U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

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DOE Microreactor Program

Instrumentation, Sensors and Controls for MAGNET

Technology Maturation Panel

GAIN-EPRI-NEI Microreactor Program Workshop

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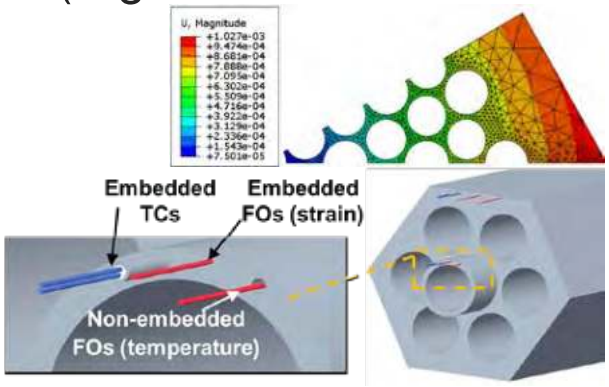
Background – Instrumentation, Sensor and Controls

- **Scope overview** – Instrumentation is a unique challenge in that technology must be placed in advance to "see" what happens inside a microreactor throughout its life with little or no access.

  Focus areas include:

  1. Nuclear Energy Enabling Technologies Advanced Sensors and Instrumentation (NEET ASI) program leveraged for demonstration of ASI-developed instrumentation in MAGNET (e.g. sensors for nonnuclear tests)
  2. Sensors for structural health monitoring
  3. Embedding sensors for performance
  4. Autonomous sensing and control



- **Alignment with program objectives**
  - The research supports development of advanced technologies and concepts for next-generation microreactor applications and systems
  - Research and deployment of infrastructure to support demonstration

Instrumentation for microreactor components - Initial focus on heatpipes

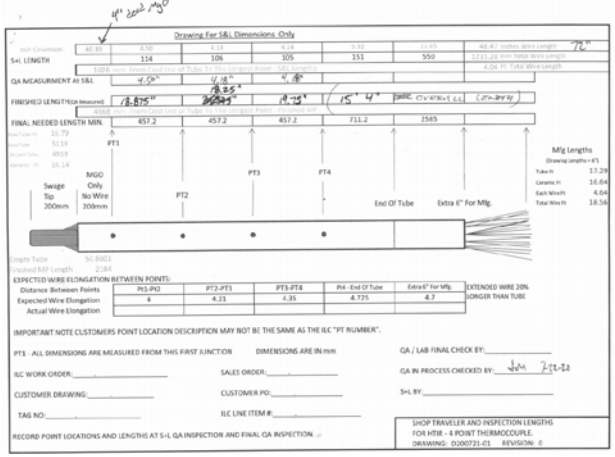
Contact: Troy Unruh, troy.unruh@inl.gov

- **Received and scanned heat pipes from ACT (commercial) and LANL**

Instrumented ACT heatpipe with thermowell (left)

Instrumented LANL heat pipe(right)

- **Distributed temperature sensor procurement and deployment (Thermocouple, Fiber, Ultrasonic)**



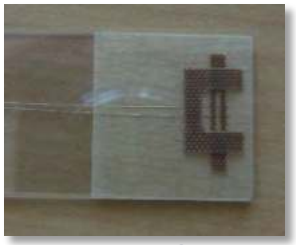
Distributed thermocouple drawing (left)

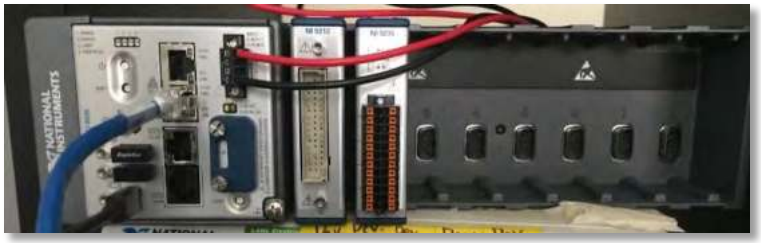
Fiber optic temperature sensor “wire wrap” around simulated heat pipe (right)

Structural integrity monitoring for microreactor core block

Contact: David Mascarenas, dmascarenas@lanl.gov

- **Determine viability of using commercial strain sensing technology for measuring the strain on the external surfaces of the core block at prototypic temperatures**

