Foreword

Special issue on the Nuclear Energy Advanced Modeling and Simulation Thermal Hydraulics Integrated Research Project

Guest Editor

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This special issue is part of a combined set of special issues of *Nuclear Technology* and *Nuclear Science and Engineering* that contain full-length, peer-reviewed papers describing work performed in the U.S. Department of Energy (DOE) Integrated Research Project (IRP) titled "Center of Excellence for Thermal-Fluids Applications in Nuclear Energy: Establishing the knowledge base for thermal-hydraulic multiscale simulation to accelerate the deployment of advanced reactors," awarded in 2020 and closing in 2024. Many of the manuscripts included were first presented in a series of special sessions at the Advances in Thermal Hydraulics 2022 topical meeting (ATH'22) held in Anaheim, California, embedded within the 2022 ANS Annual Meeting.

The project aims to build a knowledge base for multiscale methods, models, and data to support the DOE's goals and the thermal hydraulics code infrastructure of the Nuclear Energy Advanced Modeling and Simulation (NEAMS) program. In fact, given that thermal-hydraulic phenomena are characterized by a wide range of temporal and spatial scales, they are unsuitable to be modeled with a single-code approach. A multiscale approach is desirable, and it has been the focus of research within the thermal hydraulics portion of the NEAMS program for over a decade. This IRP specifically focuses on developing novel methodologies that allow a seamless transfer between scales, in contrast with previous ad hoc efforts. A series of four challenge problems has been identified in collaboration with industry to drive the research and ensure that the work is relevant to the community and not purely academic. The four challenge problems include flexible modeling of heat transfer (CP1), thermal striping (CP2), mixing in large enclosures (CP3), and multiscale core thermal hydraulics (CP4).

The papers included in these special issues cover the entirety of the work conducted in the project. Notable is the work performed in CP1 to illuminate mixed-convection heat transfer in the downcomer of advanced reactors. The work provides new insight into the complexity of the flow physics involved. It also generated a staggering and unprecedented amount of data, which has been used to improve correlations for high-Prandtl fluids. In CP2, we demonstrated the potential for novel hybrid models to tackle thermal striping at a reasonable cost (the paper by Pham et al. was also recognized as one of the best papers at ATH'22). In CP3, a series of experiments and high-fidelity numerical simulation provided invaluable data to drive the development of an AI-based coarse grid computational fluid dynamics methodology that holds promise for use within system analysis codes. Finally, in CP4, we demonstrated work toward the development of improved porous media correlations for pebble beds and a multiscale approach for rod bundles. I also note that the work on the project continues with new and exciting developments. Moreover, it was announced on April 6, 2024, that the project was selected for award negotiations by the DOE as part of the inaugural cohort of the Phase II CINR program.

Finally, I would like to thank the reviewers who volunteered their time and expertise to review the papers for these special issues of *Nuclear Technology* and *Nuclear Science and Engineering*. I would also like to thank Dr. Andy Klein, Dr. Yassin Hassan, Dr. Farzad Rahnema, and Dr. Michael Corradini for supporting and spearheading these special issues and Mr. David Strutz and Ms. Faith Michal, who have been instrumental in getting these issues published on a timely basis.