Overview of Separation Technologies in the AFCI

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1. Introduction

The AFCI program of US DOE is developing fuel systems for current and future generation nuclear reactors. It can reduce high-level waste volume, increase the capacity of geologic repositories, and reclaim the valuable energy in spent fuel. This overview from the documents of US DOE and ANL homepages shows the prospects and state of the arts for the separation technologies in the AFCI.

2. Separations

2.1. Advanced aqueous processing

Phase 1 Separations. The Phase 1 strategy is based on spent fuel processing for waste management purposes.

Phase 2 Separations. This phase adds the extraction of plutonium for recycle to thermal reactors.

Phase 3 Separations. Minor actinides are recovered for burning in fast spectrum reactor systems.

2.2. Pyrochemical processing

The fuel systems for Gen IV reactors represent a significant departure from the commercial LWR oxide fuel. Many of the fuel types that are foreseen for these reactors are intuitively not compatible with aqueous processing, and include coated-particle fuels, inert matrix fuels, metal alloy fuels, mixed nitride fuels, and carbide fuels.

3. Program progress

FY2003 accomplished the hot laboratory-scale demonstration of complete UREX+ separations process. FY2004 completed the laboratory-scale hot demonstration of the optimized UREX+ process. The plans for FY2005-07 are the selection of reference flow sheet for LWR spent fuel processing.

4. Pyrochemical processing R&D

4.1. Unit process modeling

Modeling works include the treating process steps, performing analytical studies of electrorefining, supporting the design optimization of electrorefining, creating and maintaining electronic databases, and performing statistical analysis of the spent fuel treatment process.

4.2. Mass tracking system software

It is used at the ANL-W Fuel Conditioning Facility to maintain a real-time accounting of the inventory of containers and their contents.

4.3. Waste form performance modeling

It includes the modeling and assessment of the metal and ceramic waste forms generated during electrometallurgical treatment of spent nuclear fuel.

4.4. Facility safety assessment

The cathode processor is an important piece of FCF equipment for safety analysis.

4.5. The cathode processor

The prototype cathode processor is a facility that provides a high-temperature vacuum furnace for research in processing spent reactor fuel.

4.6. High capacity reduction cells

The high-capacity reduction cells were designed to have a 1-kg UO_2 capacity.

4.7. Anode material studies

For the electrolytic reduction process, Strontium-ruthenium oxide has been identified as an inert anode conductive phase.

4.8. Structural materials to enable electrolytic reduction of spent oxide nuclear fuel in a molten salt electrolyte

The corrosion scale has areas of breakage and separation from the specimen and may be a consequence of the thickness of the surface scale, motion of the molten salt, and thermal expansion coefficient mismatch.

4.9. Planar electrode electrorefiner

The throughput is directly proportional to cell current and electrode area. At 100% efficiency ANL has demonstrated an electrorefining rate of 1.75 $kg/hr/m^2$ of anode basket area.

4.10. Process and equipment integration

General process flowsheets and most of the viability demonstrations have been completed. The individual operations must be integrated to provide an economical overall process.

5. Summary

This overview shows the prospects and state of the arts for separation technologies in the AFCI. The advanced aqueous processing completed the laboratory-scale hot demonstration using spent nuclear fuel. For development of pyroprocessing technology, ANL is performing the engineering works for scale-up of process equipment.

REFERENCES

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