PROPOSAL OF A MOLTEN SALT SYSTEM FOR LONG TERM ENERGY PRODUCTION

V. Berthou*, I. Slessarev, M. Salvatores.
Commisariat a l'Energie Atomique
CEN-Cadarache
13108 St-Paul-lez-Durance cedex, France.

* New address
Delft University of Technology
Interfaculty Reactor Institute
Mekelweg 15, 2629 JB Delft, The Netherlands.

Abstract

Long-term perspective of Nuclear Power is the important subject of discussion in recent times. In France, within the framework of the Bataille law, numerous studies are conducted to find a range of solution concerning the effective waste management. Respect to these problems, the innovative approach called TASSE ("Thorium based Accelerator driven System with Simplified fuel cycle for long term Energy production") is proposed.

TASSE is included in a long-term strategy, and is destined for the renewal of the reactor park. The main characteristics of TASSE are commensurate with specific requirements such as: to insure a large time-scale economically competitive nuclear energy production, to reduce the long-lived radiotoxic waste production in an important way, to eliminate waste already accumulated by the current reactor park, to ensure the enhanced safety and non proliferation.

The main idea of the TASSE concept is to simplify both the front and the back end of the fuel cycle (e.g. no fuel enrichment is foreseen and no fuel reprocessing too, or just the fission products separation). With the intention of the radical reduction the waste toxicity level, the thorium cycle has been chosen for TASSE. To reach a high burn up level, molten salt fuel has been chosen. This fuel is called "mobile fuel" because it behaves as a circulating flow, and in this way, it leads to the equilibrium nuclide content of the core.

Neutronic studies have been carried out for several types of molten salt composition. The equilibrium condition is defined by two important parameters: the spectrum and the choice of the burn up level. In this case, one can find the optimum neutron multiplication for the set of equilibrium states. It was found that the fast spectrum has the best neutronic potential for the system. It has to be noted that the fast neutron spectrum of fluoride molten salt fueled TASSE has a significant epithermal component, which is the drawback of this particular reactor fuel. On the other hand, the use of natural chloride salt fuel suffers from intensive neutron capture: there is a hope that Cl-37 based salt would have the optimum neutronic characteristics.

Four fluorides molten salts have been studied, and two of them give the best results -: $32ThF_4$-13.5NaF-54.5LiF and $30ThF_4$-24.5NaF-$45.5PbF_2$. The infinite multiplication coefficient K_{inf} reaches 0.9 for the once-through fuel cycle with a maximum burn up of 38% (% h.a.), while the K_{inf} of the closed-cycle (no enrichment, separation of fission products only) reaches 1.05 with a burn up of 12% (% h.a.).

The once-through fuel cycle, applied to molten salt fuel, allows using the fuel discharge directly for new TASSE loading. Hence, if fuel production rate coincides with the NP rate requirement, then no long-term fuel waste is foreseen. This is particularly valid when TRU+Th fuel would be used during transition to equilibrium regime when only the natural Th will feed TASSE.

For both cycles, the sub-critical regime has preference because of the essential neutronic tightness of natural Th.

Due to the low production of transuranium elements (TRU), the waste toxicity is reduced in an important way. TASSE, in open cycle, allows a gain the average factor of 20 ÷ 1000 (depending on the time scale) in comparison with PWR discharged fuel. In closed-cycle the toxicity reduction is expected to be a factor of 10^4.