



DOE Microreactor Program

Technology Maturation Overview

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Technology Maturation Overview

- **Goal:** to advance the technology and manufacturing readiness of tools and materials that enable microreactor designs by performing research and demonstrating results.
- Meets the following program objectives:

Satisfy R&D needs of existing developers that require national lab expertise and capabilities.
Heat pipe and high temperature moderator.

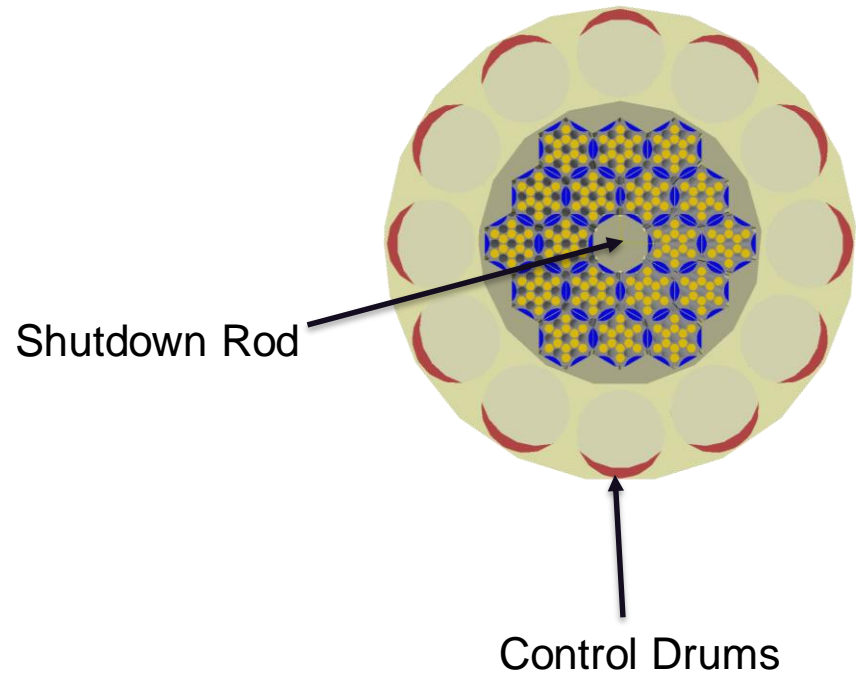
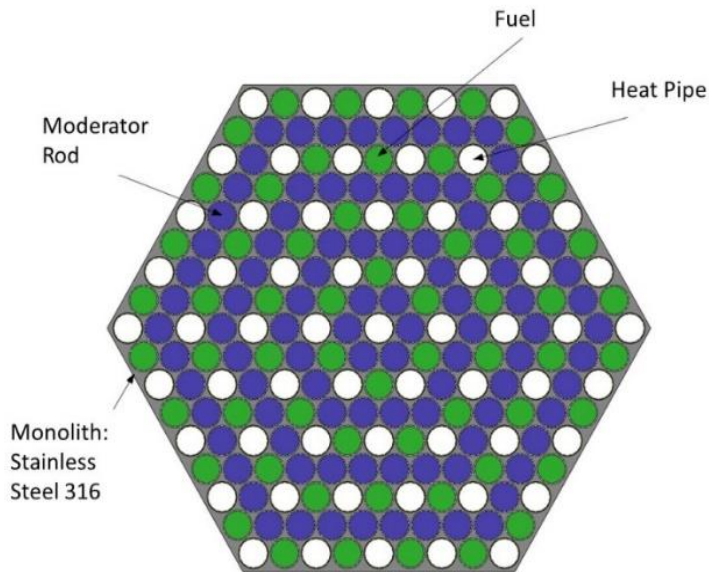
Develop advanced technologies for next-generation systems.
Design and testing of advanced manufacturing, heat exchangers, and sensors.

Demonstrate an assembly process to enable factory manufacturing
Fabrication of microreactor materials on a modular scale.

Enable future microreactor applications.
Successful operation/development of technology.

