THERMO-HYDRAULIC DESIGN VERIFICATION OF THE NEUTRAL BEAM LINER

FOR THE ITER VACUUM VESSEL

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The ITER vacuum vessel has upper, equatorial and lower port structures used for equipment installation, utility feedthroughs, vacuum pumping and access inside the vessel for maintenance. The neutral beam (NB) ports located at equatorial ports provide a path of neutral beam for plasma heating and current drive. An internal duct liner is built in the NB ports, and copper alloy panels are placed in the top and bottom of the liner to protect duct surface from high-power heat loads. Global NB liner models for the upper panel and the lower panel have been developed, and flow field and conjugate heat transfer analyses have been performed to find out pressure drop and heat transfer characteristics of the liner. Heat loads such as NB power, volumetric heating and surface heat flux are applied in the analyses for beam steering and misalignment conditions. For the upper panel, it is found that unbalanced flow distribution occurs in each flow path, and this causes poor heat transfer performance as well. In order to improve flow distribution and to reduce pressure losses, hydraulic analyses for modified cooling path schemes have been carried out, and design recommendation is made based on the analyses results. For the lower panel, local flow distributions and pressure drop values at each header and branch of the tube are obtained by applying design coolant flow rate. Together with the coolant flow field, temperature and heat transfer coefficient distributions are also acquired from the analyses. Based on the analysis results, it is concluded that the lower panel for the NB liner is relatively well designed even though the given heat loads are very severe.



Figure 1: Configuration of NB liner

Figure 2: Conjugate heat transfer analysis result for lower NB liner

- [1] ITER Design Description Document 26, "Cooling Water System", 2004.
- [2] ITER Internal Document G15 TD 54 FJ, "Nuclear Analysis of Vacuum Vessel (Heat Load Analysis of NBI Duct)", 2005.
- [3] UKAEA, Progress Update Meeting in Cadarache, "ITER Neutral Beam Duct Liner", 2008.