DESIGN AND FABRICATION OF THE KSTAR IN-VESSEL CRYO-PUMP

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The Korea Superconducting Tokamak Advanced Research (KSTAR) in-vessel cryo-pump (IVCP) has been designed, fabricated, and installed in the vacuum vessel for plasma density and plasma impurity control by pumping through a divertor gap. Since the IVCP system is to be operated under extremely low temperature and rapidly changing electro-magnetic fields, the support had to be designed to withstand the external forces including thermal stresses, electro-magnetic forces, and vibration of the vacuum vessel. During the final engineering design, structural analyses were implemented for two considerations. The first were the thermal stresses due to cool-down from room temperature to operating temperature (cryo-panel: 4.4 K, thermal shield: 55 K), and the second were the electro-magnetic stresses due to eddy currents on the pump surface during plasma disruptions. The results of the analysis were that the maximum stress and displacement of the IVCP support due to cool-down were 620 MPa and 3.9 mm, respectively. In the disruption case, the maximum stress and displacement on the radial axis were estimated to be 849 MPa and 5.36 mm, respectively. These results were satisfactory for the material criteria and support design. The IVCP system was fabricated in two half-sectors and a pre-assembling test was successfully completed in the factory. After installation in the vacuum vessel, a pressurization test (thermal shield: 30 bar, cryo-panel: 10 bar) and a helium leak test (< 5_10^{-10} mbar) were quite satisfactory. And a thermal shock test was performed using liquid nitrogen to verify stability of the pumps. As a result, through structural analyses the IVCP system was successfully designed, fabricated, and installed in the vacuum vessel.

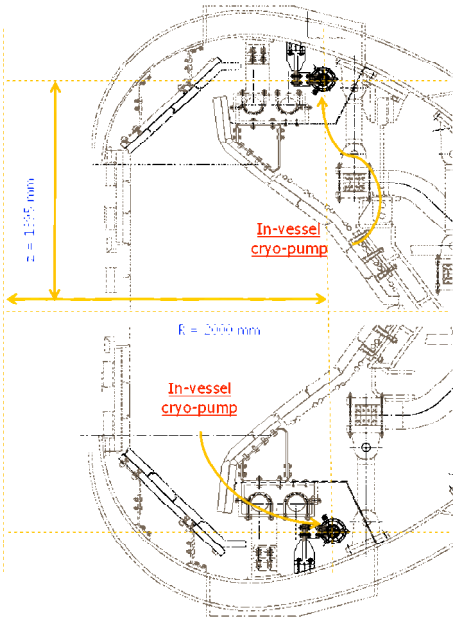

Figure 1:KSTAR In-vessel cryo-pump configuration