ELECTROMAGNETIC STUDIES FOR THE ITER GENERIC UPPER PORT PLUG

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In a next generation fusion machine, access of diagnostics to the plasma is severely limited because diagnostic components located near the plasma are exposed to high neutron fluxes. In order to resolve this problem, a concept of "diagnostic port plug", which works as both a neutron shield and a housing of diagnostics from the harsh radiological environment, was established in ITER. A ~6 m long and ~20 t weights port plug is inserted into the vacuum vessel (VV) port and is cantilevered at the VV flange. To confirm the realization of upper port plug structure, comprehensive engineering analyses and studies have been performed.

To investigate the structure behavior of the generic upper port plug, electro-magnetic (EM) analysis, static analysis and dynamic analysis have been performed. An EM analysis of the upper port plug at the upward first VDE, which produces the greatest load on the upper port plug, was performed. Here, EM loads and moments have been evaluated at the support flange, which is a key point in the cantilevered structure, by establishing a three-dimensional model. Maximum moments were obtained at support flange with Mx of 1.66 MNm and Mz of 1.8 MNm, which is about 1.6 times larger than that of the previous design [1]. For the slit effect, the EM moment on the blanket shield module (BSM) decreases with an increase in the number of slits. The EM moment on a support flange with three slits is about half, compared to a flange with no slits.

Static analyses based on the above mentioned EM loads were also performed to investigate displacements and stress of the port plug. Analytical model of the upper port plug, which having sym mechanism and its flange was used at first. Maximum stress of 328 MPa was appeared at the sym flange and displacement of 11.6 mm was observed at the top of the port plug. Since theses values are higher than the allowable one, removal of that flange from the port plug structure was considered. As a result, about 15 % reduction was achieved for both values. Maximum stress of the port plug structure itself is less than allowable stress though that of the BSM flange is about 280 MPa. Maximum displacement of 10 mm, 6.7 mm and 5 mm with no slit, one slit and three slits were obtained, respectively.

Dynamic analyses have been performed of the upper port plug finally. Maximum displacement of 14.5 mm, 10 mm and 7.5 mm with no slit, one slit and three slits were obtained at the top of the port plug in the circumferential direction, respectively. Therefore, dynamic amplification factor have been estimated to be 1.5 in the preliminary result. Here, the gap between the VV port and port plug is designed to be 20 mm. The fabrication and assembly tolerance is designed to be ± 4 mm. These results would seem to indicate an insufficient design margin for displacement of the upper port plug. In the latest design, the port plug structure has been considered to have deep slit in the BSM. The slit depth is about three times larger than this analytical model. According to the parameter survey of the EM analyses for the shield blanket [2], the EM load is decreasing with the increasing of the slit depth. Therefore, it is expected that the upper port plug structure would be withstood against the most severe plasma disruption condition.

[1] K. Sato et al., Fusion Engineering and Design 84 (2009) 1713–1715
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