§35. Study on Design and Experiment of System to Recover Tritium from Falling Liquid Flow of Laser Fusion Reactor

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LiPb eutectic alloy of $Li_{17}Pb_{83}$ is a promising tritium breeder and a falling liquid material to protect a vacuum chamber wall from heavy neutron flux in a laser fusion reactor. Fig. 1 shows a LiPb loop in a conceptual design of a laser fusion reactor named “Koyo-fast”. D-T solid pellets are injected into the vacuum chamber per several particles per second and for laser implosion is performed. At the same time liquid LiPb flows in the chamber from the top, and free liquid surface is made up. Neutron generated by the D-T reaction is targeted at the LiPb flow, and tritium is generated in LiPb. Reaction heat is also recovered by the liquid LiPb flow.

In order to estimate a system to recover tritium from the liquid LiPb loop, diffusivity and solubility of $Li_{17}Pb_{83}$ were determined using a permeation method. In our previous collaboration study, the diffusivity and solubility of H or D in LiPb are determined.[1)] The isotope effects are made clear under the conditions of their respective single components[2)] and also H_2+D_2 mixed component.[3)] In addition, composition effects are also investigated.[4)]

In the present collaboration study, a tritium recovery system for the LiPb flow in a laser fusion reactor is focused. The LiPb conditions are 300°C of inlet temperature, 500°C of outlet temperature, 1.94 m^3/s of LiPb flow rate. Then, the T concentration in LiPb flow is 8.6×10^{-9} in molar fraction. Generated tritium is recovered by a He-LiPb counter-current extraction tower.

He is counter-currently flowed through a packed bed from the bottom and LiPb is from the top. The T concentration and T_2 partial pressure are plotted as a operating line in Fig. 3. The chained line is equilibrium line for T solubility in LiPb, which is called Sieverts law. The column height can be determined by the McCabe-Thiele graphical method. The height is reasonable one. Since tritium permeation rate through the heat exchanger is estimated higher than 10 Ci/day as the safety target of fusion reactor, oxide coating to reduce tritium permeation through heat exchanger tube is inevitable.

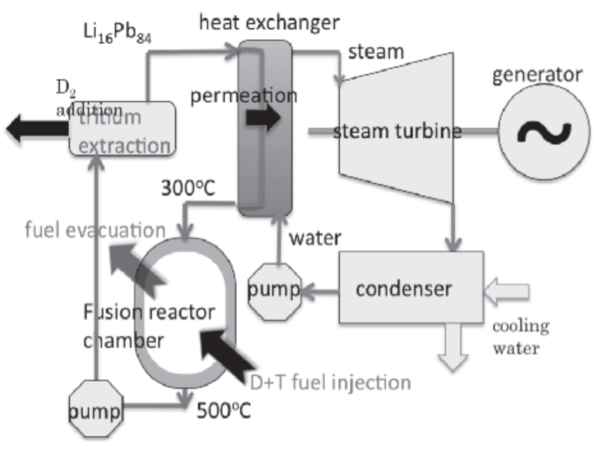

Fig. 1 LiPb loop for laser fusion reactor[4)]

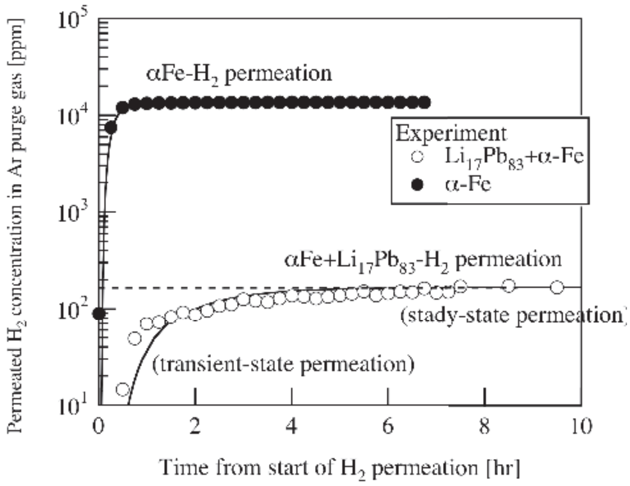

Fig. 2 Comparison between experiment and calculation for transient hydrogen permeation behavior in LiPb[3)]

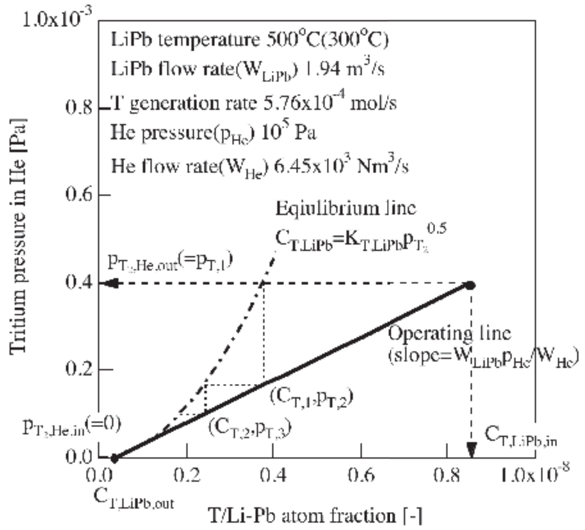

Fig. 3 Estimation of tritium concentration in LiPb-He counter-current extraction tower

1) Fukada, S., *et al.*: Annual report of NIFS, (2010) 521.
2) Edao, Y., *et al.*: Proc. Int. Conf. Tritium Sci. Technol., Nara, (2010) in printing.
3) Edao, Y., *et al.*: Proc. ICFRM-14, Sapporo, (2010) in printing.
4) Fukada, S., et al.: Proc. ICFRM-14, Sapporo, (2010) in printing.
5) Fukada, S., *et al.*: Proc. ICENES, San Francisco, (2011) in printing.