§9. Neutronics Analysis for Li/V-alloy and Flibe/V-alloy Blankets of FFHR2m1 with and without Beryllium

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The design of self-cooled molten salt Flibe blanket design for FFHR has been carried out using reduced activation ferritic steel (JLF1) as structure materials [1]. The thermal efficiency of the plant is relatively low due to high melting point of Flibe (～430 ℃) and the limit of maximum operation temperature of JLF1(～550℃). On the other hand, vanadium alloy (V-alloy) has superior thermal-mechanical properties and can be operated up to ～700℃. So the blanket with the structure material (materials) of V-alloy has potentiality for higher thermal efficiency. For blankets using V-alloy, liquid Li and Flibe were proposed as candidate liquid tritium breeders. Be is a potentially necessary neutron multiplier. Be is also an excellent neutron moderator with low absorption cross section for thermal neutrons. Use of Be is an option for both Li and Flibe blankets for FFHR2m1 although there are some issues specific to Be such as resource limitation and irradiation effect.

Four blankets concepts using Li or Flibe as tritium breeder and coolant with V-alloy structure were proposed for FFHR2m1 design namely, Li/V-alloy (Li/V), Flibe/V-alloy (Flibe/V), Li/V with Be (Li/Be/V) and Flibe/V with external Be (Flibe/Be/V). Two self-cooled blankets concepts, Li/V and Flibe/V were investigated for FFHR2m1 such as assessment of tritium breeding ratio (TBR) and shielding of Li/V and Flibe/V [2]. The objectives of the present study are to assess impact of the external Be on the tritium breeding and shielding performance of Li and Flibe blankets for FFHR2m1 design.

The neutronics analyses for the breeding blankets of FFHR2m1 are performed with MCNP-4C code and JENDL-3.2 file. A simple torus model of FFHR2m1 was used in neutronics calculation. The plasma major and minor radius of FFHR2m1 is 14 and 1.73 m, respectively. The average neutron wall loading is 1.5 MW/m^2. The available space for the blanket is 120 cm. The schematic radial configurations of the Li/Be/V and Flibe/Be/V blankets are shown in Fig.1. The typical neutron spectra in liquid blankets with and without external Be are compared in Fig.2. All spectra were calculated at the position of 19.5 cm from the FW. Beryllium effectively multiplies neutrons through the (n, 2n) reaction. In addition, Be is an excellent neutron moderator with much lower absorption cross section for thermal neutrons compared to Li. Beryllium increased low energy neutrons significantly, especially for the Li/Be/V blanket. Thus, tritium breeding through ^{6}Li(n, t) reaction is enhanced. It is possible for the Li/Be/V blanket to obtain the same TBR with thinner breeding region compared to the Li/V blanket (54 cm of breeding region) due to Be. The TBR of 1.35 can be achieved in the Li/Be/V blanket with a 25 cm thick breeding region. Because of the resulting increase in the shield thickness, the shielding property of the Li/Be/V blanket is improved significantly. The fast neutron flux (>0.1 MeV) at outside of radiation shield in the Li/Be/V blanket is 4.9×10^8 n/cm^2/s, ～5.6 % of that in the Li/V. With the same thickness of breeding region (60 cm), the TBR of the Flibe/Be/V blanket is increased to 1.40 from 1.26 of the Flibe/V blanket. The fast neutron flux (>0.1 MeV) at outside of radiation shield in the Flibe/V and Flibe/Be/V blanket is 1.4×10^9 and 1.3×10^{9}n/cm^2/s, respectively. The shielding performance of the Flibe/Be/V blanket is comparable with that of the Flibe/V blanket.

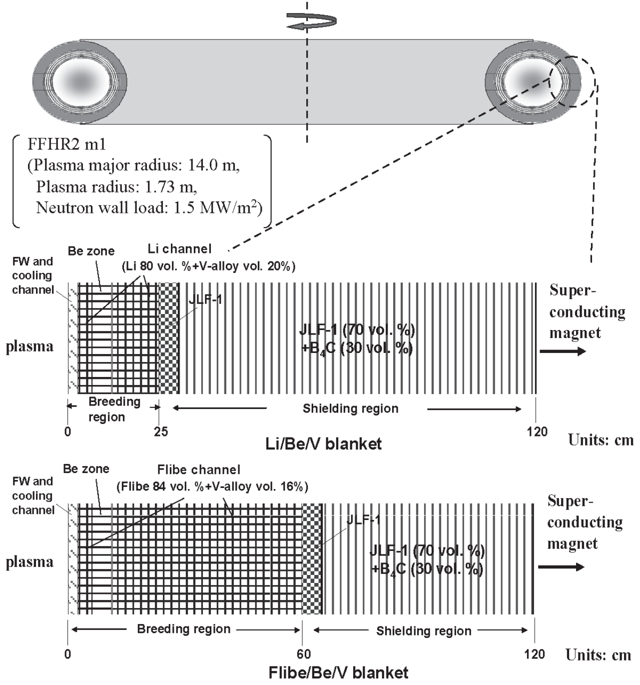

Fig. 1 Schematic radial configuration of the Li/Be/V and Flibe/Be/V blankets

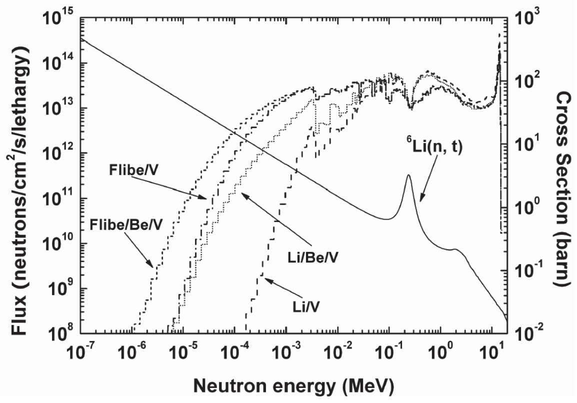

Fig. 2 Typical neutron spectra in liquid blankets and the ^{6}Li(n, t) cross section

Reference

1) A. Sagara et al., Fusion Eng. Des. 49-50, 661-666 (2000).
2) T. Tanaka, T. Muroga, A. Sagara, Fusion Sci. Technol. 47, 530-534 (2005).