# §29. Design of Tritium Recovery System for Laser Fusion Reactor

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A tritium (T) recovery system for a Laser fusion reactor called KOYO-fast of 1GWt power is designed within the present collaboration framework between Osaka University and Kyushu University. A wetted wall of liquid $Li_{0.17}Pb_{0.83}$ eutectic alloy is proposed in order to suppress radiation damage to the first wall and to recover heat generated by neutron moderation. The LiPb eutectic alloy works not only as a protector of the first wall but also as a T-breeding blanket through the n-Li reaction. Thus LiPb works as a multi-purpose blanket fluid for T breeding, coolant and energy conversion. The outside LiPb loop is operated under the conditions of temperature and LiPb flow rate as shown in Fig. 1. Generated T is removed by a T removal system composed of a LiPb-He counter-current extraction tower. Then heat transferred to coolant is converted to electricity by a steam generator and steam turbine.

In FY 2008, experiment based on the permeation method has been performed to determine the values of permeability ($P_H$ or $P_D$), solubility ($K_H$ or $K_D$) and diffusivity ($D_H$ or $D_D$) of $H_2$ or $D_2$ in $Li_{0.17}Pb_{0.83}$. Fig. 2 shows data of permeability of $H_2$ through LiPb. The pressure dependence is found to be square root of upstream pressure regardless of temperature when the downstream pressure is very low. Then, the H permeation flux, $j_H$, is correlated as follows:

$$j_{H_2} = \frac{1.8\times10^{-9}}{l}\exp\left(\frac{30.1[kJ/mol]}{R_gT}\right)\left(p_{H_2,up}^{0.5} - p_{H_2,down}^{0.5}\right)[\mathrm{mol/m^2s}]$$

The values of solubility and diffusivity determined experimentally are presented in the papers cited below [1-3], and are correlated to the equations:

$$D_{LiPb-H} = 1.8\times10^{-8}\exp\left(-\frac{11.6[kJ/mol]}{R_gT}\right)\ [\mathrm{m^2/s}]$$

$$K_{LiPb-H} = 2.1\times10^{-6}\exp\left(-\frac{18.7[kJ/mol]}{R_gT}\right)\ [\mathrm{1/Pa^{0.5}}]$$

The H-D isotopic difference determined is $K_D$=1.4$K_H$ for solubility, $D_D$=$D_H$ for diffusivity and $P_D$=1.4$P_H$ for permeability. Based on the solubility data, the conditions necessary for the T recovery system are determined as the outlet T concentration of $5\times10^{-5}$ppm and the equilibrium T pressure of $2.6\times10^{-7}$Pa.

The T removal system is composed of an extraction tower packed with steel Rashig Ring of 1inch, and LiPb and He flow in a counter-current way. The tower height and the tower diameter are 7m and 4m. The flow rates of He and LiPb in the tower are 47 $m^3$/s and 3.5$m^3$/s. These conditions can achieve $10^5$ of inlet/outlet T concentration ratio in LiPb.

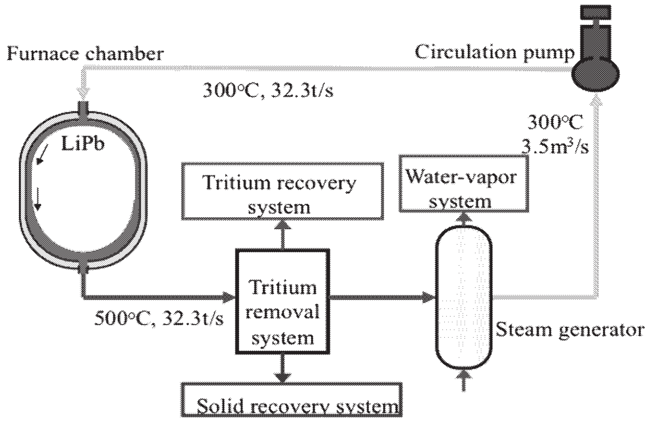


Fig. 1 LiPb circulation system for KOYO fast

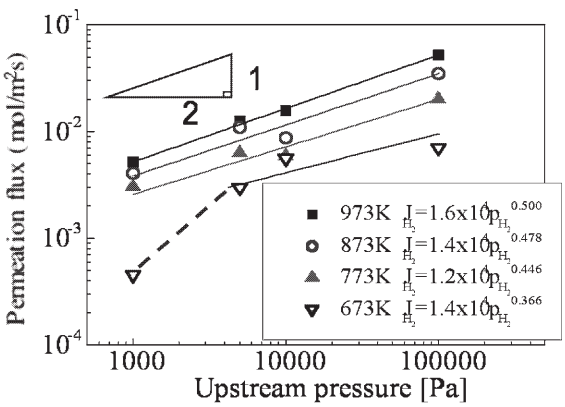


Fig. 2 Pressure dependence of hydrogen permeability through $Li_{17}Pb_{83}$

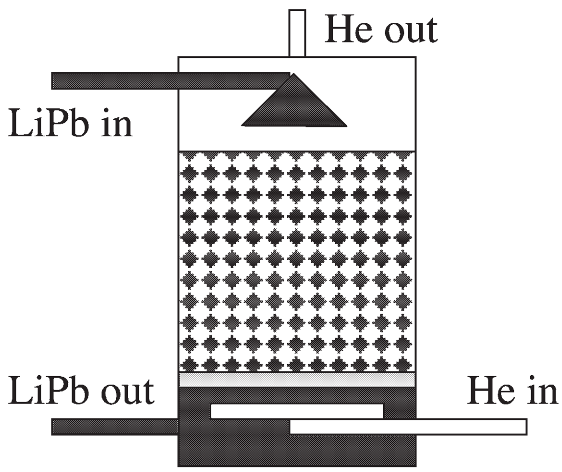


Fig. 3 LiPb-He counter-current extraction tower

**Papers published in FY2008**

(1) Y. Maeda, S. Fukada, Y. Edao, "Solubility, diffusivity and isotopic exchange rate of hydrogen isotopes in Li-Pb", Fusion Science and Technology, 54 (2008) 131-134.
(2) S. Fukada, Y. Edao, Y. Maeda, T. Norimatsu, "Tritium recovery system for Li-Pb of Inertial Fusion Reactor", Fusion Engineering and Design, 83 (2008) 747-751.
(3) S. Fukada, Y. Edao, S. Yamaguchi, "Tritium recovery from Li-Pb eutectic alloy blanket", Proc. of 2nd Japan-China workshop on blanket and tritium technology, May 9-10 (2008) 117-120.