1000 tons, and one VV sector will weigh about 1500 tons. Since these components are too heavy to handle, the TF coil will be set up one by one leaving the space to install the VV sector. After assembling all sectors except for the last, the last TF coil will be set up and the last VV sector which would be divided into smaller components will be carried in the torus and welded.

Some image of vacuum vessel

The vacuum vessel must have a plate spring type support and standalone during the assembly as shown in Fig. 1. The double wall will be welded by outside and inside wall plate as shown in Fig. 2. NDI must be done perfectly to confirm the nuclear boundary.

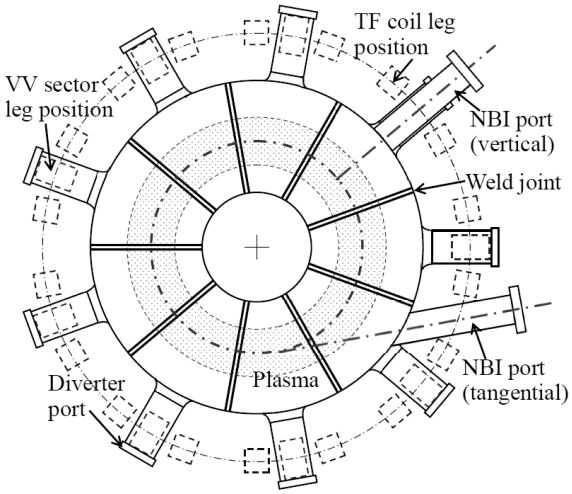

Fig. 1 Image of VV assembly.

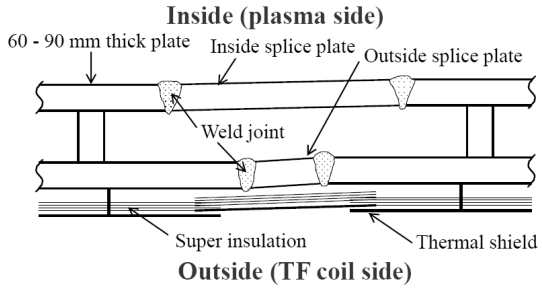

Fig. 2 Image of welding of double wall structure.

References

[1] K. Tobita, et. al., FED 136 (2018) 1024–1031. https://doi.org/10.1016/j.fusengdes.2018.04.059
[2] G. Federici, et. al., FED 136 (2018) 729–741. https://doi.org/10.1016/j.fusengdes.2018.04.001