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

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Introduction

A molten salt reactor (MSR) operating on the Th fuel cycle with on-line fuel processing offers the possibility for breeding. Neutronic calculations are performed on an infinite core made of graphite with fuel channels. The results are corrected with the effects of leakage and precursor flow.

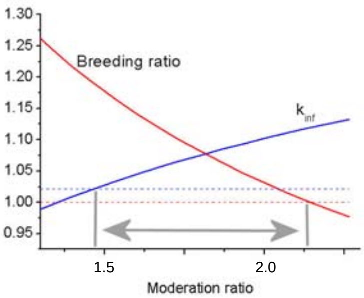

Figure 1. The breeding ratio and criticality of the salt compositions were investigated, altering the amount of the moderator. Results of FLIBE.

Fuel salt composition

The fuel salt mixture and the corresponding moderation ratio was chosen to reach a self-breeding core. The candidate salts are mixtures of ^7LiF, NaF, BeF_2, ZrF_4 and RbF, containing 12 mol% of ThF_4 and 0.3 mol% of $^{233}UF_4$. Only ^7LiF- BeF_2 (FLIBE) gives a self-breeding core. The moderation ratio 2 was chosen (see Fig.1).

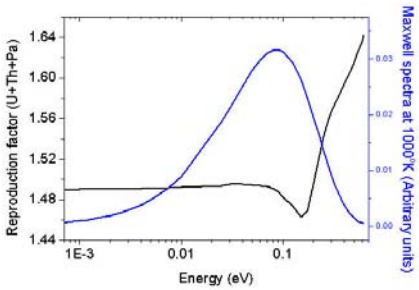

Figure 2. The increase of the reproduction factor causes the feedback of the graphite to be positive

Temperature feedback

The Doppler-broadening of the absorption cross-sections and the density changes of fissile nuclides give a net negative feedback effect in the salt. This compensates the positive feedback of the graphite. The calculated feedback coefficient of the core is -2.47 pcm/K.

Results

Two processing schemes with and without Protactinium extraction were considered:

- a fast, MSBR like
- a slow scheme with 1 or 3 year lanthanide and minor actinide extraction cycle time.

The Protactinium removal is necessary because of the 27 day half-life of ^{233}Pa, the mother nuclide of ^{233}U.

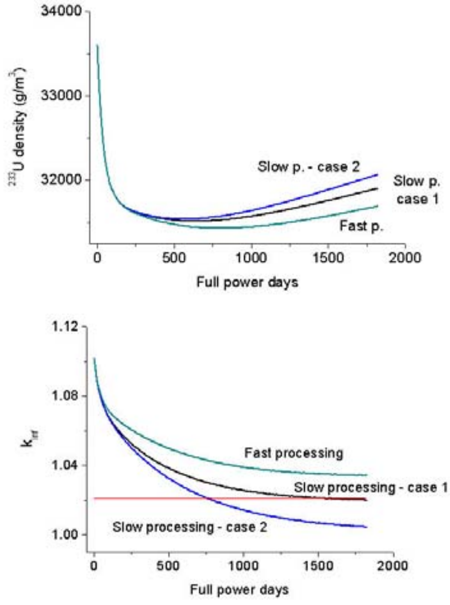

Figure 3. Comparison of processing schemes without Pa extraction

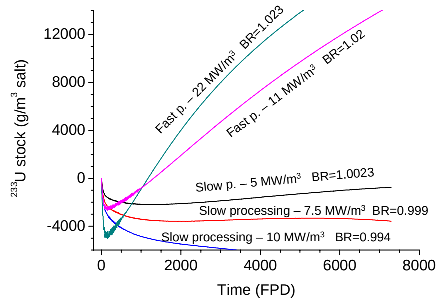

Figure 4. Effect of a change in power density with Pa extraction

Conclusions

The results show that lower power density and faster processing leads to higher breeding ratio. In the future work a better treatment of breeding ratio of such a reactor is considered.

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