§11. Impact of Structural Material on Tritium Breeding in Flibe Cooled Blanket System

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The fundamental neutronics performances of the Flibe+Be/JLF-1 blanket system have been studied in the reactor design activity of the helical-type reactor FFHR (Fig. 1) [1, 2]. The tritium breeding region of the Flibe+Be/JLF-1 (JLF-1; reduced-activation ferritic/martensitic steel) blanket system consists of the three layers, i.e. (1) Flibe channel #1, (2) Flibe (40 vol. %) + Be (60 vol. %, neutron multiplier) and (3) Flibe channel #2. In the previous neutronics calculations, the structural material in the tritium breeding region has been assumed only at the first wall and boundaries of those three layers. However, amount of the structural material would increase for installing additional partition walls, pipes etc. with a progress in the detailed blanket design. Especially in the Flibe+Be layer where 69 % of tritium fuel are produced, increase in the amount of the structural material might depress the tritium breeding performance significantly. This is due to that the installing of additional JLF-1 walls, pipes etc. directly decrease the volumes of the Flibe coolant and Be multiplier. Attenuation of fast neutrons from plasma and absorption of low energy neutrons by the additional JLF-1 structures might also depress the tritium breeding. The impact of the additional JLF-1 structures on the tritium breeding performance of the Flibe+Be/JLF-1 blanket system has been evaluated in the present study.

The local tritium breeding ratio (local TBR) of the Flibe+Be/JLF-1 blanket was calculated by using the MCNP-5 neutron and gamma-ray transport code for the simple torus model shown in Fig. 1. The volumetric ratio of the structural material of JLF-1 was changed in the Flibe+Be layer for simulation of additional partition walls, pipes etc. and the impact on the local TBR was evaluated. The materials of the Flibe coolant, Be pebbles and additional JLF-1 structures in the Flibe+Be layer were assumed to be uniformly mixed in the present calculation for a quick and approximate evaluation.

Figure 2 shows the relation between the volumetric ratios of additional JLF-1 structures in the Flibe+Be layer and the local TBR. The decreases in the local TBRs are 7 %, 13 % and 24 % for the volumetric ratios of JLF-1 structures of 5 %, 10 % and 20 %. Focusing only on the Flibe+Be layer, the decreases in the tritium breeding performance were 9 %, 18 % and 32 %, respectively. The decreases in the tritium breeding performance in the Flibe+Be layer are significantly larger than the volumetric ratios of JLF-1 structures, i.e. the decrease in volumetric ratios of the Flibe coolant and Be multiplier. This indicates that the additional JLF-1 structures attenuate fast neutrons from plasma and/or absorb low energy neutrons.

The detailed configuration of the additional partition walls, pipes etc. will be provided in the future blanket design based on heat transfer, mechanical stress and also neutornics analyses. While the accurate neutronics performance of the blanket system is required to be evaluated by simulating the detailed geometries of Flibe coolant, Be pebbles, additional partition walls, pipes etc., the present result is considered to be effective for an initial discussion in the blanket design activity. The present design of the Flibe+Be/JLF-1 blanket system is assuming the natural isotope ratios for lithium in the Flibe coolant. Therefore, even in the case that the local TBR is depressed significantly due to the additional JLF-1 structures, enhancement of the tritium breeding performance is possible by increase the isotope ratio of ^{6}Li.

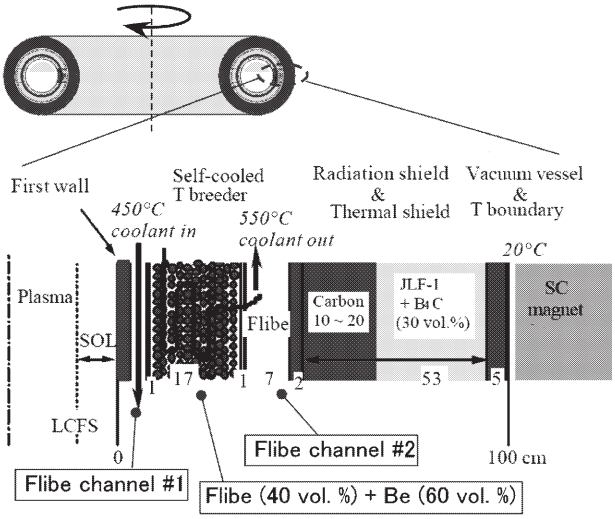

Fig 1. Structure of Flibe+Be/JLF-1 blanket of FFHR2.

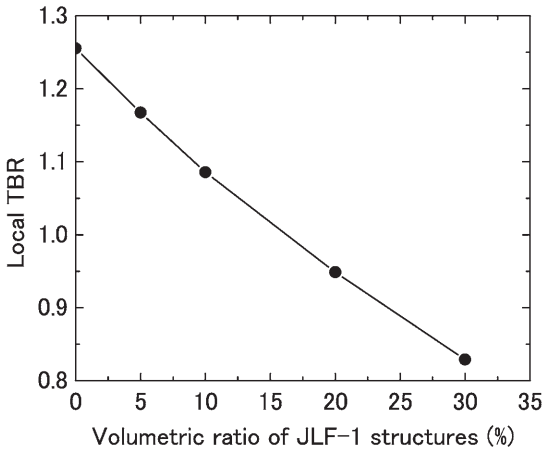

Fig. 2. Relation between volumetric ratios of additional JLF-1 structures in the Flibe+Be layer and local TBR

[1] A. Sagara et al., Fusion Eng. Des., 83 (2008) 1690-1695.
[2] T. Tanaka et al., Nucl. Fusion 48 (2008) 035005.

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