§5. Structural Design of Back-Plate and its Mechanical Properties in Weld Zones on an Intense Neutron Source for Materials Irradiation

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1. Introduction

R&Ds of a fusion demonstration reactor have been conducted as the next step of the ITER development.[1] The first wall material of the blanket will damage up to 100 ~ 150 dpa due to fast neutron irradiation, and also nuclear transformation helium will be produced simultaneously in the material. Since interaction of the damage and helium strongly affect the mechanical properties of the material, it is very important to develop an intense neutron source for materials irradiation like the international fusion materials irradiation facility, IFMIF [2], which can simulate not only the damage level (~ 150 dpa) but also ratio of the damage level and the helium content (He / dpa = 10).

The IFMIF is divided into accelerator system, target system and test cell system, and liquid lithium target back-plate is in the target system generating fast neutron. The back-plate is a disc-like structure, the central area damage up to about 50 dpa / year. Thus a low activation ferritic/martensitic steel type-F82H is applied to the central region although commercial austenitic stainless steel type-SUS316L is used in the other region of the back-plate. Since the F82H and 316L steels are TIG-welded, dissimilar weld zone (F82H/316L weld zone) is in the back-plate. The lip part (the 316L steel) of the back-plate is YAG-welded with target assembly made of 316L steel, and consequently the back-plate has 316L/316L weld zone. It is very important to study mechanical property of the F82H/316L and 316L/316L weld zones, and therefore structural analysis of the back-plate is needed in order to survey the shape and thickness of the weld zones before the mechanical test. Thus, preparation of the analysis system and preliminary analysis of the back-plate were performed as a preparation step for the structural analysis of the weld zones.

2. Preparation of analysis system and preliminary analysis of back-plate

The analysis is performed by using a supercomputer controlled from a terminal PC via an internet. Thus the preparation was done for the network setting including the firewall and for the X-server which is necessary for connection and control of the supercomputer in which the analysis program is installed. For the sake of confirming the relevance of the analysis system prepared, a 3-D steady-state elastic thermal stress analysis was performed for a lip-seal weld zone with a contact condition between the back-plate and target assembly, on a preheating phase for the target system of the IFMIF before starting of irradiation tests. ABAQUS, a generalized nonlinear finite element analysis program, was utilized for the analysis.

3. Result and discussion

Fig. 1 shows a quarter analysis model considered for symmetry of the back-plate. The F82H/316L and 316L/316L weld zones have 15 mm and 2 mm in thicknesses, respectively. The thermal load of 573 K (Initial temperature: 293 k) was distributed uniformly all over the back side of the back-plate. A sample of the analysis result is shown in Fig. 2. As shown in the figure, von Mises stress appeared at both weld zones was beyond the design allowable stress (3 Sm). The reason why excessive stress appeared is thought to be that thermal expansion coefficient of the 316L is larger about 1.7 times than that of the F82H, and uniform heating was done all over the back-plate composed of two types of materials differ in thermal expansion coefficient. Therefore it seems to exceed the allowable stress due to the thermal load condition applied, and it is necessary for the preheating phase of the IFMIF-target to control temperature at the back-plate in a feasible condition.

4. Summary

Preparation of analysis system and preliminary analysis were performed in order to conduct thermal stress analysis of the IFMIF-back-plate. In result, it was successfully demonstrated to be able to analyze form a terminal PC. The analysis showed importance of temperature control of the IFMIF-target in the preheating phase before irradiation tests.

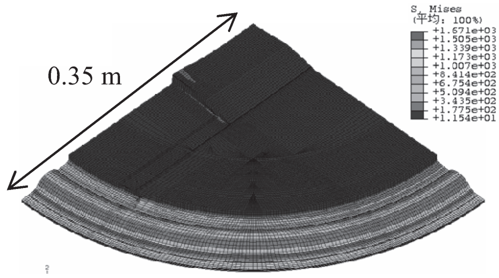

Fig. 1 von Mises stress contour on back side of back-plate (1/4 model)

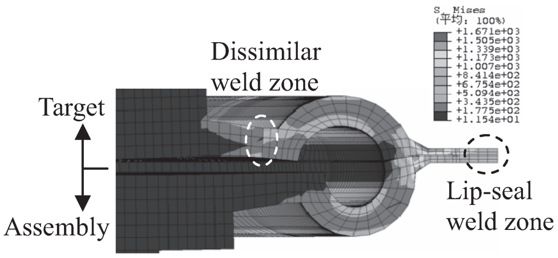

Fig. 2 Partial magnified view at around weld zones.

1) Kamada, Y., et al.: Fusion Plasma Research toward Fusion Power Plants, J. Plasma Fusion Res., Vol.81, No.11 (2005)849, in Japanese.
2) IFMIF International Team: IFMIF-KEP International Fusion Materials Irradiation Facility Key Element Technology Phase Report, JAERI-Tech, 2003-005 (2003).