Parametric studies on the fuel salt composition in thermal molten salt breeder reactors

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Abstract

In this paper the salt composition and the fuel cycle of a graphite moderated molten salt self-breeder reactor operating on the thorium cycle is investigated. A breeder molten salt reactor is always coupled to a fuel processing plant which removes the fission products and actinides from the core. The efficiency of the removal process(es) has a large influence on the breeding capacity of the reactor. The aim is to investigate the effect on the breeding ratio of several parameters such as the composition of the molten salt, moderation ratio, power density and chemical processing. Several fuel processing strategies are studied.

1. Introduction

There is a renewed interest in molten salt reactors (MSR) since the design was chosen for Generation IV. The MSR uses a molten salt fluid fuel containing actinide salts and other salts providing low melting point and good heat transfer properties. The concept of fluid fuel has numerous advantages on fuel fabrication and fuel processing and last but not least has the possibility of making changes to the composition during operation. Besides the advantages of the high temperature operation (hydrogen production, efficient electricity production) the MSR is a promising actinide burner or breeder reactor.

MSRs were extensively studied both experimentally and theoretically by ORNL in the 60’s and 70’s. The studies of Oak Ridge showed that the MSR is an attractive breeder reactor on the thorium fuel cycle. Recently many studies were carried out on the physics and chemistry of the thorium fuelled MSR. The Molten Salt Breeder Reactor (MSBR) (Robertson et al., 1970), the original design from ORNL, suffers from major drawbacks, mainly on safety and fuel processing, as the results of these investigations (MOST, 2003) show.

The ability to chemically process the fuel during operation is the most important advantage of the MSR if the goal is breeding. Without continuous removal of some Fission Products (FP) the reactor becomes subcritical quickly.

The thorium fuel cycle produces much less TRansUranium (TRU) elements than the U-Pu cycle and it can be used both in epithermal and fast mode. Since $^{232}\text{Th}$ is the only isotope present in the thorium ore, enrichment of Th is not necessary for a thorium fuelled reactor.

2. Description of the study

The aim of this study is to choose a proper salt mixture and processing scheme for a graphite-moderated self-breeder molten salt reactor. To reach