§13. Experimental Study of Counter-current Extraction Tower for Tritium Recovery in Flibe Blanket of Fusion Reactor

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FFHR is a stellarator-type concept designed by NIFS-Japan for the future commercial fusion reactor. Flibe ($2LiF+BeF_2$ mixed molten salt) is used for the self-cooled blanket material. The reactor is operated under conditions of self-sufficient tritium production and continuous heat recovery of 3 GWt fusion power. In order to achieve that, tritium of 4.5 MCi/day is produced in flowing Flibe with 6.5 m^3/s continuously between 500°C and 600°C, and overall recovery ratio of 99.9998% tritium is removed from the loop under an allowed leak rate of 10 Ci/day. Very high performance is demanded on tritium recovery and therefore a counter-current flowing tower is proposed [1].

In order to design the recovery apparatus for tritium extraction and the tritium leak rate through tube walls, mass-transfer experiment through Flibe and Flinak is performed using a permeation cell. H_2 or D_2 permeation rate through a Flinak layer is determined under controlled conditions of temperature and upstream H_2 or D_2 partial pressure. Typical results are shown in Fig. 1 and 2, and it is found that the permeation rates are in proportion to the upstream H_2 pressure. The permeation proceeds in a form of hydrogen molecules in the molten salt. In order to achieve the simultaneous removal of tritium and heat under the allowed conditions, it is preferable to remove tritium from the primary Flibe loop and heat is recovered by the Brayton cycle composed of high-temperature and low-temperature heat exchangers, gas turbine and compressor. The overall tritium balance and heat flow are shown in Fig. 3.

Flibe flows in from the top of a packed column and He does from the bottom in the counter-current extraction tower. Good contact between Flibe drops and He gas bubble is maintained and tritium dissolved in Flibe is removed by He flow. In order to achieve the recovery efficiency of 99.998% per once-through operation, 64 s of contact time is necessary under the diffusion-controlled mass transfer.

1) S. Fukada, *et al.*, Fusion Engineering and Design, (2010) in printing.
2) S. Fukada, *et al.*, Proceedings of 2008 Joint Symposium on Molten Salts, (2008) 875-880. October 19-23, 2008, Kobe, Japan.
3) S. Fukada *et al.*, Fusion Science and Technology, 52 (2007) 677-681.

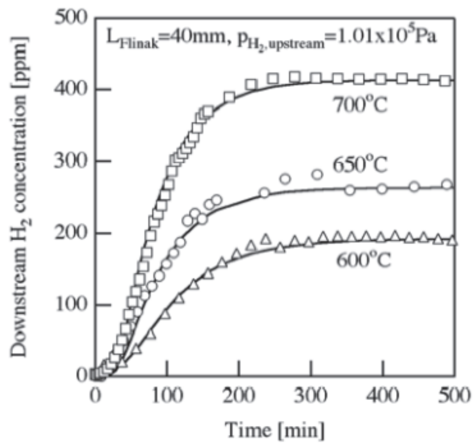

Fig. 1 H_2 permeation rate through Flinak layer

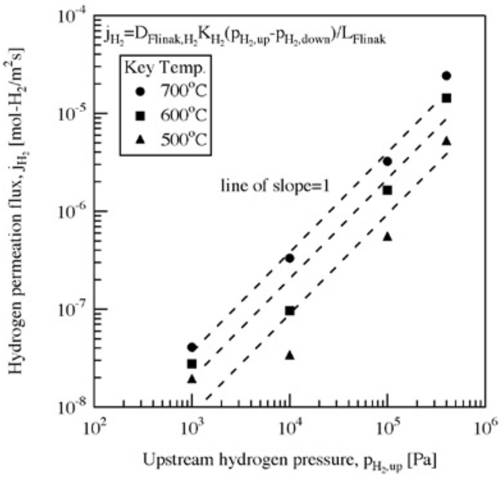

Fig. 2 H_2 permeation rate versus H_2 pressure

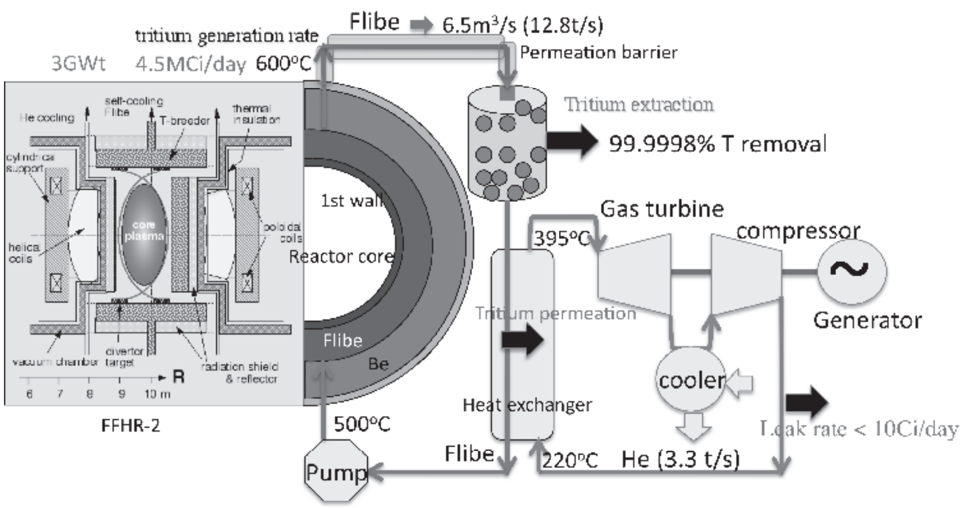

Fig. 3 Flibe loop for FFHR and He Brayton cycle