Molten Salt Sourdough and Full core Analysis

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OUTLINE

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• Methodology for Thermal MSR
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Acknowledgments

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Molten Salt Reactor History

• Most research from MSR research at ORNL in 50s/60s
• Goal of developing of a thorium breeder reactor
• More Uranium reserves discovered since mid century

MSRs Going Forward

• Several Entities pursing MSR technology
• Large design space
• Various designs enable many different fuel cycles
  • Many do not include thorium or breeding
• Early deployment likely not include reprocessing to minimize cost
Burnup and Refueling in MSRs

• Molten salt is different from solid fuels
  • Minimal radiation damage
  • Well mixed
• Burnup no longer tied to a single fuel pin
• Refueling affect the entirety of the fuel salt
• Burnup and refueling result in volume growth
Fuel Volume Growth
Sourdough Fuel Cycle

- With no reprocessing, refueling cause volume growth
- Refueling rate vary for different refuel enrichment
- Over reactor lifetime, a significant excess can be produced depending on refuel enrichment
- Used fuel is moved to new reactor of the same design
- Excess fuel not considered waste
- Creates a quasi doubling time
Sourdough Calculations

• Infinite lattice
• $3.353 \text{ g/cm}^3 \text{ LiF-BeF}_2 - \text{UF}_4$ (72-16-12 mole%, 99.998% Li-7, 1.3% U-235)
• Thermal spectrum, LEU Uranium
• Modeled in Serpent 2
Doubling time

[Graph showing volume relative to one core vs. burnup (GWD/MTU) for different enrichment levels (3%, 5%, 7%, 10%, 15%, 20% enriched).]
Refueling Enrichment
Power Capacity

The graph shows the power capacity relative to one core over time for different enrichments: 3%, 5%, 7%, 10%, 15%, and 20% Enriched. The y-axis represents the power capacity in a logarithmic scale, ranging from $10^0$ to $10^5$, while the x-axis represents time in years, ranging from 0.0 to 20.0 years.
Thorcon-like reactor

- 5.5 m$^3$ initial fuel salt
- 3.353 g/cm$^3$ LiF-BeF$_2$ –UF4 (72-16-12 mole%, 99.998% Li-7, 1.3% U-235)
- 557 MWth
Refueling Enrichment

![Graph showing refueling enrichment vs. relative daily volume growth.](image-url)
Benefits of Sourdough Fuel Cycle

• Minimizes reprocessing
• Spreads upfront fuel cost of new reactor over previous unit's operation
• Spent fuel is contained in operating reactors
  • novel partitioning chemistry allowing economic FP reuse
  • accelerator-driven waste transmutation
  • fusion-fission hybrid reactors
Drawbacks of Sourdough Fuel Cycle

• Not a VERY long-term waste solution
• Relies on expansion of MSR fleet and steady demand
• Need for transport of radioactive fuel salt
• Excess fuel volume storage
• Modeling limitations
Conclusion and Future work

- Many positive benefits
- Possibly ease public concern over spent nuclear fuel
- Need to add volume expansion in modeling codes
- Apply methodology to specific Reactor design
- Calculate Cost and resource usage
Thank you