§12. Conceptual Design of Support Post for FFHR Cryogenic Components

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FFHR is a concept design of a steady state fusion reactor which has been studied to demonstrate LHD-type fusion power plant. The superconducting magnet system in the FFHR consists of one pair of helical coils and 2 pairs of poloidal coils. Total weight of the coils and the supporting structure exceeds 16,000 tons. This weight is supported by cryogenic support posts which are set on a base plate of a cryostat vessel. The coils and supporting structure must be cooled down to liquid helium temperature. Fig.1 shows a schematic bottom view of FFHR cryogenic components and the base plate of the vessel. The support post must have following functions; (a) Reduce heat load to cryogenic components. (b) Support the weight of the components. (c) Absorb the thermal contraction of the components. (d) Maintain a cyclic deformation. (e) Safe warranty against an external load such as an earthquake. LHD adopted a folded multi plates consisted of Carbon Fiber Reinforcement Plastic (CFRP) and stainless steel plates. The post has been contributing to the long term stable operation of LHD[1-2]. The same technique can be a candidate design for FFHR support post. This report describes a conceptual design of the post adopting the same type of the LHD support post.

The displacements by a thermal contraction of the cryogenic components in FFHR are 55mm and 30mm at the position of the outer and inner poloidal field coil, respectively. The number of the post was set 20 for the outer region and 10 for the inner region considering the span between each post to be almost the same. The cross-sectional area of the plate in a post assumed that the CFRP plate has 1200mm in width and 80mm in thickness. The length of the plate was decided according to buckling load estimation for a long column. Safety factor was set to 5 times as much as the weight for one support post; ((Total weight / number of posts) x safety factor). Then the length and numbers of plates for each material were chosen. The optimized length of CFRP plate was 1200mm and the numbers of the plates were 5 / 3 for the inner / outer columns, respectively. The geometry of the stainless steel plate was optimized as the same manner of the CFRP's and that was 1200mm in width, 30mm in thickness, 1000mm in length, and 4 plates for both side, respectively. The setup of the post is shown in fig. 2. Using this fundamental design, a flexibility and stress distribution of the post were calculated by using FEM analysis. The flexibility against a radial displacement was 22.9kN/mm and the maximum stress when 55mm of forced displacement was subjected to the top of the post was 155MPa for CFRP plate and 544MPa for stainless steel plate as shown in fig. 3. These were under allowable level for the materials. The heat loads were also calculated and 10.5kW to 80K and 0.34kW to 4K were obtained. Those results indicated that the LHD-type support post was also valid for the FFHR in mechanical and thermal points of view even the device became such a huge size.

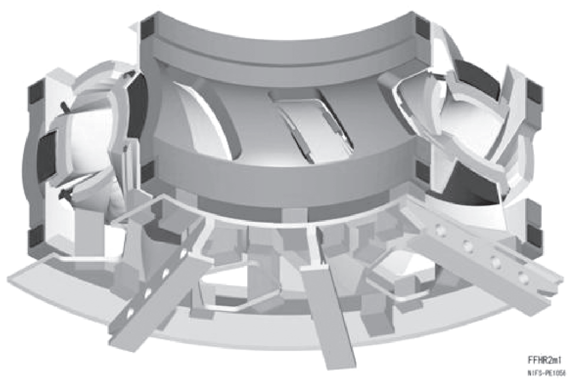

Fig. 1. Schematic of cryogenic components, support posts and the base of the cryostat vessel in FFHR.

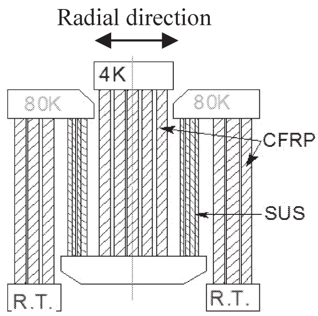

Fig. 2. Fundamental design of the support post and the temperature distribution.

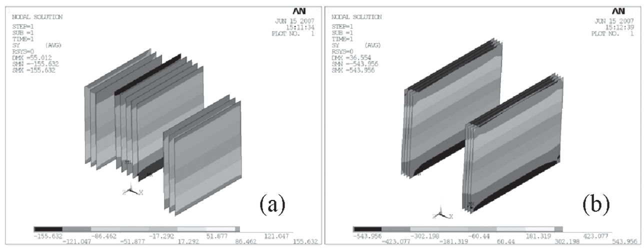

Fig. 3. Stress distribution in the support post against 55mm forced displacement; (a) bending stress in the CFRP plates (max. 155MPa), (b) bending stress in the stainless steel plates (max. 544MPa).

References
1) Tamura, H. et al.: Fusion Technology **1996** (1996) 1019.
2) Tamura, H. et al.: Adv. in Cryog. Eng. **45** (2000) 753.