# §10. Neutronics Characterization of Liquid Lithium Blanket with RAFM and V-alloys for DEMO

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The key issues for the Li/V system are development of an MHD coating and the industrial maturity of vanadium alloys. Although significant progress has been made on these issues, the technical establishment needs further R&D. Thus, alternative concepts are also being explored for near-term application such as ITER-TBM or the early period of DEMO and as an intermediate step toward a Li/V blanket. The combination of liquid lithium with Reduced Activation Feritic/Martensitic Steel (RAFM) is one of the possible options for this purpose. In this case, the structural material has a higher technical feasibility than the case of vanadium alloys. On the other hand, the limited upper operating temperature of RAFM will induce lower plant efficiency than that of Li/V blanket.

Another possible advantage of Li/RAFM is the potential use of He as a coolant, which is thought to be difficult for Li/V because of high reactivity of V alloys with impurities in He. The blankets using Li-Pb or Flibe are thought to require means such as ceramics coatings to reduce the tritium permeation, regardless of the cooling materials. Self-cooled liquid metal blankets need an MHD insulator coating once electrically conductive walls are used. Thus coating development is considered to be the key feasibility issue for most of the liquid breeder blankets. The helium-cooled Li/RAFM blanket, however, has an excellent possibility that neither a tritium barrier coating nor an MHD insulator coating is necessary.

For comparative evaluation of Li/V and Li/RAFM systems, critical information is necessary such as neutronics performance of the systems. This paper shows characterization of Li/RAFM blankets in comparison with Li/V blankets with respect to the neutronics performance.

In the present calculation, the same geometry as the authors' precious paper [1] was assumed with a simple torus fully covered with uniform blanket layers consisting of self-cooled breeder channels and a radiation shield. Vanadium alloy of V-4Cr-4Ti or RAFM (Fe-9Cr-2W) was assumed as a structural material. The volumetric ratio of the structural material in the channels was ~17 vol. % and the remaining ~83 vol. % was filled with 35% 6Li enriched liquid lithium. Tungsten armor of 5 mm was attached on the surface of the first wall of 5 mm.

Fig. 1 shows the local TBR and fast neutron flux at the outside of the radiation shield. A significant difference in the shielding performance is not seen between Li/V and Li/RAFM. However, the Local TBR of Li/V is higher than that of Li/RAFM because of (n, 2n) reaction of $^{59}V$. According to the guideline of TBR>1.3 and $\phi_n<1x10^{10}/cm^2s$, Li/RAFM is still feasible with the enhanced shield.

An $Er_2O_3$ coating is a promising electrical insulator to mitigate MHD pressure drop in the Li blanket. In this study,

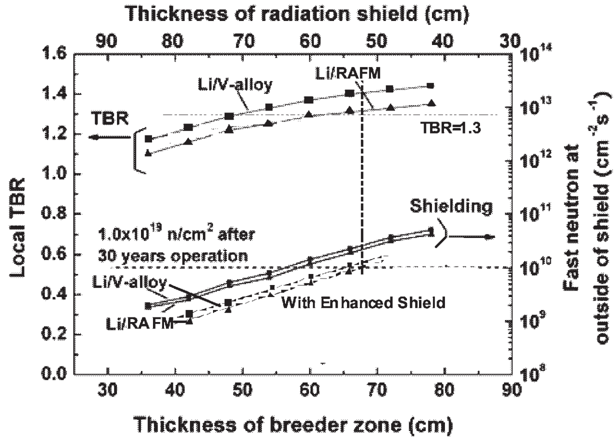


Fig. 1. Local TBR and neutron shield performance calculated for Li/V and Li/RAFM blankets of FFHR-2 with 6Li enrichment to 35% . The total thickness of the blanket zone is fixed to be 120cm.

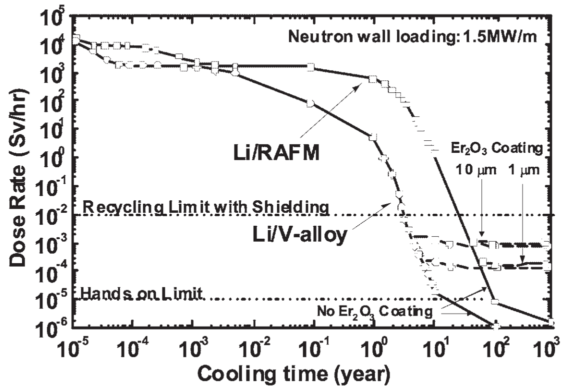


Fig. 2. Dose rate vs. cooling time for Li/V and Li/RAFM blankets with $Er_2O_3$ coating after operation for 10 years.

the activation of Li/V and Li/RAFM blankets were calculated with and without the $Er_2O_3$ coating. Fig. 2 shows a comparison of the dose rate for the Li/V and Li/RAFM blankets after ten years' operation with $Er_2O_3$ coatings of 0, 1 and 10μm thick. The dominant nuclide from Er is 166mHo ($T_{1/2}$ :1200 yr) at the range from several tens to thousand years. It was shown that a V-alloy is a better low activation material and can be recycled without shielding after ~20 years cooling, relative to RAFM which needs cooling for ~100 years for the unshielded recycling. With the $Er_2O_3$ coating, however, the both alloy systems have similar activity after ~50years because of the activity of $Er_2O_3$. It should be noted that the recycling with shielding is still feasible for both systems, which is known to be impossible for 316SS or Fe-Cr-Mo ferritic steels. The effect of the $Er_2O_3$ coating on TBR was shown to be small.

[1] T. Muroga, T. Tanaka and A. Sagara, Fusion Eng. Design, 81, 1203 (2006).