Advanced Fuel and Fuel Cycles S&T

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NEA, 2015 February 12
Outline

Advanced Fuel and Fuel Cycles

• Canadian Nuclear Laboratories
• Fuel S&T Drivers
• Advanced Fuel and Fuel Cycles S&T
• Summary
CNL

Four sites:
Chalk River
Whiteshell
Ottawa
Port Hope
S&T Facilities

Fuel Fabrication  Thermalhydraulics  Surface Science  Hot Cells

NRU  BRF  ZED-2
Fuel S&T

nuclear fuel S&T, including fuel cycles, fabrication, testing, and post irradiation examination
Advanced Fuel and Fuel Cycles

Advanced Fuel and Fuel Cycles are aimed at sustainability for both, power reactors and research reactors.

Power reactors: Gen III and Gen IV, small reactors.

Reference fuel for SCWR: Thoria/13% Plutonia.
Sustainability

• Expand limits of resources
  • Reduce, reuse, recycle
  • Alternative fuels cycles (thoria)
• Increase safety and reliability
• Decrease environmental impact
  • Reduce waste
  • Manage spent fuel cycle
• Develop proliferation-resistant fuel and fuel cycles
Areas of Interest
Advanced Nuclear Fuel and Fuel Cycles

Core optimization

(LEU or RgPu)ThO$_2$

ThO$_2$

• “seed” and “blanket” fuel bundles can be used to breed U-233
• concepts yield fissile utilization competitive with natural uranium
• cores can be optimized for either power or U-233 production
• all concepts can be implemented in the same, conventional HWR core

Fuel Fabrication

Metallic fuel

Proliferation resistant, Recyclable fuel
For Research Reactors
Fuel Fabrication

Ceramic fuel
Fuel Fabrication

Development of joining techniques
High precision machining
Welding and brazing

Weld Controller

Load Sensor

Electrode

Sample in holder

High frequency welding
Fuel Characterization

X-Ray photoelectron spectroscopy analysis of fuel sheath from experimental fuel
EBSD

Pole figure Region 1

Direction of Tensile Stress

Twin boundary and possible blunted transgranular crack at the twin boundaries

EBSD band contrast map

- UNRESTRICTED -14-
Glove box facilities

Actinides
Fuel Cycles

Current global cycle, LWRs + HWRs

Transition to once-through thorium in CANDU

Transition to fast reactors

Transition to Th with U-233 recycle in CANDU

Thorium with U-233 gives a 75% reduction over the current cycle
Fuel Cycles

- Cumulative Uore Consumed [kt]
  - NU
  - NU $\rightarrow$ LEU+Th
  - NU $\rightarrow$ U-233+LEU+Th

- Long-term Decay Power [GW]
  - NU
  - NU $\rightarrow$ LEU+Th
  - NU $\rightarrow$ U-233+LEU+Th
Testing and Post Irradiation Examination

Fuel testing
Evaluation of fuel performance
Failure investigations
Testing and Post Irradiation Examination

- PWR fuel with 670 MWh/kgU
- 0.8 wt.% U-235 in U; 0.9 wt.% Pu in HE
- Tested to additional burnup of 517 MWh/kgHE (NRU)
Comparison of fuel temperatures versus power rating for ICAF and solid rod fuel
Advanced Fuel and Fuel Cycles

What is next

Support Candu
Thoria Roadmap
Small Reactors
Summary

Advanced Fuel and Fuel Cycles

CNL
Fuel S&T driver: sustainability
Areas of interest

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