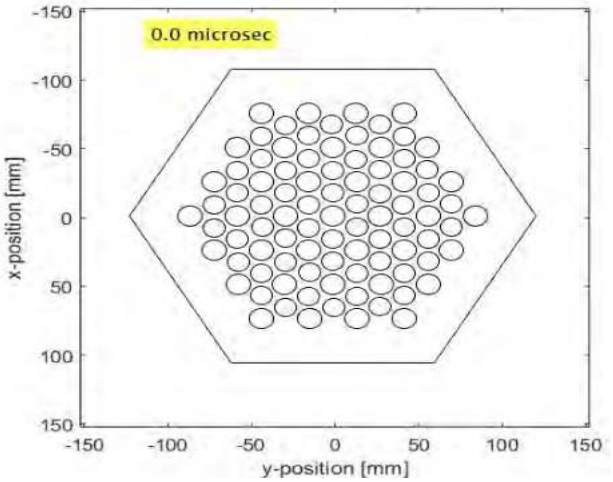




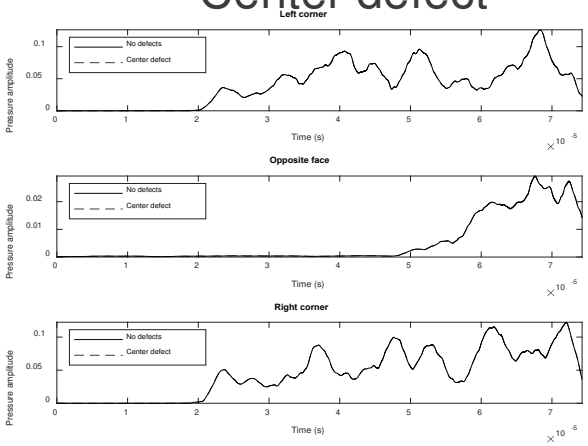
External strain sensing equipment

- **Simulations to explore feasibility of ultrasonic techniques for identification of web defect locations in stainless steel, molybdenum, and graphite**

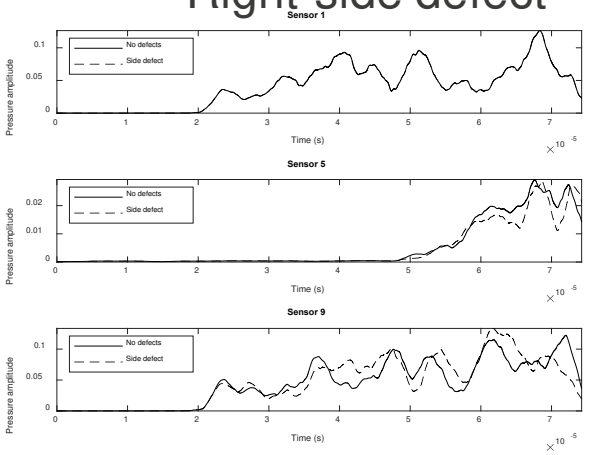
Baseline



Center defect



Right-side defect

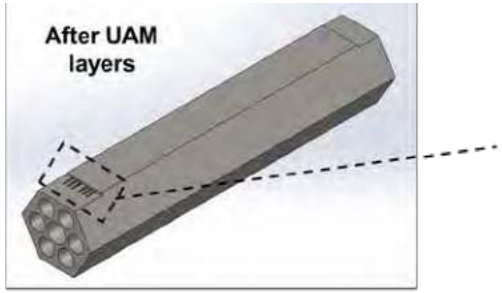


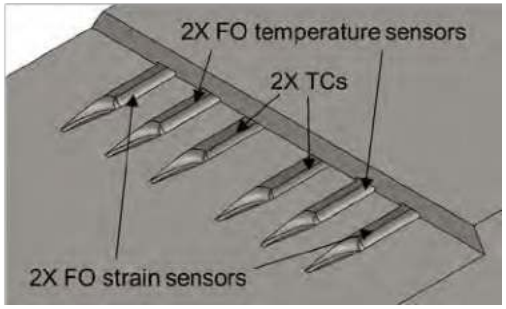
Sensor embedding for cross-cutting microreactor applications

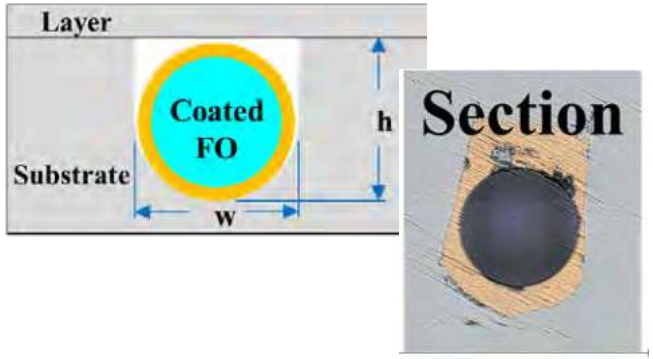
Contact: Chris Petrie, petriecm@ornl.gov

