U.S. Department of Energy

Fusion of Distributed Fiber Optics, Acoustic NDE, and Physics-Based AI for Spent Fuel Monitoring

PI: Paul Ohodnicki- University of Pittsburgh (Pitt)

Program: FC-4.2 SPENT FUEL AND WASTE DISPOSITION: STORAGE AND TRANSPORTATION

Collaborators: Kevin Chen – University of Pittsburgh (Pitt), Ryan Meyer, Kayte Denslow, Glenn Grant – Pacific Northwest National Laboratory (PNNL), Gary Cannell – Fluor Corporation

ABSTRACT:

The project will leverage the fusion between fiber optic (FO) distributed acoustic sensing and acoustic nondestructive evaluation (NDE) with AI- classification frameworks to quantitatively characterize internal state of dry cask storage systems (DCSS) external to the canister, without introducing additional risks. Distributed temperature and acoustic FO sensing will be combined with acoustic NDE using piezoelectric transducers to access maximum information about operational condition of DCSS without penetrating canister walls. Physics-based simulations and reduced order modeling will be coupled with experiments using model facilities to train and apply AI-classification frameworks for efficient, accurate interpretation of acoustic and temperature data. A primary objective will be to develop new NDE-based characterization tools providing robust information about operational state of health and risk profile for DCSS, including gas composition, pressure, canister integrity, leakage, and temperature. Lab experiments will be performed in years 1-2 with deliverables including prototype sensor instrumentation and AI-classification frameworks. Early work is followed by field validation in years 2-3 at PNNL and Hanford waste storage facilities. On-going programs, including an ARPA-E REPAIR project with Pitt / PNNL and DOE programs at PNNL, in collaboration with Fluor, will be fully leveraged. Facilities established in parallel programs by PNNL / Fluor enable the year 3 demonstrations.

Technical approach is summarized in **Figure 1**, with major research tasks indicated including: ***(1) Distributed Fiber Optic Sensor Technology***, ***(2) Advanced Acoustic NDE Methods, (3) Physics-Based Modeling and AI Framework of Acoustic Signatures,*** and ***(4) Laboratory and Field Validations***. Advanced NDE will excite controlled acoustic modes on the container surface and across the interior to be monitored in real-time using Pitt patented fs-laser enhanced distributed FO acoustic sensing and discrete acoustic transducers. Distributed temperature sensing will also be possible using deployed FO sensors. Unique capabilities for fs-laser enhanced fiber processing can tailor the number and distribution of sensor elements and signal to noise ratio to minimize interrogation system costs. Physics-based models will be developed with Ansys to simulate DCSS acoustic response as a function of parameters relevant for integrity monitoring. Relevant parameters include: (1) He leakage, (2) vessel pressure and gas composition, (3) internal water in condensed or vapor form, (4) storage container temperature distributions, and (5) corrosion. The goal is to enable new robust, rapid, and non-invasive tools for assessment and characterization of internal DCSS conditions relevant for US Nuclear Regulatory Commission (NRC) regulations and standards.

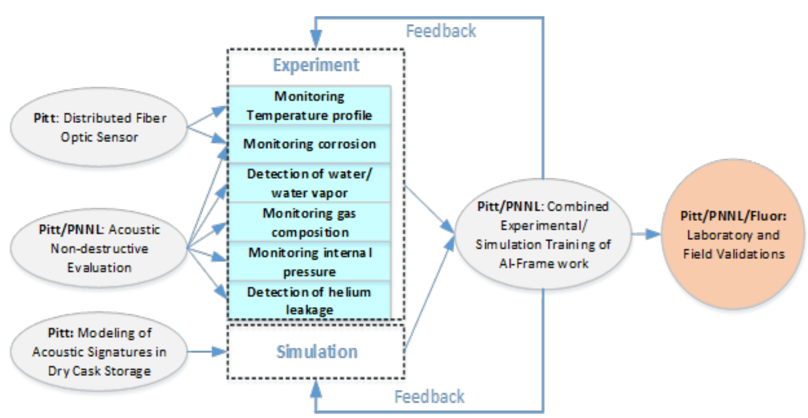

Figure 1: Proposed research project summary diagram.