Pulsed Thermal Tomography Nondestructive Examination of Additively Manufactured Reactor Materials and Components

PI: Alexander Heifetz,
Argonne National Laboratory

Collaborators: Boris Khaykovich, Massachusetts Institute of Technology Nuclear Reactor Laboratory

William Clearly, Westinghouse Electric

Sasan Bakhtiari, Argonne National Laboratory

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ABSTRACT:

The proposed research activity is aimed at developing and demonstrating a novel non-destructive examination (NDE) technique for in-service inspection of additively manufactured (AM) reactor components and materials. Recent advances in AM technology could allow cost-efficient fabrication of parts for operating reactors. The newly designed and built AM parts for fuel assemblies are expected to provide higher fuel performance such as improved heat transfer, thermal hydraulic (T/H), material life, as well as accident tolerance. However, because of stringent safety requirements, long-term performance of AM reactor components needs to be investigated before AM is widely accepted. Because of the complex shapes and significant surface roughness of components due to layer-by-layer welding process in AM, conventional methods might not be useful for in-service NDE of AM components.

We propose to develop and demonstrate an advanced pulsed thermal tomography (TT) architecture and algorithms for in-service NDE of reactor components. TT is ideally suited for in-situ NDE of AM metallic components because the method is non-contact, and offers high resolution 3-D imaging of material flaws. A tomography method which can produce a 3-D reconstruction of material property distribution based on one-sided pulsed thermal imaging has been developed by the applicants. The scope of proposed work consists of building on our existing TT capabilities for NDE of complex materials to develop a system capable of in-service NDE of AM components. The project will follow a spiral development trajectory by starting from benchtop NDE studies and progressing to reactor qualification evaluations.

This project brings together the expertise of researchers from national laboratory, university and industry to develop an innovative solution to the challenging problem of NDE of AM components. Skills and expertise across this diverse spectrum include NDE, algorithm development, reactor qualification and AM technology. The work on the project will involve various subtasks related to hardware and software development. NDE methods proposed for development and demonstration in this project will fill a gap in reliable and versatile techniques for in-service monitoring and detection of flaws in AM components. The results of this research activity will accelerate deployment of components produced with AM techniques in commercial nuclear reactors.