Foreword

Special Issue on Irradiation Experiments Supporting Advanced Nuclear Technologies

Guest Editors

Piyush Sabharwall and Joseph Nielsen

Idaho National Laboratory

This special issue of *Nuclear Science and Engineering* highlights both experimental and modeling work that underpins irradiation experiments crucial for advancing reactor technologies and sustaining current reactor systems. We dedicate this special issue to the engineers, researchers, and scientists whose tireless efforts ensure the maintenance of the existing reactor fleet and propel the development of next-generation reactors.

The 11 papers featured in this issue underscore significant research conducted under the auspices of the U.S. Department of Energy's Office of Nuclear Energy (DOE-NE). These papers cover a diverse range of topics, illustrating the comprehensive efforts to advance nuclear science and enhance industry capabilities in nuclear technologies and reactor systems.

Key areas of focus include thermal modeling of Advanced Gas Reactor experiments, development of a thermal–to–14-MeV neutron conversion device, and the interaction of aluminum cladding materials under gamma irradiation. Additionally, the studies explore the effects of high-reactivity Advanced Test Reactor (ATR) experiments on photon heating, irradiation effects to understand material embrittlement, and verification of neutronic analysis tools. The analysis of the Advanced Fuels Campaign Fission Accelerated Steady-State Test, evaluation of U-10Mo fuel plate performance modeling, and discussion on U.S. accelerated irradiation testing and postirradiation characterization capabilities further highlight the extensive nature of this research.

Irradiation experiments typically involve exposing materials or substances to ionizing radiation, such as gamma rays or neutrons, to study their response and performance. These experiments are crucial for evaluating how materials perform under extreme conditions, such as high radiation and temperature. This knowledge is vital for the development of nuclear reactors and fuels. In the United States, such experiments are primarily conducted in high-temperature, high-radiation, and highly corrosive environments within laboratory and test reactor facilities, including the ATR and the Transient Reactor Test (TREAT) Facility at Idaho National Laboratory, as well as the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory. Additionally, research reactors like TRIGA reactors, university campus reactors, and other radiation sources such as ion beams and the Intermediate Voltage Electron Microscopy (IVEM)–Tandem facility at Argonne National Laboratory are utilized for irradiation testing.

The research at these facilities enables fuel and material qualification, including safety, performance, and compatibility testing of fuels, coolants, and materials in prototypic environments and radiation fields. Beyond experimentation, the modeling of nuclear physics, fluid flow behavior, and radiation effects is complex due to the interdependency of physics models, encompassing reactor physics, thermal hydraulics, fuel performance, and coolant chemistry. These simulation tools require coupled and integrated modeling, presenting analytical challenges. To gain confidence in modeling results and ensure that experiment designs provide the required information for material or fuel qualification, verification of models and validation of modeling results are essential.

This special issue provides valuable insights into both experimental and modeling work supporting the current reactor fleet and the future advanced reactor fleet. We aim to raise awareness among researchers about irradiation experiments, modeling tools, and facilities associated with DOE-NE programs, ultimately empowering industry and supporting the evolution of nuclear technologies and reactor systems.