THERMO-STRUCTURAL ANALYSIS OF INTEGRATED BACK PLATE IN IFMIF/EVEDA LIQUID LITHIUM TARGET

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The International Fusion Materials Irradiation Facility (IFMIF) is an accelerator-based intense neutron source for testing candidate materials for fusion reactors [1]. The Engineering Validation and Engineering Design Activities (EVEDA) of IFMIF are in progress under the Broader Approach Agreement. As a part of this engineering design, we carried out thermo-structural analysis of the back plate in the IFMIF target. The back plate is operating under a severe neutron irradiation condition of 50 dpa/y and the maximum value of the nuclear heat generation is 25 W/cm^3 in the center region of the back plate. Therefore, the thermo-structural design of the back plate is one of the critical issues for the target design. The target assembly including the back plate is made of Reduced-Activation Ferritic/Martensitic (RAFM) steel such as F82H and EUROFER. Two design options for the back plate are under investigation. The first option is the "integrated type" where the Li flow channel includes an integral back plate. This option requires replacement of the entire target assembly prior to life time of the back plate portion of the target assembly. The second option is the "bayonet type" with mechanical attachment of the back plate to the target assembly [2].

In this study, the thermal stress of the integrated back plate induced by the nuclear heating was estimated using the ABAQUS code with a linear analysis. In the previous analysis, the calculation model included only the back plate and a small part of the target assembly [3]. In this analysis, the calculation model was modified to extend the modeling region up to most of the target assembly, therefore it was possible that the boundary conditions such as the constraint conditions were given more accurately. To estimate thermal stresses in the different operation phases of IFMIF, two cases of calculations were performed. In the first case, to simulate the start-up phase, a thermal stress was calculated due to the initial temperature rising by the liquid Li before the irradiation. In the second case, to simulate the rated operation phase, a thermal stress was calculated due to the nuclear heating by the neutron irradiation.

The calculated results showed that the maximum deformation and the maximum stress were found at the center of the back plate in both cases. The direction of the thermal deformation at the center of the back plate was toward the outside of the target assembly in the first case, while it was toward the inside of the target assembly in the second case. It is expected they are canceled each other out through the operation phases of IFMIF, therefore the thermal deformation of the back plate will be mitigated. The maximum value of von Mises stress was 51 MPa in the first case and 328 MPa in the second case. In both cases, the maximum value was lower than the permissible stress of 455 MPa for F82H steel defined by yield strength at 300°C. These results provided a prospect of the thermo-structural design for the present integrated back plate configuration.

[1] IFMIF International Team, IFMIF Comprehensive Design Report, IEA on-line publication, http://www.iea.org/Textbase/techno/technologies/fusion/IFMIF-CDR_partA.pdf and partB.

[2] P.Agostini et al., Definition Report of the EVEDA Bayonet Back Plate, IM-M-R-001 (2009)

[3] F.Groeschel et al., IFMIF/EVEDA Annual Report 2008 Annex 3: Lithium Target Facility, BA SC 05-5.4 Annex 3 (2009)