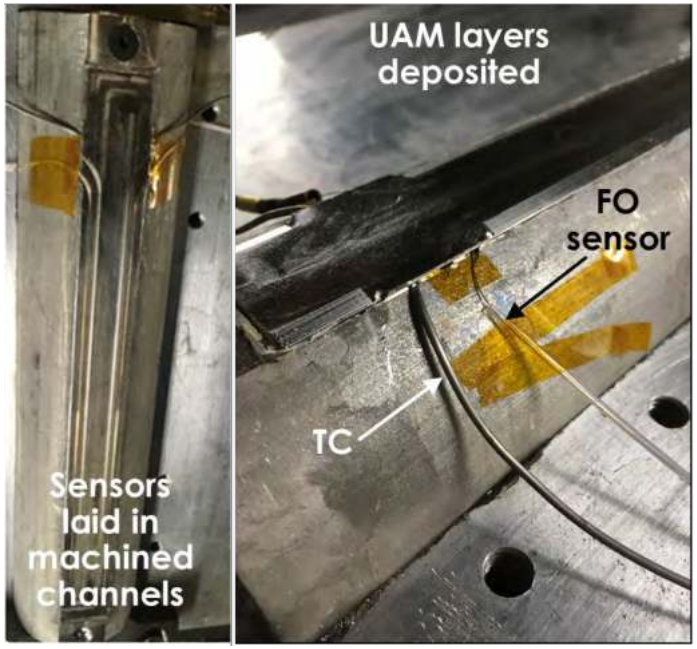
OAK RIDGE National Laboratory

- **Thermocouples and fiber optic temperature and strain sensors embedded into core block and simulated heat pipes**

