Overview of the Status of NGNP with a Focus on Materials R&D

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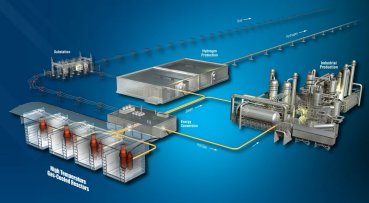
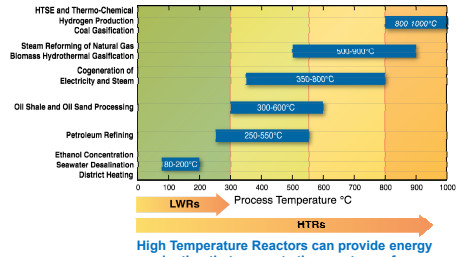
March, 2011

www.inl.gov

Idaho National Laboratory



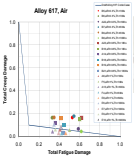
Beyond Electricity – Applications of HTGRs

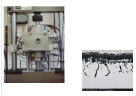


High Temperature Reactors can provide energy production that supports the spectrum of industrial applications including the petrochemical and petroleum industries

Next Generation Nuclear Plant

NGNP Technology Development and Qualification Needs

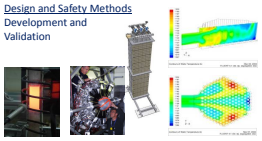




High Temperature Materials Characterization, Testing and Codification

Fuel Fabrication, Irradiation, and Safety Testing

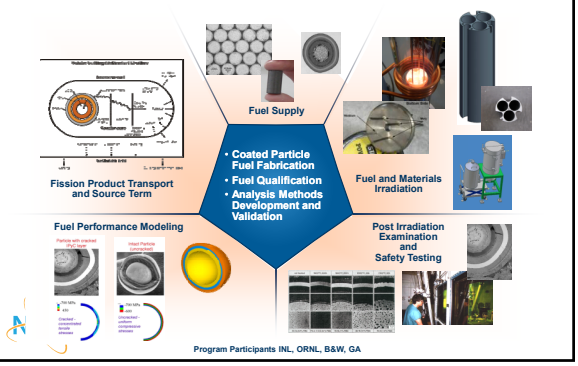
Graphite Characterization, Irradiation Testing, Modeling and Codification



Design and Safety Methods Development and Validation

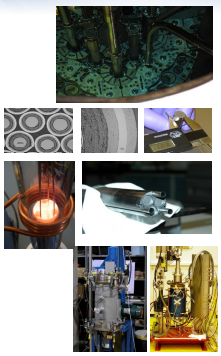
Next Generation Nuclear Plant

NGNP/AGR Fuel Program Elements

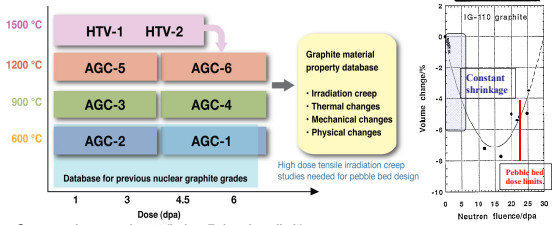


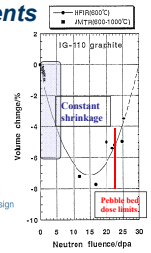
TRISO Fuel Accomplishments

- Completed most successful U.S. irradiation of TRISO-coated particle fuel (AGR-1). 300,000 particles tested to peak burnup of 19.4% FIMA and peak temperatures less than 1250°C under prototypical HTGR conditions with no failures
- Completed fabrication of AGR-2 fuel produced by industrial teams (B&W, PBMR and CEA/CERCA) at defect levels approaching those required for the NGNP
- Irradiation of AGR-2 is underway
- PIE of AGR-1 is underway. Safety testing is anticipated to start before the end of the calendar year
- Design of AGR-3/4 is underway



Advanced Graphite Creep Experiments

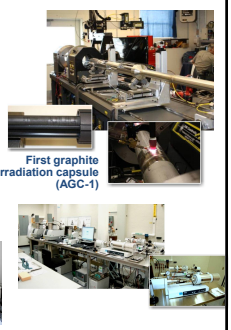




- Compression experiment (below 7 dpa dose limit)
  - Creep rate as a function of temperature (600, 900, 1200°C)
  - Must not achieve turnaround – otherwise not constant
- Investigating effects of fabrication on performance
  - Grain size, coke sources, fabrication method
  - Four types of graphite – each from a major graphite supplier

Graphite Accomplishments

- Established analytical measurement laboratories at INL and ORNL to perform extensive material characterization of graphite. INL lab is being upgraded to handle irradiated graphite
- Characterized over 800 graphite samples for AGC-1 and AGR-2 irradiation
- Detailed characterization of a graphite billet from one vendor is nearing completion and a second billet from a different vendor is underway
- Irradiation of AGC-1, first of six large graphite creep capsules for NGNP complete
- Fabrication and assembly of AGC-2 the second capsule is underway and irradiation will begin in early 2011



First graphite irradiation capsule (AGC-1)

Graphite Characterization Labs at INL and ORNL

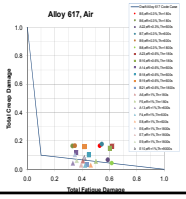
Impact of Outlet Temperature on Materials Issues

700 to 750°C	750 to 800°C	800 to 950°C
• Conventional pressure vessel steel with cooling (<371°C)	• Conventional pressure vessel steel with additional cooling (<371°C)	• Potential for Grade 91 pressure vessel up to 425°C
• Alloy 800H ASME Code qualified	• Alloy 800H Code Case extended	• Alloy 617 Code qualification
• Steam-side corrosion	• Steam-side corrosion	• Creep-fatigue damage
• Stress-assisted grain boundary oxidation	• Dissimilar welded joints	• Corrosion limited by Cr_2O_3 stability
	• Accelerated oxidation or carburization	

High Temperature Materials Accomplishments

- Completed initial material screening tests to determine acceptability of candidate alloys for large metallic components in NGNP
  - Alloys 617 and 800H for heat transfer systems and A508/533 pressure vessel
- Established test loop to measure impact of impurities on IHX alloys and extended models for predicting He impurity interaction with IHX alloys up to 1000°C
- Measuring elevated temperature alloy properties
  - Established test protocols for high temperature experiments
  - Investigating impact of NGNP helium environment on Alloy 617 creep-fatigue behavior
  - Working to modify ASME Code Rules for creep-fatigue interaction
  - Characterizing impact of fatigue damage on subsequent properties of A508/533 pressure vessel steel

High Temperature Mechanical and Environmental Testing of Key Alloys



ASME Code Rules

Summary

- High temperature gas-cooled reactors can enable nuclear energy to enter the process heat market helping to reduce the large carbon footprint in that sector
- NGNP is a demonstration plant to demonstrate the feasibility of delivering process heat, electricity and hydrogen for potential end users
- Data needed for qualification and licensing take a long time to develop given the need for specialized facilities (nuclear test reactors, hot cells, specialized high temperature/high pressure testing facilities)
- We are focused in the near term on continuing qualification activities in fuel, graphite, high temperature materials and methods to reduce risks and develop data needed for design and licensing
- Going forward, R&D will continue its engagement with private sector partners and NRC by sharing technical information and planning