§4. Experimental Evaluation of Neutronics Properties of Liquid Blanket Systems Using DT Neutron Source

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Neutronics design studies for the advanced Li-cooled and Flibe-cooled blanket systems have been conducted at NIFS focusing on the tritium breeding performance, neutron shielding performance, activation properies of the blanket materials etc. Issues in the neutronics studies have been investigated under the present collabolative program and the experimental evaluations have been started by using the DT neutron source in the FNS facility of JAEA.

Activation properties of materials related to the Li-cooled and Flibe-cooled blanket systems have been evaluated by the DT neutron irradiations using the 80^o line in the FNS facility.[1), 2)] To simulate the neutron spectra in the liquid blanket systems, three types of mockups, Li mockup, Be mockup and Li+Be mockup consisting of solid Li and solid Be blocks were constructed in front of the DT neutron source with the dimensions of 25 x 25 x 30 cm^3 (Fig. 1). Small foils of vanadium alloy NIFS-HEAT2, metal Er and Teflon were set in the mockups for the radioactivity evaluations of the structural material, electrical insulator for the Li-cooled blanket system and fluorine in Flibe coolant, respectively. The typical DT neutron generation rate was ~7x10^{10} - ~2x10^{11} n/s. The neutron fluxes at the samples in the Li+Be mockup were ~3x10^8 n/cm^2/s (5 cm from the front surface) and ~1x10^8 n/cm^2/s (10 cm from the front surface). After the irradiations of 20 minutes - 2.5 hours, the radioactivities of the foils were evaluated from the gamma-ray intensities measured with Ge detectors. The values of evaluated radioactivities were compared with those calculated with the neutron transport code MCNP-4C, nuclear data JENDL-3.3 and activation code FISPACT-2001 for the accuracy validation of the calculation system. Radioactivities of eight nuclides, i.e. ^{51}Ti, ^{52}V, ^{48}Sc from NIFS-HEAT2, ^{161}Er, ^{171}Er, ^{167}Ho, ^{168}Ho from Er and ^{18}F from Teflon, were evaluated in the present irradiations. The differences between the evaluated and calculated activities were within ~20 % for most of the nuclides except ^{168}Ho with 40 % difference. Sources of the differences have been investigated and discussed. The large difference for the ^{168}Ho production is due to the cross section of the ^{168}Er (n, p) ^{168}Ho reaction drastically changing around 14 MeV. It has also been pointed out that the calculation accuracies for the ^{52}V and ^{171} Er productions are improved by increasing the number of energy groups in the activation calculation process from 175 to 315. The cross-section data in the thermal neutron region dominating the ^{51}V(n,γ)^{52}V reaction are finer for the increased energy groups. For the production of ^{171}Er through the (n,γ) reaction of ^{170}Er, the resonance peaks in the cross section could degrade the accuracy.

Experimental evaluation of neutron transport and tritium production in the Li/V-alloy blanket system has been planned at the FNS facility by using a Li/V-alloy mockup. In the Li/V-alloy blanket system without solid Be multiplier, vanadium in the structural material has a significant impact on the tritium production rate by the (n,2n) reaction.[3)] Therefore evaluation of the neutron transport around the boundaries of the Li and the V-alloy regions is considered to be important for the validation of the TBR (tritium breeding ratio) calculations in the reactor design.[4)] Application of NE-213 and lithium glass scintillation detectors has been discussed for the neutron spectrum and tritium production rate measurements as shown in Fig. 2.

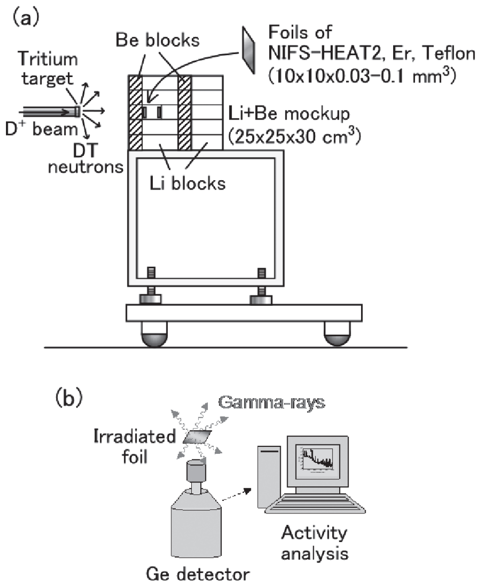

Fig. 1. Schematic drawings of (a) DT neutron irradiation with Li+Be mockup for radioactivity evaluation of blanket materials and (b) activity analysis with Ge detector.

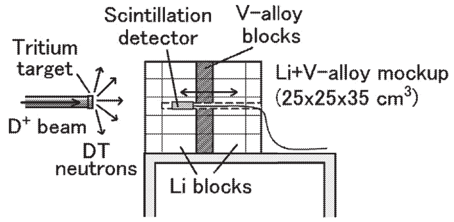

Fig. 2. Schematic drawing of DT neutron irradiation with Li+V-alloy mockup planned for evaluation of neutron transport and tritium production in Li/V-alloy blanket system.

References
1) Z. Li *et al.*, Fusion Engineering and Design 81 (2006) pp. 2893-2897.
2) Z. Li *et al.*, to be published in Fusion Science and Technology.
3) T. Iida *et al.*, NIFS annual report April 2005 - March 2006, p. 261.
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