NEUP Nuclear Energy University Programs
U.S. Department of Energy

Project Title

Performance Assessment of Enhanced Accident Tolerant Fuels within Aggressive Operational Power Histories

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Program: Advanced Fuels FC-2

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ABSTRACT:

This project will ***develop a process*** that evaluates the whole-core operational and safety performance of a reactor-and-fuel combination by integrating core-wide three-dimensional neutronics with MOOSE/BISON multi-physics fuel performance assessments using explicit time and space dependent fuel rod operational power histories generated in the whole-core analysis. Demonstration of the process will target large contemporary PWRs with traditional UO2 fuel and Zircaloy cladding to establish a baseline analysis, while the ***innovative application*** of this project will extend the developed process to evaluate operational and safety performance, via reactor physics and fuel performance analyses, of key emerging/leading concepts of enhanced Accident Tolerant Fuels (ATFs) within increasingly aggressive operational scenarios such as load-follow maneuvers in PWRs and long-cycle rodded and unborated operation in small modular reactors (SMRs). The ATFs to be considered include standard UO2 fuel pellets cladded with advanced iron-based alloys (FeCrAl) as well as particle-based Fully Ceramic Microencapsulated (FCM) fuels with FeCrAl cladding, but the process being developed and demonstrated could ultimately be applied to any candidate ATF concept in a light water reactor. In fact, given that ATF R&D priorities are in a dynamic state, the scope related to ATFs will be targeted for the second half of this three-year project to strengthen the programmatic alignment of this project with the DOE Advanced Fuels Campaign by identifying the most promising and relevant ATFs at that time for further evaluation after the early part of the project fine-tunes the process developed herein and generates baseline analyses against which a larger scope of ATF concepts can be compared.

The ***mission relevance*** of this project will contribute to the broader ATF program within DOE by establishing a key part of a process for analyzing and evaluating ATF concepts and furthering the understanding of reactor physics and fuel performance aspects of key representative ATF concepts. This expands upon the capabilities within the ATF program to analyze ATF concepts for use in existing LWRs, and provides robust analysis of ATF concepts in both existing LWRs and potential LWR SMR applications of ATF concepts. Furthermore, the work supports upcoming programmatic needs for tools or data that can be used to support metrics evaluation and down-select decisions to reduce the number of ATF concepts being carried from into the next phase of the ATF program. A major outcome of this project is the development and demonstration of a process for full-core neutronic analysis that can be applied to a broad range of ATF concepts and could be coupled to, or integrated with, system wide thermal-hydraulic and/or fuel performance analyses. Thus, this process supports quantitative evaluation of ATF concepts, which is a necessary step in scoring these concepts on various ATF metrics that are being developed and should aid decision makers in their ranking of these concepts according to how they score in the various areas.