MSTP
Recycle and Waste

Location: Online - MS Teams
Date: 13th January 2025
Time: 1pm BST, 90minutes

Meeting Notes

Meeting slides distributed with these notes.

Introduction and Updates

Previous minutes and actions reviewed and accepted. No actions to be carried forwards.

James Amphlett informed participants that he has now started a new, molten salts, based business considering their use for recovery of valuable materials from used nuclear fuel. He looks forward to talking more about this and with others in future.

Dominic Rhodes shared that Newcleo have now entered the UK GDA process, the first AMR developer to do so.

Mike Edmondson Shared that, following a strategic review by the UK Government, NNL has been re-branded as UKNNL with a new logo. This is a statement of intent, the review highlighted the need for the laboratory to operate more closely with Government the details of this are yet to be developed but more information can be found here: Strategic review of the National Nuclear Laboratory (accessible webpage) - GOV.UK.

Activity: Chemical Recycle Discussion

Summarise separately, next section.

Forthcoming meetings

- IAEA Workshop on MSR Taxonomy (Feb/Oct)
- 2025 Molten Salt Reactor Annual US Program Review - April 22, 2025 – April 24, 2025, PNNL, US
- European Research Reactor Conference 2025,
  6 -10 April 2025, Aix-en-Provence, France
- TopFuel 2025: Nuclear Reactor Fuel Performance Conference – 5-9 October 2025, Nashville, US
- 22nd Symposium on Separation Science and Technology for Energy Applications
  Currently being planned for October 20-23, 2025

Any Other Business and Meeting Close

No other business raised.

The next full MSTP meeting will be 5th February, the next RAW-WG will be organised shortly after.

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Activity: Chemical Recycle Discussion

Previously several areas have been identified for the RAW-WG to address (see **Appendix**), seeking clarification on the state of the technology and how members of RAW-WG can work together to contribute to progress in this area. The objectives of the discussion were to understand:

- What is current status?
- What is particular to molten salt systems?
- What are the outstanding challenges?

What can this group do to accelerate?
e.g. Statement of research needs, paper/publication, supplier engagement, requirement spec, collaborative research programme)

Context

The term chemical recycle can refer to the recycle as part of fuel salt clean up during operation, as an operation between use in reactors or as a treatment process before disposal. There are a number of processes that have been proposed, several of these are highlighted on the slides presented.

The contaminants that need to be removed during recycle are dependent on which of the above operations is the objective. For example, online clean up (example of what Exodys reactor is looking to achieve) will not require the remove of all contaminants – some will be removed during processing through volatilisation (off-gas), others will be removed by plate out[1] (e.g. noble metals), many however will stay in the salt and reduction in neutron flux due to absorption by fission products will be compensated for by an increase in fissionable material. However, after a reactor cycle there might be a need to achieve a greater degree of fission product removal before the salt can be re-used in another reactor or disposed of. It is therefore important to understand what the chemical recycle is going to achieve.

[1] It may be preferential to remove plate out materials or deliberately plate them out at a preferred location to prevent build up on heat exchangers, which would reduce the efficiency of operation.

Deployment Options

The points identified during the discussion where chemical recycle might be employed were:

- **During Reactor Operation:**
  - Partial removal of fission products – to maintain operability of design or extract valuable materials)
  - Full removal of fission products – to manage neutron economy/efficiency or reduce post operation waste processing (this might not remove 100% of fission products)
- **Between Reactor Operations:**
  - Partial removal of fission products – to enable re-use in a 'daughter' reactor or extract valuable materials
  - Complete removal of fission products – to manage neutron economy/efficiency and radioactivity/dose in 'daughter' reactor or reduce post operation waste processing (this might not remove 100% of fission products)
  - Recovery of fissile (and or fertile) material – for re-use elsewhere
- **Post Reactor Operations:**
  - Partial removal of fission products – extraction of economically viable materials and accept generated waste burden
  - Complete removal of fission products – to meet sustainability / disposal goals, e.g. removal of all long-lived isotopes and/or environmentally impactful fission products and resulting impact on waste disposal options
  - Recovery of fissile (and or fertile) material for re-use elsewhere

The list above represents a list of options for the designer of the fuel cycle and will be made based on what that fuel cycle is designed to achieve – this might be driven purely by economics or might attempt to address the Energy Trilemma: sustainability, security and affordability.