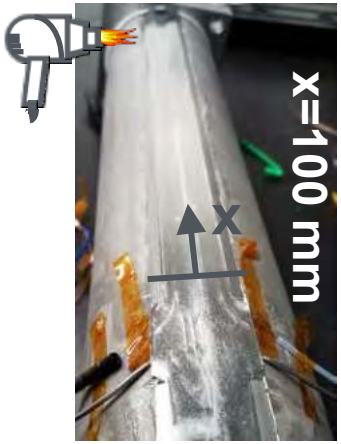


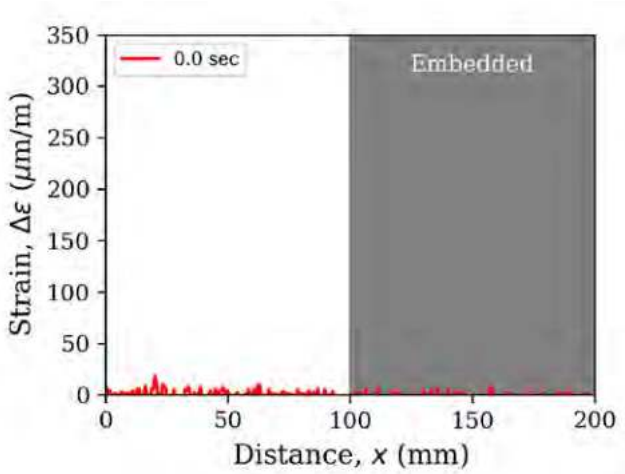






[1] C. M. Petrie et al., Smart Materials and Structures 28 (2019) 055012



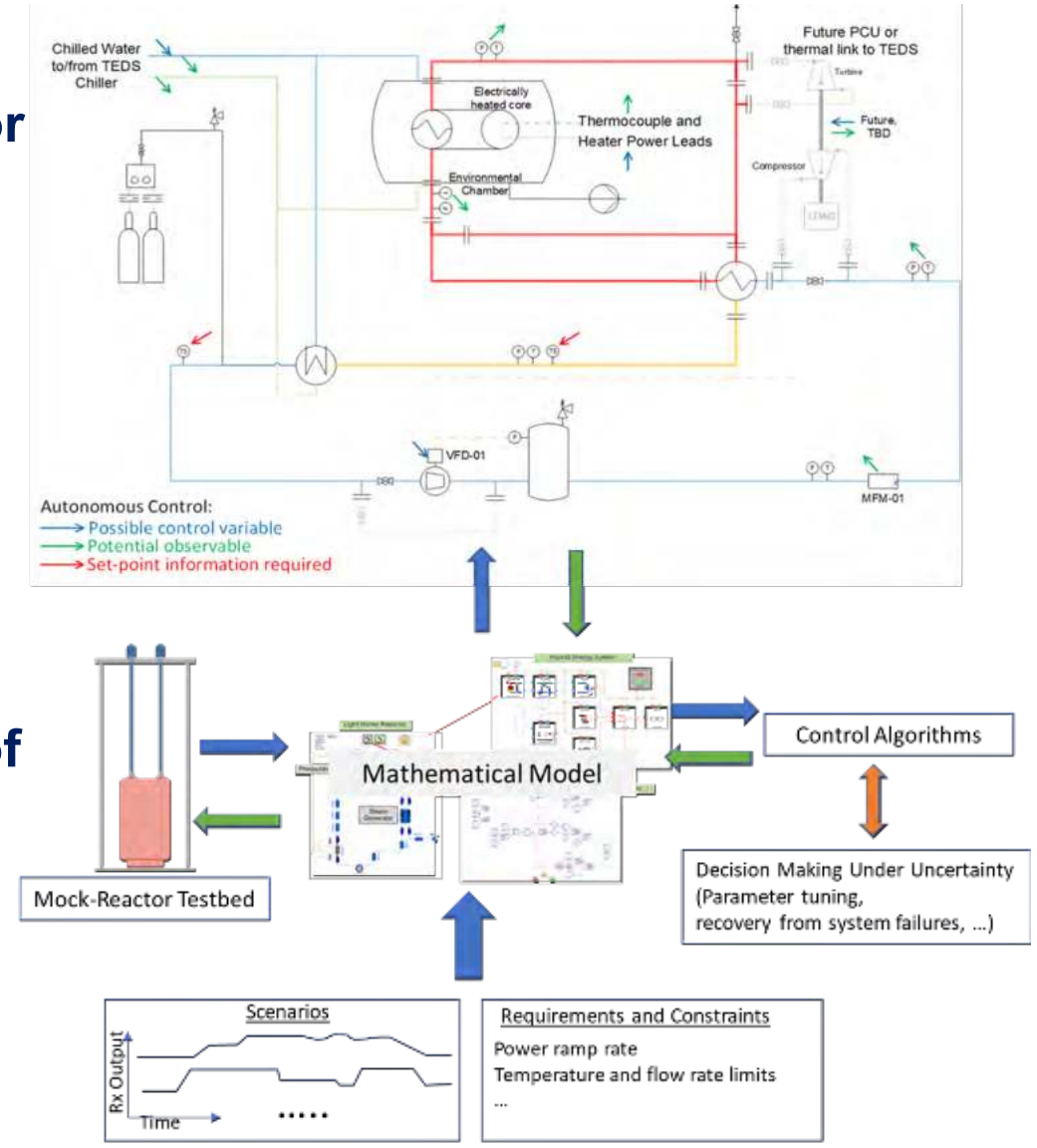


Autonomous control for use in MAGNET

Contact: Pradeep Ramuhalli, ramuhallip@ornl.gov

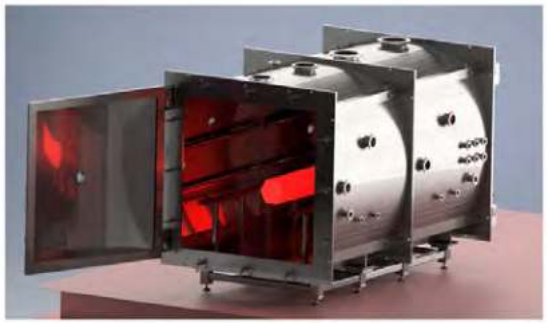
OAK RIDGE National Laboratory

- **Infrastructure development for autonomous operation of MAGNET**
- **Instrumentation upgrades identified to enable autonomous operation**
- **Scenarios and requirements identified for demonstration of cross-cutting control and decision-making for autonomous operation**



Future work plans and priorities: Instrumentation, Sensors and Controls

- **Develop plan for testing internal and external sensors in MAGNET**
  - **Distributed temperature sensors (thermocouples, acoustics, fiber optics)**
  - **Dimensional measurement sensors (LVDTs)**
  - **Neutron flux sensors (fission chambers, SPNDs)**
  - **Structural health monitoring (contact, non-contact, embedded sensors)**
  - **Embedded sensors (various sensors)**
- **Perform structural health monitoring evaluations in MAGNET**
- **Embed sensors in prototypic geometries and perform comprehensive thermal testing**
- **Demonstrate control strategies for selected test article in MAGNET and submit control design for nuclear application testing in TREAT**



MAGNET test chamber

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