§4. Finite Element Analysis of the FFHR Blanket

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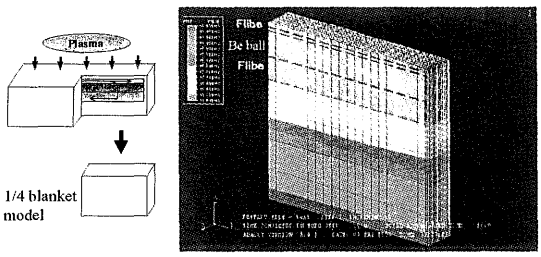
Thermal and stress analyses of the blanket have been made using a finite element analysis (FEM) program ABAQUS. The FEM model consists of five layers; the first layer from the plasma side is the first wall, and the second is the upstream Flibe. The third is a stack of beryllium ball neutron multiplier. The fourth is the downstream Flibe. The fifth is the shielding block. A reduced activation ferritic steel or a vanadium alloy is considered for the first wall and shielding structural material. Mesh plates separating the beryllium ball layer from Flibe inlet and outlet channels are ignored in the model.

Figure 1 shows an example of temperature distribution. In this case, the structural material is V-4Cr-4Ti alloy and the first wall thickness is 20mm. The highest temperature is 964K at the farthest corner from the Flibe inlet. Figure 2 shows the highest temperature as a function of the first wall thickness. The highest temperature does not depend significantly on the structural material, while it is seen from this figure that operable temperature window for the ferritic steel is extremely limited.



INPUT DATA	OUTPUT DATA
First wall material:Vanadium alloy	The highest temperature:964K
Thickness of first wall:20mm	Temperature of coolant entrance:723K
Width of coolant:300mm	Temperature of coolant exit:828K

Fig.1. Temperature distribution.

Figure 3 shows Mises stress distribution under the same condition as shown in Fig. 1. The maximum Mises stress of 47.7MPa is found at the center of the first wall. No significant difference is found between the vanadium alloy and the ferritic steel. Figure 4 shows the maximum Mises stress in the first wall or in the side wall as a function of the first wall thickness. The maximum Mises stress in the first wall strongly depends on the first wall thickness when the coolant channel is 300mm wide, while the dependence is much less when the channel width is 100mm. In the latter case the Mises stress is largest in the side wall of the blanket.

The optimum parameter set within the present study, i.e. first wall thickness of 5mm and the channel width of 100mm, has been chosen based on the following criteria:- i) to keep the highest temperature reasonable and ii) the maximum Mises stress lower than 1/3 of U.T.S. The condition is especially stringent in the design where ferritic steel is used.

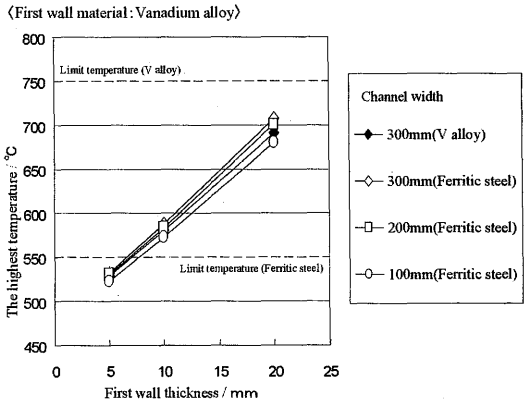
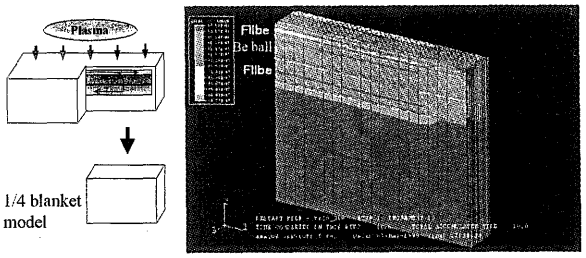


Fig.2. Relationship the highest temperature and the first wall thickness.



INPUT DATA	OUTPUT DATA
First wall material:Vanadium alloy	Maximum Mises stress:47.7MPa
Thickness of first wall:20mm	
Width of coolant:300mm	

Fig.3. Mises stress distribution.

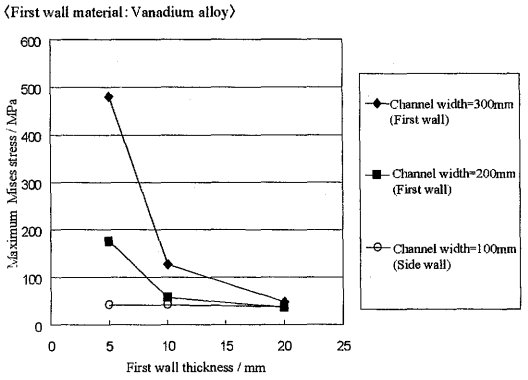


Fig.4. Relationship maximum Mises stress and first wall thickness.