U.S. Department of Energy

Grand Challenge to Accelerated Deployment of Advanced Reactors – A Predictive Pathway for Rapid Qualification of Core Structural Materials

PI: Gary S. Was, University of Michigan

Collaborators: Brian Wirth, University of Tennessee; Steven Zinkle, University of Tennessee; Arthur Motta, Pennsylvania State University; Kevin Field, University of Michigan; Emmanuelle Marquis, University of Michigan; Lijun Qian, Prairie View A&M University; Xiaoning Qian, Texas A&M University; Stephen Taller, Oak Ridge National Laboratory; Muhammet Ayanoglu, Oak Ridge National Laboratory; Ben Eftink, Los Alamos National Laboratory; Andrea Jokisaari, Idaho National Laboratory; Stuart Maloy , Pacific Northwest National Laboratory; Mychailo Toloczko, Pacific Northwest National Laboratory

Program: IRP-1 Grand Challenge IRP - Accelerating Reactor Deployment

ABSTRACT:

A core aspect of addressing U.S. clean energy climate change goals is the Office of Nuclear Energy's goal of accelerating the deployment of advanced nuclear reactor types. All of these strategies are reactor design-specific and all address issues once the design is complete. Yet completion of the reactor design is the lengthiest step in nuclear power reactor deployment and most companies never get past this point. This is because they are not able to license their designs without data on the performance of core structural materials and fuels that are not yet qualified for advanced reactor core conditions. Qualification of core materials is the biggest challenge for deployment of advanced reactor designs and it impacts **ALL** advanced reactor designs.

While chemical interaction with the coolant is a concern in some designs, as is mechanical behavior (creep, fatigue, fracture toughness) in others, the degradation of materials properties and performance from radiation damage is the showstopper for all SMR and larger designs. Regardless of the design, these companies are facing the prospect of not being able to acquire the data they need to support license applications. The two obstacles standing in their way are: The lack of test reactor availability, and the amount of time it takes to obtain the required data. Given that qualifying materials for advanced reactor designs is a major roadblock to advanced reactor deployment, the biggest bang for the buck in achieving rapid deployment of advanced reactor types is figuring out how to accelerate the qualification of core structural materials. The only solution to the greatest obstacle to rapid deployment of advanced reactor types is ion irradiation in combination with advanced characterization and predictive modeling that provide a tool for the qualification of core materials.

The objective of this project is to provide a predictive tool that incorporates ion irradiation and computational materials modeling to determine the microstructure and mechanical properties of core structural materials that are benchmarked against reactor data on the same alloys, and codified in ASTM standards, thus providing licensees with a justification of the efficacy of their core material performance when establishing their safety case for the NRC. The objective will be achieved by a combination of ion irradiations and computational materials modeling that benchmarks microstructures and mechanical properties against those from both BOR-60 and FFTF irradiations on the same alloy heats and processed in the same way. Through codification of best practices and development of a predictive tool, the project will accelerate the deployment of advanced reactor designs critical to achieving the U.S. clean energy climate change goals.