Technology Needed For Microreactors

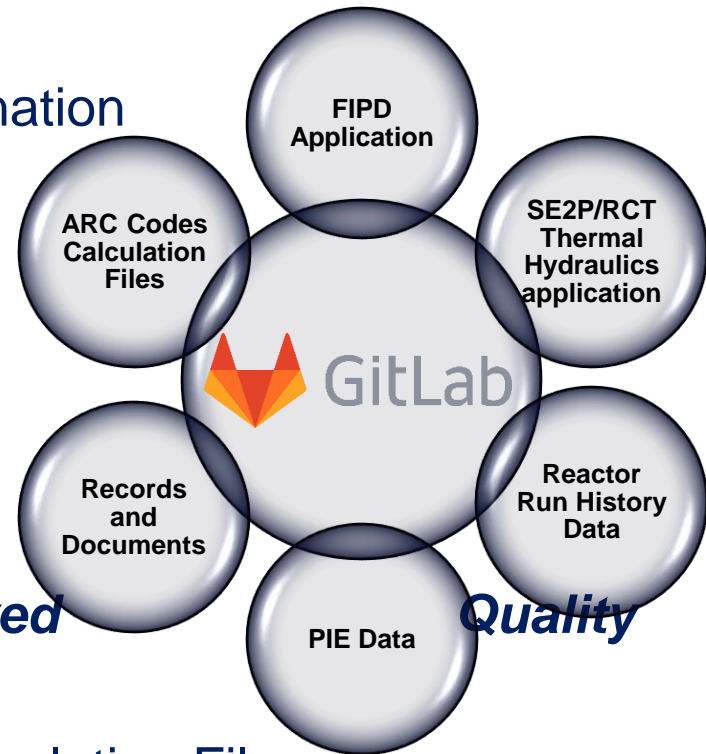
- Microreactors comprise the following materials:
 1. Fuel (e.g. Legacy Metallic)
 2. High Temperature Moderator Material
 3. Heat Transfer/Power Conversion
 4. Structural Material
 5. Reflector/Control Materials
 6. Instrumentation and Sensors



Metallic Fuel Data Qualification

Data Management: GitLab Repository

- Goal: Obtain and Qualify Post Irradiation Examination Data from EBR-II
 - Contact Profilometry
 - Laser Profilometry
 - Neutron Radiography (NRAD)
 - Isotopic Gamma Scan
 - Fission Gas Release (FGR)



- ***Procedure implemented with the NRC-approved Assurance Program Plan (QAPP)***

- Argonne Reactor Computation (ARC) Codes Calculation Files

- REBUS Data
- RCT & SE2P Data
- EBR-II Records

Slide Courtesy of
Latif Yacout

QAPP approved
by NRC

Specifications

QA document for each
dataset

- ***NRC inspection of the QAPP and its implementation occurs in near future.***

High Temperature Moderator - Yttrium Hydride Measurements

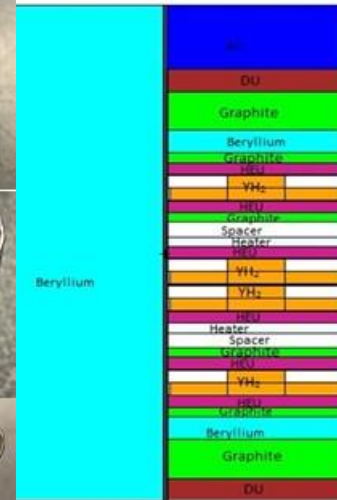
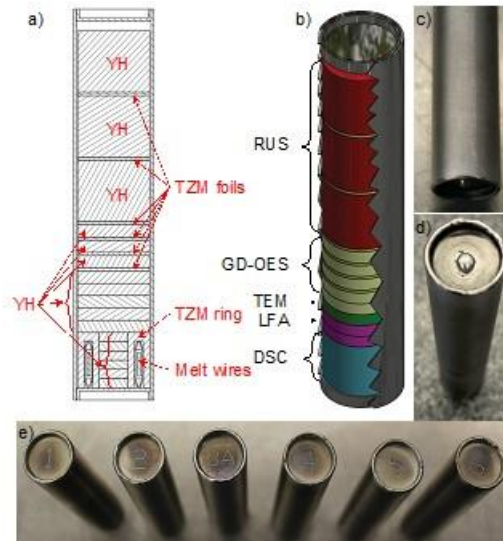
Integral Critical Experiment - Hypatia

- Yttrium hydride offers ability to reduce fuel mass while retaining hydrogen up to ~800 C.
- Critical Experiment: Jan 11-21, 2021
- Contained HEU, $\text{YH}_{1.8-1.9}$ canned in 6" Mo disks with 2" $\text{YH}_{1.8-1.9}$ samples, Be, and graphite.

