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FOR THE DEPARTMENT OF ENERGY

Deep Burn Team



Coated Particle and Deep Burn Fuels

Monthly Highlights

December 2010



TRISO-Coated Particle with Mixed Pu, Th Oxide
Kernel after High Pu Burnup

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Coated Particle and Deep Burn Fuels

Monthly Highlights for December 2010

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Acronyms and Abbreviations

CP	Coated Particle
DB	Deep Burn
DOE	Department of Energy
DSC	Differential Scanning Calorimetry
FCM	Fully Ceramic Matrix
FCPICS	Tracking program for project
FRAPCON	Computer code for calculating the behavior of fuel rods
HTR	High Temperature helium-cooled Reactor
INL	Idaho National Laboratory
KLMC	Kinetic Lattice Monte Carlo computer code
Logos	Logos Nuclear Systems
LWR	Light Water Reactor
ORNL	Oak Ridge National Laboratory
REDC	Radiochemical Engineering Development Center (ORNL)
RSS	Research Safety Summary
SEM	Scanning Electron Microscope
TGA	ThermoGravimetric Analysis
TRISO	tri-structural isotropic
TRU	transuranic elements
UTK	University of Tennessee, Knoxville

1. Project Management and Planning

Program reporting (*ORNL*)

During FY 2011 the CP & DB Program will report Highlights on a monthly basis, but will no longer produce Quarterly Progress Reports. Technical details that were previously included in the quarterly reports will be included in the appropriate Milestone Reports that are submitted to FCRD Program Management. These reports will also be uploaded to the Deep Burn website www.ms.ornl.gov/deep_burn/index.shtml

The Monthly Highlights report for November 2010, ORNL/TM-2010/323, was distributed to program participants on December 9, 2010. The final Quarterly for FY 2010, Deep Burn Program Quarterly Report for July – September 2010, ORNL/TM-2010/301, was announced to program participants and posted to the website on December 28, 2010.

Archiving program records (*ORNL*)

Program participants are requested to send reports, milestone documents and other pertinent documents to the webmaster, Shirley Shugart, shugartsa@ornl.gov, for uploading to the website.

2. Thermochemical Data and Model Development

2.1 Thermochemical Modeling

Thermochemical behavior of fluorite phase (*ORNL*)

Data was gathered on the U-La-O system in order to model the fluorite solid solution. This is problematic as the extant compound energy formalism forces the transition from low to high oxygen potentials to O/M values less than 2, which is not observed. Shifting the valence of La in the model appears to solve that problem, and efforts to fit data to the model continue.

2.2 Core Design Optimization in the HTR Pebble Bed Design (*INL*)

Pd interactions with SiC (*ORNL*)

First principle calculations for intrinsic, Si, and C defects in Pd are nearly completed. The results of these calculations will be used as input in a Monte Carlo simulation. The Monte Carlo code is being developed.

Ag transport in TRISO fuel (*UTK*)

A manuscript describing Kinetic Lattice Monte Carlo modeling of Ag transport through TRISO fuel particles was accepted for publication in the Journal of Nuclear Materials.

2.3 Radiation Damage and Properties

Thermal conductivity of SiC (*ORNL*)

The results for thermal conductivity in perfect SiC obtained by equilibrium Green-Kubo and non-equilibrium methods were obtained. The linear dependence of inverse thermal conductivity (thermal resistivity) on the inverse sample lengths was verified for four sets of lengths (3000, 1500, 750 and 350 lattice parameters). The calculation of the thermal conductivity of SiC with grain boundaries has started.

3. TRISO Development

3.1 TRU Kernel Development

Glovebox installation at the REDC (ORNL)

Several items must be completed on the new TRU Kernel Fabrication System in Lab 109 at the ORNL Radiochemical Engineering Development Center (REDC) before the Readiness Assessment can be performed. During December, the welding tests on the new glove boxes were completed. One weld failure was identified in the upper corner of the furnace repair box and work to secure authorization to repair the weld in place is underway. The design of the new off gas manifold was completed and distributed for approval as required prior to fabrication. An electrical review of equipment associated with the kernel development was initiated; any electrical issues that are identified should be addressed in January. Installation of a new glove port on the sol-gel glove box was completed and fabrication of new feedthroughs for the optical inspection microscope in the characterization glove box is underway.

New HEPA filters for the glove box line were ordered owing to an unexpected revision to the compliance requirements. The emergency order for these filters with delivery scheduled for Jan. 24, 2011 has inserted an 18 working day delay in the schedule to secure operational approval, delaying the date for operational approval of the kernel fabrication line to March 21. Milestone M31AF080204, "Report on Operational Approval to fabricate transuranic-bearing kernels in Bldg. 7920," due Feb. 23, 2011, will have to be rescheduled in FCPICS. This milestone is a prerequisite for meeting M21AF080202, "Demonstrate fabrication of transuranic kernels of Pu-239/3.5at% Np-237 using newly installed glove box facilities in ORNL 7930 Hot Cell Complex," due April 25. The need for a Baseline Change Proposal to reschedule this milestone is being evaluated.

