THE FUEL CYCLE FOR MOSART: TAXONOMY AND TERMINOLOGY RELATED ISSUES

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Abstract

The concept of molten salt reactor has long history and numerous advantages on fuel fabrication and possibility of making changes to the composition during operation without reactor shutdown [1]. The Molten Salt Actinide Recycler and Transmuter (MOSART) system uses in primary circuit a fuel Li,Be/F salt mixture with addition of transuranic fluorides providing adequate melting point and good heat transfer properties. The ability to chemically process the fuel during operation is the most important advantage of the MOSART if the goal is TRU incineration. In MOSART design, the conventional concept of processing fuel in facilities that are separate from the reactor plant, needs to be abandoned in favour of integrating the processing operations directly into the reactor building. This arrangement allows significant savings in capital, operating, shipping, and inventory costs.

The main requirements for TRU handling and processing as well as radwaste management in MOSART include: (1) fissile materials non-proliferation, (2) virtually complete TRU incineration, (3) minimization of TRU in radwaste disposal (no more than 0.1% of its initial content in used fuel).

General requirements for the fuel Li,Be,An/F (where An = Pu, Np, Am, Cm) salt mixture clean-up unit are formulated in Table 1: (1) actinides multi recycling to the reactor circuit without soluble fission products within one month, (2) removal of soluble fission products from the fuel salt with a period not more than 1 yr, (3) main operations include only molten salt and liquid metal with relatively low concentrations of fissile nuclides, (4) operations with isolated pure fraction of fissile materials are avoid, (5) xenon and krypton poisoning is kept low by injecting a purge gas directly into the circulating fuel stream, an in-line stripper removes the gases, which are routed to a charcoal system for retention and decay.

Fuel Li,Be,An/F salt clean up for soluble fission products can be based on the use of various methods tested to varying degrees during the development of pyrochemical methods. The most universal method is the reductive extraction method. A detailed analysis of the reductive extraction method as a basis for developing a processing flowsheet for MOSART is given in [2]. It includes the following main operations:

- holding of fuel salt in tanks, with a passive heat removal system based on, for example, heat pipes and air-cooled radiators. In the holding devices, the solid components) of the fuel salt are also separated;

- extraction of zirconium and corrosion products in extractor devices, where Zr, Cr, Fe, Ni are released into bismuth, which are separated and removed as radioactive waste in the subsequent bismuth distillation operation;

- extraction of actinides and part of lanthanides, where the main part of actinides and a small part of lanthanides are separated into the liquid bismuth phase;

- extraction of lanthanides and actinide residues, where the remaining part of actinides and lanthanides are separated from the salt, which are then sent for hydrometallurgical processing after the bismuth distillation operation;

- separation of excess salt, where excess lithium fluoride formed in the process is removed and the excess salt is subsequently transferred to radioactive waste management;

- re-extraction of actinides in re-extractors from bismuth into Li,Be/F solvent purified from fission products, where actinides are fluorinated using a fluorinating reagent and actinide fluorides are dissolved;

- salt adjustment for BeF_2, required to equalize the LiF to BeF_2 ratio, since after the reductive extraction of fuel components (zirconium, actinides, lanthanides), the fluoride melt with the remains of fission products (alkaline and alkaline earth elements) contains an excess amount of lithium fluoride compared to the original composition.

This paper describes the fuel cycle processes for the MOSART, giving the current status of the technology and outlining the needed development. The main R&D needs for the fuel Li,Be,An/F salt clean-up, are determined: (1) the degree of the fuel salt purification from certain groups of fission products; (2) limits on actinide losses to waste; (3) safety limits on fissile materials loading into pyrochemical processing units with fuel salt; (3) regulations for the operation of taking part of the fuel salt for processing with simultaneous loading of the same amount of fuel salt purified from fission products.

Along with the development of the flowsheet for the fuel salt processing, it is necessary to begin to work out, first at the conceptual level, and then in the experimental plan, a number of additional and auxiliary operations: (1) holding a fuel salt portion sent to the purification stage from soluble fission products; (2) crystallization and sorption for the fuel salt purification from samarium, europium, caesium, strontium and barium; (3) closing the processing flowsheet for lithium.

It is concluded that the principal needs are to develop the reductive extraction operations, which have been demonstrated in the laboratory but not on an engineering scale. A program to develop continuous liquid-phase reduction reconstitution, improved noble gases and metals control, and special instrumentation should also be a major developmental effort.

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REFERENCES

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TABLE 1. FISSION PRODUCTS REMOVAL TIMES AND METODS FOR MOSART

Element	Removal time	Method
Kr, Xe	50 sec	Helium sparging
Zn, Ga, Ge, As, Se, Nb, Mo, Ru, Rh, Pd, Ag, Tc, Cd, In, Sn, Sb, Te	2,5 hrs	Deposition
Zr	1 – 3 yrs	Reductive extraction
Y, La, Ce, Pr, Nd, Pm, Gd, Tb, Dy, Ho, Er,		
Li, Be (Sr, Ba, Sm, Eu)	1 yrs	Crystallization / Sorption
Li, Be (Cs, Rb)	30 yrs	Replacement