Advanced Test Reactor Irradiation

- Direct hydride and powder metallurgy fabrication method comparison.
- 600, 700, and 800°C
- Post irradiation examination measurements upcoming.
- 2×10^{21} n/cm² fluence.

Pictures Courtesy of Theresa Cutler, Travis Grove, Erik Luther, and Chase Taylor

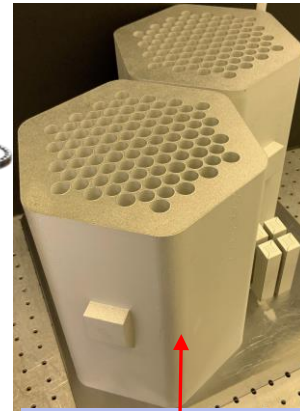


Heat pipe test articles are being manufactured for non-nuclear demonstrations.

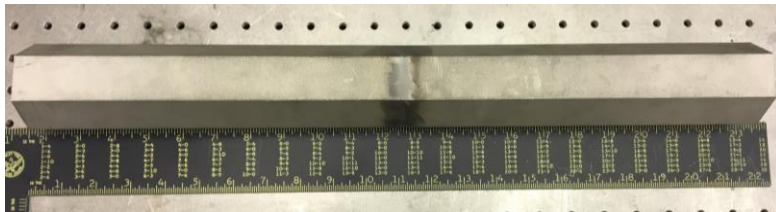
- 7-hole article with a single heat pipe
- 37 heat pipe article - fuel rods will be simulated with cartridge heaters
- Goals:
 - Demonstrate use of additive manufacturing (AM) for fabrication of test articles.
 - Demonstrate joining techniques for individual pieces.



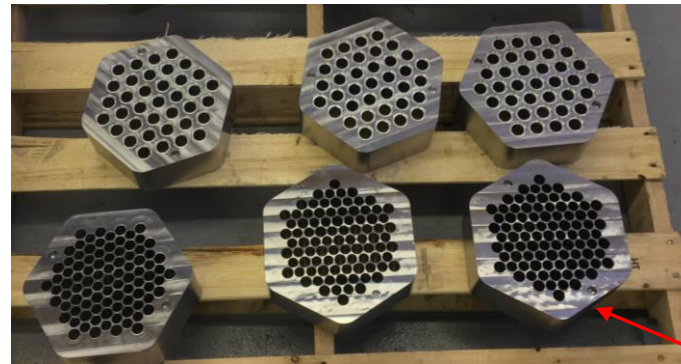
Heat pipes/wicks on order



Sample parts were built with AM but did not meet adequate tolerances, so traditional manufacturing explored instead.

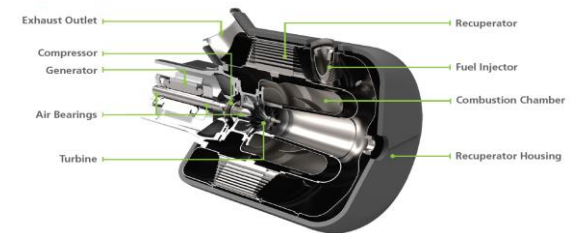
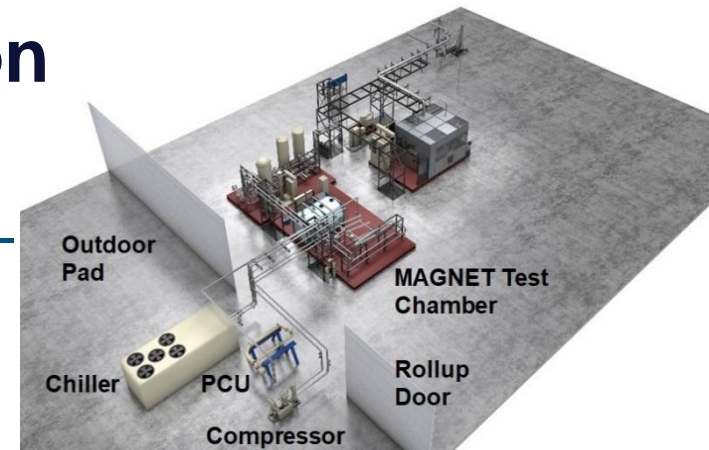


