An Experimental Program to Investigate Advanced Reactor and Small Modular Reactor Technologies

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Objectives

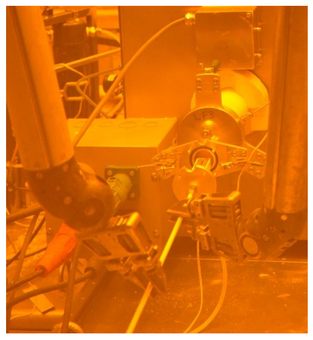
Develop capabilities and perform experiments relating to non-water-cooled SMR technologies that will support regulatory guidance and provide information for policy decision making:

- Perform experiments on fission product releases from lead coolants and molten salts
- Develop experimental capabilities to measure thermo-physical/dynamic properties of molten salt systems
- Develop atomistic modelling capabilities for the prediction of molten salt properties

Fission Product Releases Experiments

Previously:

- Performed release tests using irradiated molten salt fuel and UO_2 fuel under lead coolant



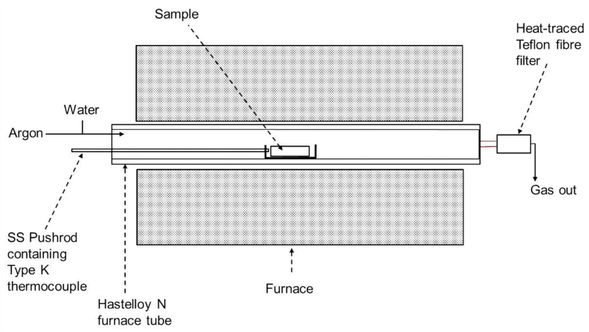


Figure: The fission product releases tests were performed in the B234 Universal Cells.

Progress in FY:

- Inter-test comparison of molten salt and lead release data

Remaining work:

- Post-test examination of molten salt and lead samples

Key outcomes:

- First-of-a-kind measurements of releases from molten salt fuels and UO_2 fuel under lead in accident conditions

Federal Stakeholders

- Natural Resources Canada (NRCan)
- Canadian Nuclear Safety Commission (CNSC)

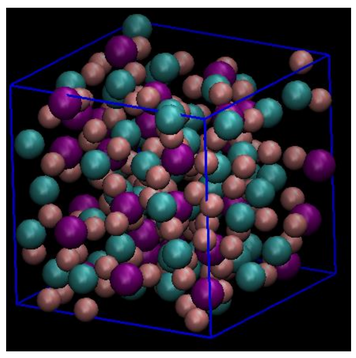
Atomistic Modelling of Molten Salts

Previously:

- Literature review to determine interatomic potentials that could be used for Molecular Dynamics (MD) simulations
- Modified CP2K code to calculate thermal conductivity, electrical conductivity, viscosity of simple fluorides/chlorides

Progress in FY:

- MD simulation of more complex salts including FLiBe, KNO_3
- Transferred model to licensed software VASP to facilitate modelling of heaver atoms (e.g. actinides)



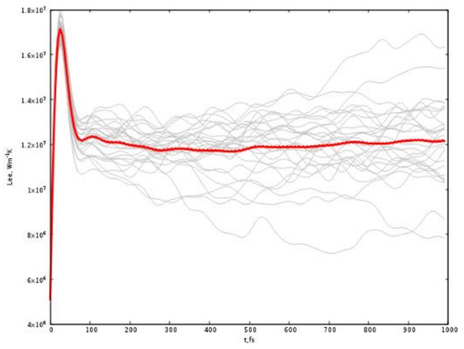


Figure left: Cell of 100 atoms of FLiBe salt used in MD simulation

Figure right: Predicted energy current autocorrelation function for LiF at 1300K

Remaining work:

- MD simulation of molten salt fuel systems (incl. actinides)
- Open-literature publication of modelling results

Key outcomes:

- Predictive capability for fundamental properties of molten salt fuels and coolants

Measurement of Thermophysical and Thermodynamic Properties of Molten Salts

Previously:

- Literature review and knowledge gap assessment
- Strategic plan for laboratory capability development
- Procurement and commissioning of "dry" glovebox ("drybox") for salt sample preparation
- Developed encapsulation protocol for Differential Scanning Calorimetry (DSC) samples in the drybox
- First benchmark measurement of KNO_3 thermal diffusivity using Laser Flash Analysis (LFA)

Progress in FY:

- Assessment of push-rod dilatometry technique for molten salt density measurement

Figure: Apparatus used to evaluate dilatometric measurements of nitrate salt density (Netzsch 402C/7)

- DSC measurements of nitrate and chloride salts using commercially available crucibles
- Finite Element Method (FEM) simulations of graphite sample holders for LFA leading to improved design

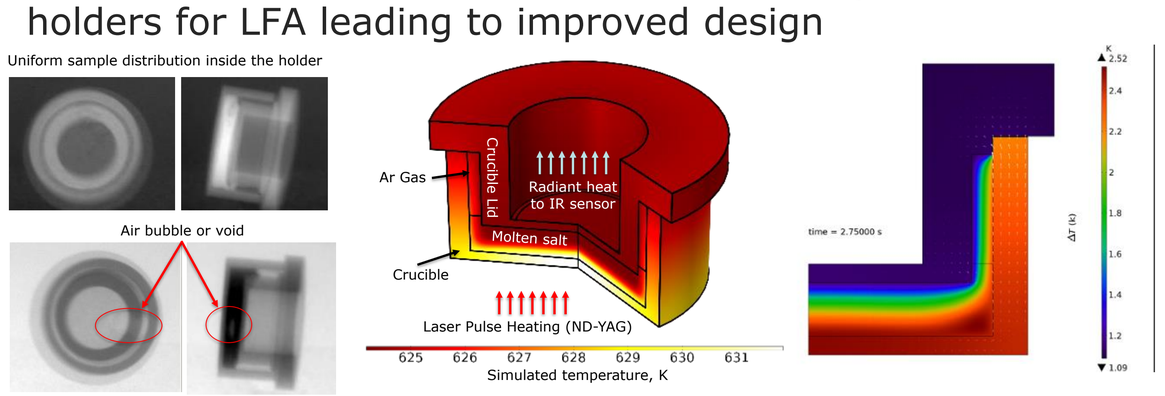


Figure: X-ray radiography of nitrate salt in graphite sample holder and FEM results

Remaining work:

- Further modification of Thermogravimetric Analyser (TGA) to enable corrosive gas (chloride) applications
- Testing commercially available DSC crucibles for compatibility with fluoride salts

Key outcomes:

- Assessment of existing laboratory capabilities and development of new capabilities for fundamental property measurements of molten salts