

Characterization of the MCFR fuel cycle options

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Category:

Molten Salt Reactors

Classes:

I. Graphite based MSRs

Families:

I. 1. Fluoride salt cooled reactors
I. 2. Graphite moderated MSRs

Types:

- Salt cooled reactor with pebble bed fuel
- Salt cooled reactor with fixed fuel
- Single-fluid Th-U breeder
- Two-fluid Th-U breeder
- Uranium converters and other concepts

II. Homogeneous MSRs

II. 3. Homogeneous fluoride fast MSRs
II. 4. Homogeneous chloride fast MSRs

- Fluoride fast Th-U breeder
- Pu containing fluoride fast reactor
- Chloride fast breeder reactor
- Chloride fast breeder + burn reactor

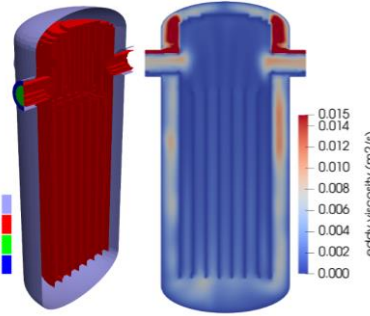
III. Heterogeneous MSRs

III. 5. Non-graphite moderated MSRs
III. 6. Heterogeneous chloride fast MSRs

- Solid moderator heterogeneous MSR
- Liquid moderator heterogeneous MSR
- Heterogeneous salt cooled fast MSR
- Heterogeneous lead cooled fast MSR

IV. Other MSRs

- Directly cooled MSRs
- Subcritical MSRs
- Hybrid moderator MSRs
- Chloride salt cooled fast reactors
- Frozen salt MSRs
- Hybrid spectrum MSRs
- Heterogeneous gas cooled MSRs



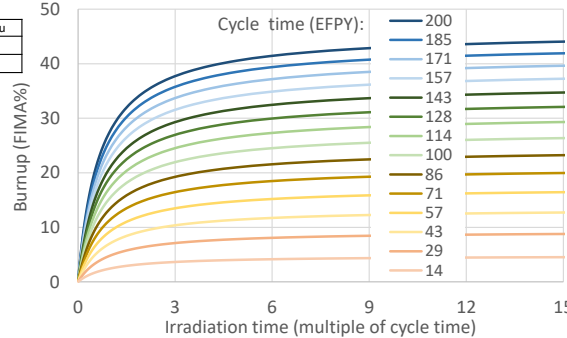
Fuel tap MCFR

Simulated reprocessing cases

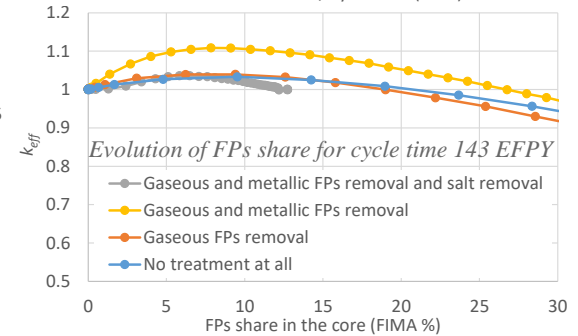
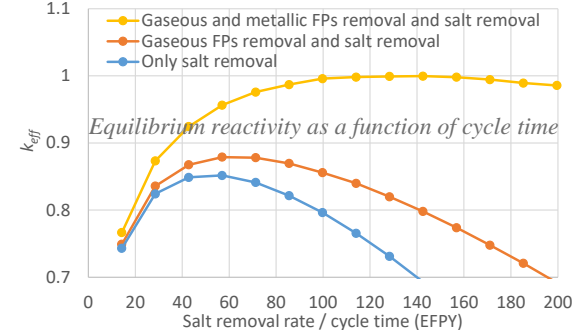
Fuel salt removal from the core (fuel tap)				Fuel salt continuous treatment in the core (FPs removal)			
Case nr.	Cycle time (Y)	Removal constant λ (1/s)	Share removed (%/Y)	Case nr.	Gaseous FPs proton nr.	Gas. FPs rem. const. λ (1/s)	Metall. FPs proton nr.
1	14.26	0.45E+09	7.01	All	1 2 7 8 10 18 36 54 86	1/30	30, 31, 32, 33, 34, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52
2	28.51	0.90E+09	3.51				
3	42.77	1.35E+09	2.34				
4	57.03	1.80E+09	1.75				
5	71.28	2.25E+09	1.40				
6	85.54	2.70E+09	1.17				
7	99.80	3.15E+09	1.00				
8	114.06	3.60E+09	0.88				
9	128.31	4.05E+09	0.78				
10	142.57	4.50E+09	0.70				
11	156.83	4.95E+09	0.64				
12	171.08	5.40E+09	0.58				
13	185.34	5.84E+09	0.54				
14	199.60	6.29E+09	0.50				

Adopted from: IAEA TRS-489, Status of Molten Salt Reactor Technology, International Atomic Energy Agency, 2021.

Neutron spectrum / Salt type	Thermal	Fast	Fuel (cycle)	Enr. U	MA	Closed Th-U	Closed U-Pu	B&B U-Pu
Fluorides	✓	✓	Fluorides	✓	✓	✓	✓	✗
Chlorides	✗	✓	Chlorides	✓	✓	✓	✓	✗



Conclusion: MCFRs are promising alternative to MSFRs, due to minimal scattering XS, they provide very hard neutron spectrum (fuel cycle performance), but they are also transparent for neutrons (bulky cores).



Volume	Composition	Chemical Formula
14m ³	Fluoride Salt Thorium Cycle	77.5LiF-22.5ThF ₄
18m ³	Fluoride Salt Uranium Cycle	77.5LiF-22.5UF ₄
19.1m ³	Chloride Salt Uranium Cycle	68NaCl-32UCl ₃
65.8m ³	Chloride salt Thorium Cycle	50NaCl-50ThCl ₄

Critical core sizes

Reflector type: ■ PbO ■ ²⁰⁸Pb ■ Lead ■ Zirconium ■ SS316

