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IFMIF リチウムターゲット熱構造解析
Thermal Structural Analysis for IFMIF Lithium Target

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1. Introduction

The Engineering Validation and Engineering Design Activities (EVEDA) of the International Fusion Materials Irradiation Facility (IFMIF) are in progress under the Broader Approach (BA) Agreement. As a part of this engineering design, we carried out the thermal structural analysis using ABAQUS version 6.9 to optimize the thermal design conditions for the back plate of the liquid lithium target in the IFMIF.

2. Calculation model and conditions

The modeling region was a part of the lithium target assembly which was from the inlet nozzle to the outlet pipe. The half model was adopted for symmetry. The Hexa meshes were only used in this model. The reduced-activation ferritic/martensitic (RAFM) steel, F82H was assumed as the material of the target assembly including the back plate.

The calculation conditions were set to simulate two operation modes of the IFMIF. “Mode-1” was the start operation with temperature rising from room temperature to nominal lithium temperature of 250°C under beam off condition. “Mode-2” was the normal operation with switching on the beam under constant lithium temperature of 250°C. The beam has its footprint on the back plate center. The input data of the nuclear heating were based on those due to the neutron through lithium and secondary gamma, calculated by Simakov et al. [1].

3. Calculated results

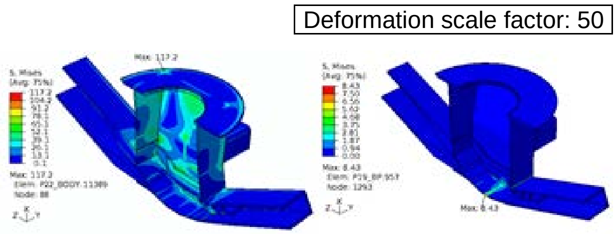
The calculated results are summarized in Table-1. In Mode-1, the maximum stress and displacement were larger than those in Mode-2 because of the rapid temperature rising. The distributions of von Mises stress are shown in Figure-1 where the deformations are exaggerated by a factor of 50. In Mode-1, the larger stresses were observed at the edges such as joint parts, while in Mode-2, the stress concentration occurred at the center of the back plate or the footprint of the beam.

4. Summary

The calculated maximum von Mises stress was 117 MPa, it was lower enough than the permissible stress of 427 MPa (minimum yield stress of F82H at 250°C) referred in the data of Tavassoli et al. [2]. Thus thermal soundness of the lithium target was validated. The calculated maximum displacement was 1.37 mm, so it was expected that deformation of the lithium target was small to avoid the lithium flow instability.

References

[1] S.P. Simakov et al., Journal of Nuclear Materials 307-311 (2002) 1710-1714.
[2] A.A.F. Tavassoli et al., Fusion Engineering and Design 61-62 (2002) 617-628.



(a) Mode-1 (b) Mode-2

Figure-1 Distributions of von Mises stress

Table-1 Summary of calculated results

IFMIF operation	Boundary temp. (°C)	Beam	Max. von Mises stress (MPa)		Max. displace -ment (mm)
			Whole	Back plate	
Mode-1	20 -> 250	off	117	60.3	1.37
Mode-2	250	off -> on	8.43	8.43	3.07e-3