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

K. Nagy, J.L. Kloosterman, D. Lathouwers and T.H.J.J. van der Hagen
Delft University of Technology, Mekelweg 15, 2629 JB, Delft, The Netherlands

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.

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, BeF₂, ZrF₄ and RbF, containing 12 mol% of ThF₄ and 0.3 mol% of ²³³UF₄. Only 7LiF-BeF₂ (FLIBE) gives a self-breeding core. The moderation ratio 2 was chosen (see Fig.1).

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 ²³³Pa, the mother nuclide of ²³³U.

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.