Pictures Courtesy of Colt Montgomery, Michael Brand, John Carpenter, and Amber Black

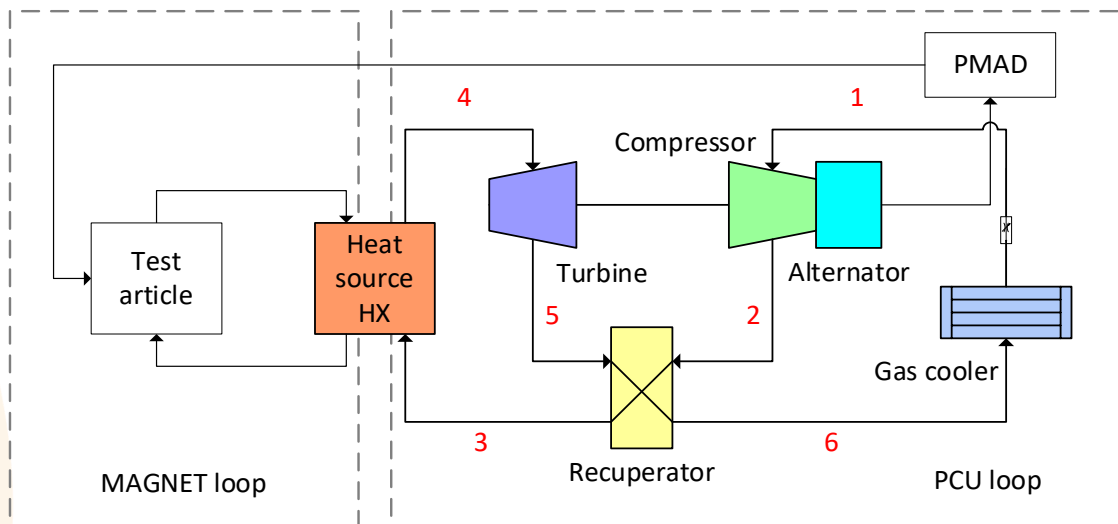


Microreactor Power Conversion Integration and Testing

- Integration of a modified Capstone C30 turbine-alternator-compressor unit into MAGNET
 - Will provide researchers with the ability to evaluate the test article heat transfer under representative operating conditions with the transient system behavior associated with a closed Brayton cycle PCU
 - Eng'g design for installation underway

