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In-Vessel Inspection System: Design progress of high vacuum and temperature compatible remote handling for fusion purposes

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The plasma facing components (PFCs) in a tokamak are subjected to high heat flux and high temperature during plasma operation, which causes erosion of the first wall. There is also hot spot formation on the PFC due to physical phenomenon like thermal electron emission. In addition to fore-mentioned phenomenon, the events such as Edge Localized Mode (ELM), vertical displacement event (VDE) are serious concern for the fatigue damage of the PFCs. Therefore, health monitoring of the PFCs is an essential requirement in any tokamak, which is met by periodic inspection of the PFCs. The periodic inspection can be performed during the tokamak shutdown period or during plasma operation. The latter is most desirable as it allows quick and frequent in-service inspection of the PFCs between the plasma shots without breaking the vacuum.

The work presented in this paper covers the conceptual design of In-Vessel Inspection System (IVIS) and storage chamber to carry out in-service visual inspection of SST-1 like tokamak under vacuum in between the plasma shots. The designed IVIS manipulator is ~2m long with 04- Degrees of Freedom (DOF), comprising of three rotary joints and one linear motion for deployment within the tokamak. The manipulator is designed to handle a cantilevered payload of ~1kg with a positional accuracy of <2mm. IVIS is initially stowed in a 4m long Ultra-High Vacuum (UHV) storage chamber isolated from the VV by an UHV gate valve. During (one quarter i.e. + 90°) viewing, the gate valve will open so that IVIS can be deployed inside the VV, complete the viewing procedure and return back to its initial position outside the VV. Issues like choices of the structural materials to minimize the out-gassing under vacuum and high temperature during conditioning are discussed with feasible solutions. Improvements to enhance IVIS operation under temperature and vacuum conditions for SST-1 like machine are reviewed. Results for theoretical calculations, kinematic and structural integrity analyses are presented in detail along with ways to optimize the design.

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