High-fidelity modeling of fuel-to-coolant thermomechanical transport behaviors under transient conditions

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ABSTRACT:

The objective of this project is to develop a high-fidelity modeling tool that can capture some of the important phenomena in high burnup UO_2 and accident tolerant fuels (ATF) during transient conditions. Accurate modeling of the time-dependent phenomena that impact material performance must be used to determine the figures of merit and safety margin. Phenomena such as fuel fragmentation, cladding oxidation, pellet-clad interaction, clad ballooning, and clad rupture are examples that pose challenges to modeling during these transients. For Practice of a 3-year project, the research scope will focus on the development of high-fidelity tightly coupled multiphysics tools that can capture the time-dependent material response and associated thermal hydraulic conditions during these events. These tools will be validated against existing separate effects tests and in-pile integral experiments and will be used to model near-term Transient Reactor Test facility (TREAT) loss-of-coolant accidents (LOCA) experiments currently being developed.

The proposed work is relevant to DOE-NE mission because it aims to develop a high-fidelity modeling tool that can capture some of the important phenomena in high burnup UO_2 and Accident Tolerant Fuel designs during transient conditions. This work will also benefit the NRC helping to validate TRACE/FAST for high burnup fuel analysis. The NRC will use TRACE/FAST to audit analyses submitted by the licensees in license amendment requests. This work would specifically address a need of the NRC to have a validated tool to assess LOCA calculations for high burnup fuel and ATF submitted by licensees. Results of this work will identify better models and validating the code against TREAT LOCA experiments will be extremely beneficial.

The deliverables for this project will include BISON and FAST code modifications that improve the ability to model thermomechanical transport behavior in ATF and high burnup fuels.; 1) Two-way coupled models for TRACE/BISON and TRACE/FAST validated against TREAT LOCA experimental data. 2) Model uncertainty quantification essential for future applications, 3) software design document and code assessment reports.