Neutronics Investigation into Lithium/Vanadium Test Blanket Modules

T. Muroga and T. Tanaka

National Institute for Fusion Science, Oroshi, Toki, Gifu 509-5292, Japan
muroga@nifs.ac.jp, teru@nifs.ac.jp

Technical discussion on ITER-Test Blanket Modules (TBM) has been made in Test Blanket Working Group (TBWG). The discussion is based on the concepts of breeding blankets to be developed for DEMO. The present concepts of lithium self-cooled blanket are categorized into "No beryllium (Li/V)" and "With beryllium (Li/Be/V)" concepts. The former and the latter systems use neutron reaction with ^{7}Li and Be for enhancing the Tritium Breeding Ratio, respectively. It has been shown that, with appropriate designs, tritium breeding self-sufficiency will be satisfied for either systems. The DEMO blanket and TBM for Li/Be/V concepts have been investigated by Russian R&D program and Detailed Description Document for the TBM is available.

The Li/V concept has some advantages over Li/Be/V concept; (1) the blanket structure can be simplified, (2) the system is free from the issues of natural resource limit and handling safety concerning beryllium, (3) no periodic replacement of blanket material is necessary. The present study is the initial effort of investigating Li/V TBM from the neutronics aspects.

The primary purpose of the module test was defined as validation of the tritium production rate prediction carried out based on the neutron transport calculation. For this purpose the module was designed to be composed of sectioned thick boxes which accommodate slow tritium flow. This system enables to measure the tritium production rate as a function of the distance from the first wall. The size of the boxes was limited so as to satisfy the introduction limit of liquid lithium into the test port.

In this study, the neutron energy spectrum and tritium production rate have been calculated using MCNP code with JENDL-3.2 database. The available ITER-FEAT structure was used as the system for the calculation of the module. In addition, ITER-FEAT structure with all the plasma-facing area replaced with Li/V breeding blanket (a hypothetical Li/V reactor) was used for comparative calculation.

A comparison was made of the neutron spectrum in ITER-TBM and the Li/V reactor, and showed that the flux of low energy neutrons, including thermal neutrons, is significantly higher in ITER-TBM than that in the Li/V reactor. Thus it is possible that the tritium production by reaction of ^{6}Li with thermal neutrons should be enhanced in ITER-TBM. As a result the contribution of ^{7}Li to the overall tritium production in the module will be significantly lower than that in the reactor blanket. For better simulation for the reactor environment, it is necessary to shield thermal neutrons in the TBM area. For this purpose, a calculation was made for the case in which the module was covered with a B_4C layer. It was shown by the calculation that the spectral tailoring is possible by adjusting the thickness of the B_4C layer. Predicted tritium production rate was obtained in the spectrum-tailored module.

Coating with thin tungsten layer was considered as protection of the first wall. The effects of the coating to the reactor TBR and the tritium production rate of the module were estimated.