Defining the Problem

There is a two-way relationship between the need to design a process (engineering) that meets design requirements and constraining the design by what is scientifically achievable (chemistry AND physics). The process design will, again, be determined by the project objectives, i.e. the energy trilemma: weight assigned to affordability, safety and sustainability. The requirement to meet each aspect of the energy trilemma is likely to be different from community to community; i.e. remote locations with access to disposal are likely to put a higher weighting on cost versus densely populated areas with few disposal options who might advocate for a 'waste led' approach. The need for (/expansion of), or presence of an existing disposal facility is likely to have a significant bearing on options pursued.

The use case will also determine the recycle requirement – online clean-up is better suited to a continuous process versus post operation treatment which would most likely require a batch operation. The underlying chemistry may be similar, but the engineering design might differ considerably. Other aspects such as gas-salt and particle-salt operation are likely to be common to both.

There is a wide spectrum of material that might be separated, each of these will have an associated value with its removal. These will vary from high economic (saleable) value species such as fissionable material and medical isotopes and high environmental impact species such as actinides with long half-lives to those that have only a modest economic, operational or environmental impact. There will be a cost associated with the separation of each of these (noting that group extraction might be acceptable in some cases) and the value to the designer will be a result of balancing value of removal against versus cost of achieving that – re-enforcing here that value and cost are not just economic measures. Specifics such as Cs137 were discussed.

"Before I came here I was confused about this subject. Having listened to your lecture I am still confused. But on a higher level."

Enrico Fermi

(c/o Prof Bruce Hanson)

How can this group add value?

There is still a perception issue when it comes to MSRs with those not directly involved perceiving them as a single technology promising all advantages but with all disadvantages. A simple description of the challenge would help articulate the differences, choices and options available. The description of the discussion recorded here provides a good starting point for this, but this might be illustrated as a schematic relating deployment options (i.e. MSR variant) to chemical (or other) recycle possibilities.

ACTION (All): Review this text as an accurate reflection of the discussion held and a summary of the situation

ACTION (MikeE): Provide a schematic describing the text for comment.

ACTION (MikeE): Provide output to Engagement WG for dissemination.

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Contributors to meeting:

(In person unless otherwise stated)

Name	Institution
1. Ed Pheil (online)	Exodys Energy
2. Aline Dressler	NAAREA
3. Dominic Rhodes	Newcleo
4. James Amphlett	Nordic Salt Cycle
5. Luke Townsend	Nuclear Waste Solutions
6. Isabelle Morlaes	Orano
7. Eduardo Cuoc	Rolls Royce SMR
8. Esben Klinkby	Seaborg Technologies
9. Alex Scrimshire	Sheffield Hallam University
10. Emma Atherton	The Environment Agency
11. Bruce Hanson	The University of Leeds
12. David Harbottle	The University of Leeds
13. Frederick Oritseweneye Pessu	The University of Leeds
14. Bruno Merk	The University of Liverpool
15. Connor Smith	UKNNL
16. Kim Goggins	UKNNL
17. Michael Edmondson	UKNNL
18. Mike Harrison	UKNNL
19. Robert Mossop	UKNNL
20. Sidrah Hussain	UKNNL

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Appendix: Theme areas

Recycle (separation and purification)
- Chemical
  - Reduction
  - Precipitation
- Pyro-processing
  - Dissolution
  - Electroreduction
  - Electrorefining
  - Reductive Extraction
- Halide Volatility
- Fluoride recovery and salt purification
- Heterogeneous – use aqueous?

Generic
- Determination of physical parameters - pumping and thermal hydraulics
- Scale up
- Wicking
- Knowledge sharing, which may be challenging with vendors

Waste (storage, treatment and products)
- MSR
  - Insoluble
  - Soluble
  - Fuel Salt
- Recycle
  - Alkali / Alkaline Earth (Pyro)
  - Rare Earth (Pyro)
  - Volatile Halides and by-products (HV)
- Both
  - Disposability - long-term waste form evolution
  - Future waste immobilisation materials / methods
  - Cross-cutting: NWS / LoC process/ Qualification / Storage
  - Off-gas
  - Decommissioning Wastes

Safeguards
- Process monitoring, (mal)operation instead of safeguards?
- Safeguards, regulation etc. is a broad overarching theme across all of MSTP