THERMO-MECHANICAL ANALYSIS OF RETRO-REFLECTORS FOR INTERFEROMETRY AND POLARIMETRY IN W7-X

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The stellarator Wendelstein 7-X (W7-X) is presently under construction at the Max-Planck-Institut für Plasmaphysik in Greifswald, Germany. The plasma density profile will be measured from the phase shift of two far-infrared-laser beams (lambda=10.6 µm and 5µm) which pass through the plasma. Due to the shape of the modular coils and the divertor it is geometrically not possible to emit and measure the laser beams at opposite positions of the machine. Instead, a retro-reflector (RF) will be used which has to be incorporated in the plasma vessel heat shield. The beam is thus reflected back to the diagnostic which requires high accuracy of the reflecting surfaces. Preliminary investigations for an initial design were already reported in [1]. The now presented improved design avoids mutual stresses in the reflector plates under heat load. The RF consists basically of three elements, namely a cube corner and two plates. Due to the thermal loads from plasma radiation it will be moved and deformed during operation. While moving the whole RF has little influence on its functionality, it is important to keep local deformations of the reflecting plates and angle deviations between the three surfaces to a minimum.
Using ANSYS, a thermal FE-analysis of the RF, including plasma radiation, cooling, thermal conduction and radiation between all parts was performed. The thermal analysis results were then used as inputs for a mechanical calculation which yielded information on local deformation and tilting of the reflecting surfaces. MATLAB routines were used for post processing, e.g. for calculating the resulting curvature radii in the regions with the largest deformation. This led to a better understanding of the thermal and mechanical processes in the reflector, and it was shown that increasing the thickness of the reflecting plates can have a positive effect on the temperature distribution and deformation.
The method was also utilized for optimising the layout of the reflector fixation. Using the same approach for different designs it was possible to compare and optimize the performance concerning maximal temperatures, influence of asymmetries, and local deformations. Due to space restrictions an asymmetric design has finally been chosen which is able to assure the mechanical stability without having a negative influence on temperature or deformations. Further optimization will concentrate on shaping the thermal contacts in such a way that local curvatures are minimized.

[1] M. Y. Ye et al., Thermal-Mechanical Analysis for in-Vessel Diagnostic Components in W7-X, AIP Conference Proceedings, volume 993, 2008, pp 211-214