Work control documentation for kernel production (ORNL)

Preparation of work control documentation for the TRU kernel fabrication task continued this month. Approvals are required for the five steps used to produce sintered kernels: 1) prepare the TRU solutions, 2) form TRU microspheres using the internal gelation system, 3) wash the TRU microspheres, 4) qualify the microspheres (diameter and sphericity), and 5) calcine and sinter the microspheres. Review of the Research Safety Summary (RSS) and the corresponding procedure was completed for steps 1, 2 & 3 and approval is expected in early January. Preparation of the RSSs and procedures for steps 4 & 5 is nearly complete.

Uranium additions to TRU microspheres (ORNL)

The potential to add a significant fraction of uranium to the TRU microspheres has been discussed several times. A different project has installed an internal gelation system in a newly renovated laboratory in ORNL Building 4501. This system could be used to conduct preliminary tests with uranium and TRU simulants.

3.2 Coating Development

TRISO coating system (ORNL)

The fabrication of components for the new coating furnace is ongoing. The design of the custom coating glove box is complete and a capital funds account for the procurement of the glove box is being set up. The purchase requisition will be submitted as soon as the capital funds are released. The design, component procurement, and Safety Basis Supplement preparation work related to the Deep Burn TRU Coating Laboratory in ORNL Building 3525 has been placed on hold pending approval of the FY11 budget.

4. LWR Fully Ceramic Fuel

4.1 FCM Fabrication Development

FCM fabrication process optimization (ORNL)

Draft technical plans for the optimization of processing technology for SiC matrix fuel were discussed and developed. The plan includes the test matrix for the parametric study of the effect of the processing conditions such as raw material selection and sintering temperature on the microstructures and mechanical properties of the sintered silicon carbide matrices.

FCM fabrication development (ORNL)

Two FCM pellets with surrogate (zirconia kernel) TRISO particles were hot-pressed. The hot-pressing method and conditions were altered in each case and improvements were made during the second attempt. Through the use of SiC nano-powder and oxide sintering aids a dense matrix was achieved. Optimization of the hot-pressing technique will continue during the upcoming months to achieve uniform and defect-free pellets with high TRISO particle fraction.

4.2 FCM Irradiation Testing (ORNL)

Design work for the HFIR irradiation of surrogate FCM fuel is continuing.

5. Fuel Performance and Analytical Analysis

5.1 Fuel Performance Modeling (ORNL)

The incorporation of SiC and graphite matrix physical property models into FRAPCON-3 was finished and preliminary analyses were performed. This effort was documented in a letter report submitted to DOE – this fulfilled L3 milestone number M41AF080302 (WP No. FTORAF0803, Rev 0)

Appendix I

Coated Particle and Deep Burn Fuels Program - ORNL FY2011

Milestone Status December 31, 2010

Item No.	Milestone number and description	Level	Due Date	% Complete
1	M31AF080104 - Report on Completed Design and Procurement of Simultaneous Thermal Analyzer.	M3	2/5/2011	80
2	M31AF080105 - Model physical properties of TRISO fuel and fuel matrix to high dose.	M3	7/20/2011	13
3	M31AF080106 - Issue report on thermochemistry and fission product transport and attack of high-burnup fuel including experimental verification path-forward.	M3	9/23/2011	**
4	M31AF080102 - Simultaneous thermal analyzer is to be installed in a glove box to be used for identification and characterization of evolving fuel chemistry.	M2	9/23/2011	15
5	M31AF080103 - Submit report summarizing progress and path forward on thermochemistry of high-burnup fuel including experimental path-forward.	M2	9/30/2011	15
6	M31AF080204 - Report on Operational Approval to fabricate transuranic-bearing kernels in Bldg. 7920.	M3	2/23/2011	50
7	M21AF080202 - Demonstrate fabrication of Transuranic kernels of Plutonium-239/3.5at% Neptunium-237 using newly installed glove box facilities in ORNL 7930 Hot Cell Complex.	M2	4/25/2011	30
8	M21AF080203 - Complete fabrication and assembly of new coating furnace and issue letter report summarizing status of planned glovebox coating facility. Document work to date on installation of in-cell TRU-coating facility. Develop plan for continuation of in-cell installation of coating equipment in 2012.	M2	6/30/2011	20
9	M31AF080205 - Issue report documenting initial PIE of fuel compacts from the FTE-13 irradiation experiment focusing on Deep Burn relevant aspects of fuel.	M3	12/31/2011	25
10	M41AF080302 - Incorporate SiC and graphite matrix physical properties models into FRAPCON and perform preliminary analysis.	M3	12/17/2010	Completed
11	M31AF080303 - Issue report documenting the results of FRAPCON calculations comparing the fuel-clad physical interaction of SiC and graphite matrix options for fully ceramic matrix fuel form.	M3	2/25/2011	20
12	M31AF080307 - Report on final design of rabbit irradiation vehicle for fueled and surrogate FCM fuel.	M3	3/17/2011	10
13	M31AF080306 - Issue report on FCM optimization with surrogate TRISO.	M3	8/12/2011	10
14	M31AF080305 - Issue report documenting work performed to expand parameters beyond initial point design economic analysis of the Deep Burn fuel system to understand critical drivers which may impact fuel design.	M3	11/25/2011	0
15	M2N11OR130202 - 7.2.7 Procure glove boxes for TRU-TRISO coating	M2	3/31/2011	70

** status not reported

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