§76. Concept Design of Li-enclosed Capsule in Pile

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A vanadium alloy is expected as a candidate material of blanket system with liquid Li coolant for fusion reactor application. Since there is not yet enough knowledge about radiation effect and compatibility between liquid Li coolant and structural materials, its engineering design cannot be determined. In order to resolve this problem, it is necessary to exam the compatibility experiment in liquid Li with Li-enclosed capsule in pile, so that it is required to develop the Li-enclosed capsule as an irradiation vehicle in pile.

In this study, we discuss the compatibility experiment in liquid Li with Li-enclosed capsule in the domestic reactor such as JMTR and Joyo, and aim at acquiring the data in order to design the capsule.
Task items in this plan are shown in the following;

- Analyses of the tritium production and leakage amount from Li-capsule in irradiation
- Evaluation of thermal expansion difference (TED) in Li-fulfilled capsule
- Analysis of corrosion resistance of material against Li coolant
- Design of Li-enclosed capsule

A liquid lithium corrosion test to V-4Cr-4Ti alloys was examined with corrosion capsule made of V-5Ti alloy. The V-5Ti capsule was fabricated in the IMR/Tohoku Univ. and Daido Bunseki Research with EB weld for enclosing the endcap and tube part.

The corrosion test in liquid lithium was performed at NIFS. Coupons and V-notched Charpy specimens of V-4Cr-4Ti alloys were prepared for as-received and laser-welded specimens. Specimens were immersed in liquid lithium at 700C for 100h.In this experiment, the lithium was charged under Ar atmosphere in a globe box. Figure 1 shows the schematic design of capsule for corrosion test and the photograph of specimens after corrosion test. When the remnant of lithium was removed with pure water, hydrogen was produced by chemical reaction between water and lithium and it affected the embrittlement of vanadium alloys because of hydrogen absorption. To avoid it, the aqueous solution with 30% of hydrogen peroxide was used for rinsing the lithium off from specimens Figure 2 shows the result of hardness test in the depth of V-4Cr-4Ti alloys after corrosion test. A hardened layer was formed to the depth of 60μm. It is considered that the hardened area was produced by increase of nitrogen atoms near the surface and nitrogen was moved from liquid lithium under corrosion test.

In order to manufacture the thermal expansion dosimeter (TED) by vanadium alloys, a vanadium alloy ingot was fabricated at Daido Bunseki Research and the parts of TED were fabricated at the SFC co. To enclose liquid sodium in the TED inside, a friction welding method is discussed between JAEA-Oarai and the Oarai branch of IMR/Tohoku.

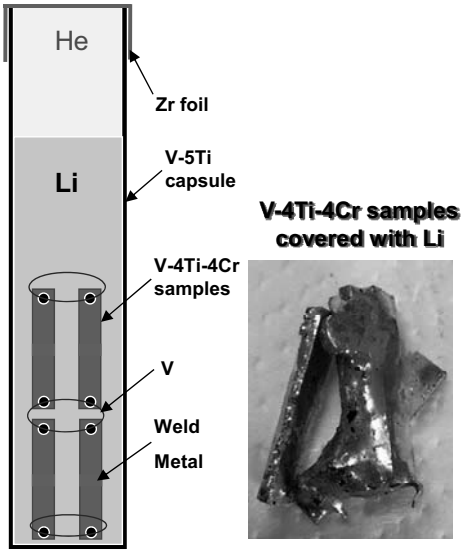

Fig.1. A design of a capsule for corrosion test in liquid lithium environment.

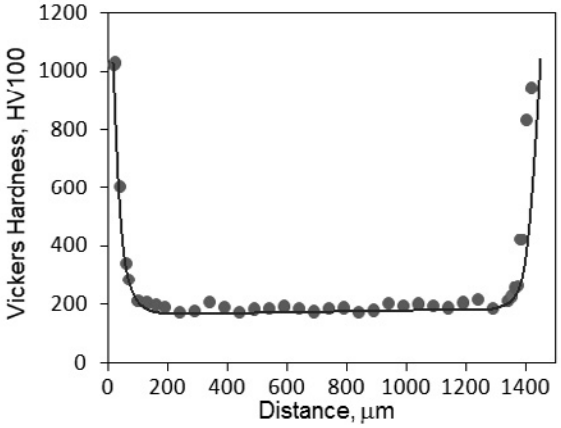

Fig.2. A plot of hardness distribution in depth for V-4Cr-4Ti alloy after lithium corrosion test at 700C.