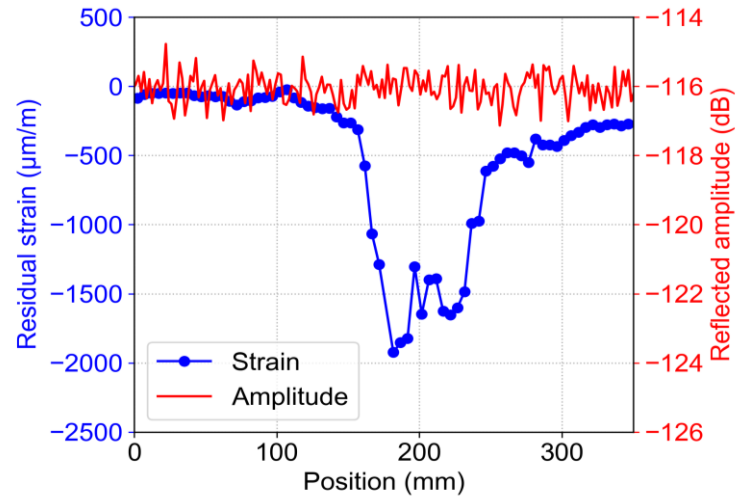
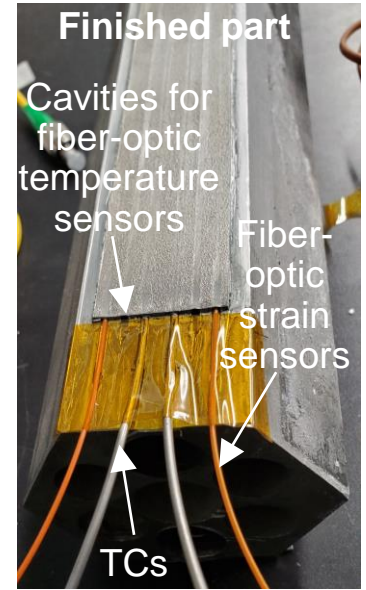
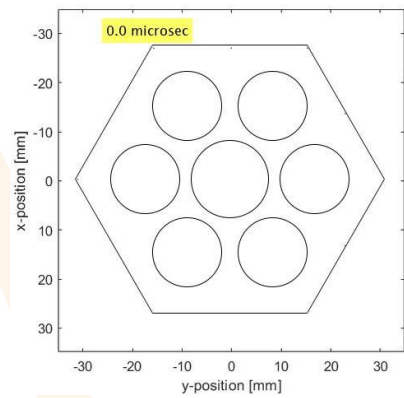
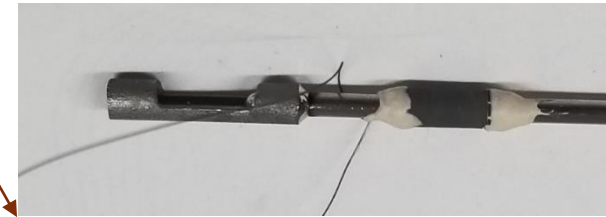
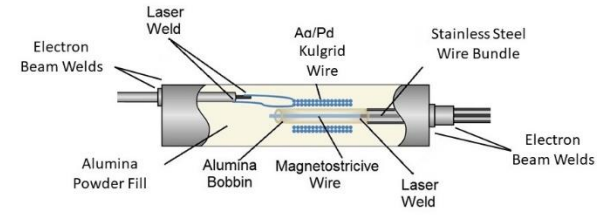
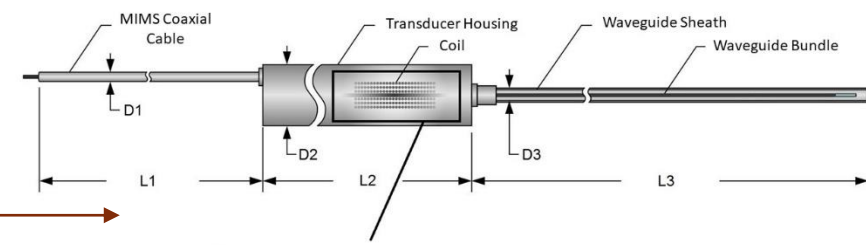


Pictures Courtesy of Donna Guillen and TJ Morton, INL



Instrumentation and Sensors

- Distributed Ultrasonic Thermocouple
- Embedded sensors for strain measurements
- Higher temperature measurements can be obtained with a fiber Bragg grating optical fiber
- Digital Image Correlation (DIC) for structural integrity



Pictures Courtesy of David Mascarenas, LANL, Chris Petrie, ORNL, and Troy Unruh, INL

Residual strain and signal amplitude after fiber embedding



Conclusions

- Technology Maturation research aims to advance areas such as yttrium hydride qualification, heat pipe knowledge, instrumentation and sensors, and metallic fuels/structural material.
- Solid structural material is being enhanced and code cases completed for Grade 91 stainless steel.
- Successful experiments with yttrium hydride recently performed.
- Seeking input on future needs and desires for technology.

Acknowledgements

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MRP Microreactor
Program