Neutronics experiments using small partial mockup of the ITER test blanket module with solid breeder

S. Sato[1], Y. Verzilov[1], M. Nakao[1], K. Ochiai[1], M. Wada[1], T. Nishitani[1]

[1] *Japan Atomic Energy Research Institute, Tokai-mura, Naka-gun, Ibaraki-ken, 319-1195 Japan*
sato@naka.jaeri.go.jp

In fusion DEMO reactors, the blanket is required to provide a tritium breeding ratio (TBR) of more than unity by neutron induced reactions in lithium. In order to verify the accuracy of the tritium production rate (TPR) and also to study the impact of the tungsten armor on the TPR experimentally, neutron irradiation experiments have been performed with a small partial mockup relevant to the ITER test blanket module proposed by JAERI using DT neutrons at FNS of JAERI.

A solid breeder blanket mockup, composed of a set of slabs of 16 mm thick F82H, 12 mm thick Li_2TiO_3 (^6Li enrichment of 40 %) and 200 mm thick Be with about 660 mm height and about 660 mm width each, was installed, and DT neutron irradiation experiments were conducted. In the experiments three types of mockups were tested: without the armor; with 12.6 mm thick W armor; and with 25.2 mm thick W armor. Two campaigns were also performed for the mockup without the armor. A reflective enclosure made of SS was installed surrounding the DT neutron source in one campaign. It can take into account the effect of the incident back-scattering neutron source. It was not installed in the other campaign. Fifteen slices of Li_2CO_3 pellets, with 13 mm in diameter and 0.5, 1, and 2 mm in thickness, were embedded inside the Li_2TiO_3 slab. After the irradiation, induced radioactivities were measured by beta ray intensity of these pellets with a liquid scintillation counter, and the TPR was evaluated.

Numerical analyses were conducted by using MCNP-4C with FENDL-2. The calculation results agree well with the experiment ones within 13 and 2 % for the campaign with and without the enclosure, respectively. From this study, it can be clarified that the TPR can be predicted in very high accuracy for the case without the enclosure. Uncertainties with the enclosure are larger than those without one. It is expected that this occurs, due to the uncertainties of the cross section data about the back-scattering neutron. There are a number of back-scattering neutrons entering the blanket in the actual fusion reactor. The contribution of the back-scattering neutrons in the present experiment with the enclosure is larger than that in the actual fusion reactor, so it can be concluded that the prediction accuracy is in the range of 2 – 13 % in the calculation for the actual fusion reactor.

From the experiment with the 12.6 mm and 25.2 mm thick tungsten armors, the integrated TPRs were reduced by 8 and 3 % relative to the case without the armor, respectively. The fast and thermal neutron fluxes are reduced by the tungsten, so it can be concluded that the TPRs were reduced by installing the tungsten armors. In the blanket design proposed by JAERI, it is expected that the reduction of the TBR is less than 2 % as the thickness of the W armor is less than 5 mm.