§3. Chemical Aspects in Molten-salt FLIBE System Design for FFHR

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Liquid tritium breeding materials have many advantages such as no irradiation damage, easy control of chemical composition, and continuous replacement in the blanket. Among liquid breeder candidates, the molten mixture of lithium fluoride and beryllium fluoride (60%LiF-40%BeF_2 denoted as FLIBE) is a promising material for the blanket in FFHR because of its chemical stability, large fluidity and low electric conductivity to reduce MHD pressure drop. The applicability of FLIBE molten-salt as the tritium breeding material for FFHR was discussed to design the most suitable and advanced blanket. We investigated some chemical aspects such as material compatibility, tritium breeding and tritium recovery to point out the insufficiencies of basic studies for FLIBE.

The FLIBE temperatures at the inlet and the outlet of the blanket were determined to be 723 K and 823 K, respectively, based on the melting point of FLIBE and the creep behavior of JFL-1 considered as a structural material.

It is considered that beryllium loaded inside the FLIBE flow in the blanket for high TBR reduce TF produced by the nuclear reaction of LiF with neutron. By the reduction of HF, the corrosion for the structural material may become moderate, but this means the corrosion of beryllium metal proceeds. Thus, we should not only predict the corrosion behavior from the thermodynamic point of view, but investigate the dissolution of beryllium and corrosion behavior of beryllium and structural materials by experiment. From the viewpoint of tritium inventory and corrosion behavior T_2 or HT is more favorable than TF, and TF concentration should be kept as low as possible in the blanket system. Because the rate of the chemical reaction of TF with H_2 dissolving in FLIBE to produce HT is not enough high to keep TF concentration low, experiments on the reaction rate of TF with beryllium are very important.

HT and T_2 having a large release rate coefficient to the gas phase are considered to permeate easily through the structural material to the environment, which should be prevented for safety and high efficiency of tritium recovery. Because the tubing walls for FLIBE should be the first barrier for tritium permeation, it is necessary to use a chemical barrier between the first and the second tubing walls of a double-wall tube. For example, if He + O_2 gas is used as a chemical getter, chemical form of tritium permeating through the first tubing wall changes from T_2 to T_2O, which hardly permeates through the second tubing wall at all. The heat exchanger wall must also have a chemical barrier to reduce tritium permeation to the secondary loop. The chemical barrier for the heat exchange wall must transfer heat at an enough large rate with small tritium permeation rate. Flowing liquid metal or pressurized gas is considered as the tritium permeation barrier having a high heat transfer coefficient, but further investigations are required.

In order to increase the release rate of HT and T_2 from FLIBE, it is useful to make liquid FLIBE spray with a lot of nozzles of a small diameter to increase the surface area of FLIBE droplets. With the advantage of this concept, we can design a FLIBE blanket loop system, whose tritium inventory is less than 0.1 g in 500 ton of FLIBE. However, we must note that an investigation about the interfacial energy of FLIBE are necessary to discuss about the possibility of producing such small droplets. The diffusivity and solubility in FILIBE in well-characterized conditions are essential parameters for design of the tritium recovery system.