§38. Development of Neutronics Benchmark Technique for New Shield and Breeder Materials

Murata, I., Manabe, M., Tamaki, S. (Osaka Univ.),
Tanaka, T., Sagara, A.

In the design of the helical reactor FFHR, blanket systems cooled by liquid molten salts such as Flinabe, Flibe and Flinak have been proposed, because tritium self-sufficiency with a thinner blanket layer, high-efficiency power generation at high temperatures and chemical stability can be expected.[1)] However, detailed benchmark experiments of neutron transport have not been performed for materials used in the molten salt blanket systems. Since validation of calculation accuracies of tritium breeding and radiation shielding is significantly important to ensure the achievement of required blanket performances, benchmark experiments using the intense 14 MeV neutron source (OKTAVIAN) at Osaka University are considered in the present study.

The dimensions of a cuboid-shaped Flinak assembly required for the benchmark of tritium production rates are investigated by calculation using the neutron transport code MCNP-5 and nuclear data library JENDL-3.3. The Flinak assembly is placed at the center of the irradiation room with 1 m thick concrete walls (Fig. 1), which simulates the OKTAVIAN facility. The distance between the front surface of the assembly and the neutron source is 30 cm and the length of the assembly is fixed to 60 cm. The height and width of the assembly were changed between 15 cm and 65 cm to decide the smallest dimensions required for measurement of tritium production rates on the central axis of the assembly. In the assembly, blocks of Be neutron multiplier (5 x 5 x 10 cm^3) are installed at 5 cm from the front surface. If the dimensions of the assembly are too small, the accuracy of the measurement will be degraded due to (1) increase of neutrons escaping outside of the assembly and (2) increase of neutrons which are reflected at the concrete walls of the irradiation rooms followed by entering into the assembly and reaching the center axis.

Figure 2 shows distribution of ^{6}Li (n, α) T and ^{7}Li (n, n'α) T reaction rates on the center axis of the Flinak assembly. In the ^{7}Li (n, n'α) T reaction which has the threshold energy of 2.8 MeV, almost no change is observed by installing the Be neutron multiplier. In contrast, the ^{6}Li (n, α) T reaction rate, which can occur by low energy neutrons, increases significantly around the Be blocks. This indicates that examination of the calculation accuracy for the neutron multiplying effect can be performed using the present assembly configuration.

Comparison of the results calculated with and without the concrete walls indicates that influence of neutrons reflected by the walls is considerable at the positions deeper than 30 cm and this would degrade the accuracy of the evaluation. The thickness of the molten salt cooled blanket is 30-40 cm in the FFHR design. Therefore, the accurate evaluation in the front half of the assembly is considered more important. It is concluded that the cross section of the assembly should be larger than 55 x 55 cm^2 to suppress the influence of neutrons reflected by the concrete walls within 5 %.

For quick and efficient evaluation of tritium production rates in the Flinak assembly, usage of Li grass scintillation detectors is discussed. Analysis of the detector response in the assembly is being conducted by neutron transport calculation to investigate the applicability.

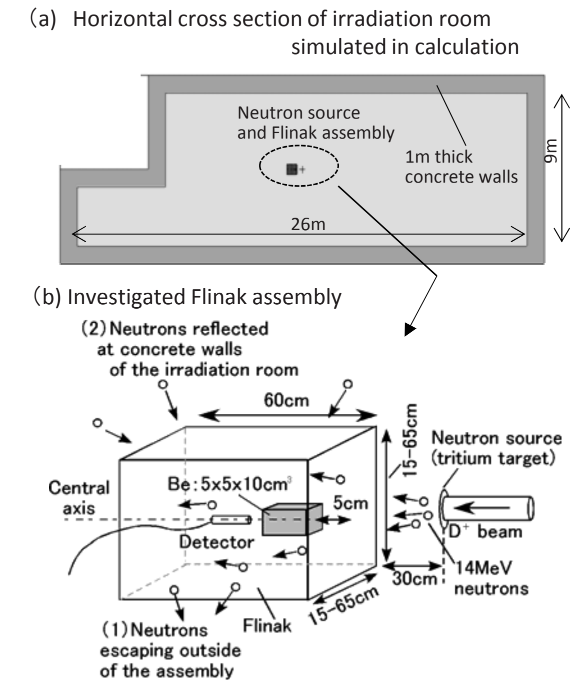

Fig. 1. Schematic drawing of a calculation model.

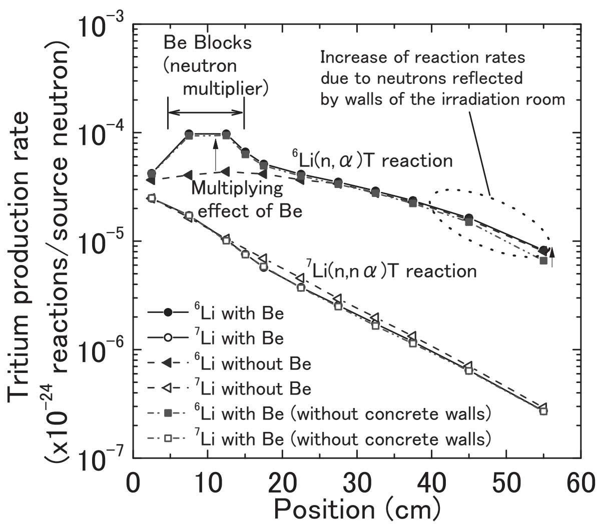

Fig. 2. Distribution of tritium production rates on the central axis of the Flinak assembly.

1) Sagara, A.: Fusion Eng. Des. **89** (2014) 2114.