Establishing MIT's Experimental Capabilities for Fuel Performance Investigations

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ABSTRACT:

We propose to upgrade the diagnostics and post-irradiation examination (PIE) facilities of the fuel performance group in the Nuclear Science and Engineering (NSE) department at MIT, co-located with the MIT Nuclear Reactor Lab (MIT NRL). Our overall objective is to establish new thermomechanical experimental capability to investigate irradiated fuel concepts, in order to inform and validate high fidelity fuel performance tools (e.g. MOOSE/BISON), supported by the Department of Energy, and broaden our role as innovators and educators in this area. The proposed upgrades complement the existing irradiation capabilities and broaden our role as a Nuclear Science User Facilities (NSUF) partner. Our eventual goal is to develop a unique experimental multi-purpose platform for both teaching and advanced research, to perform cutting-edge, high-resolution thermomechanical testing and code validation in light water reactor (LWR) and Generation IV operating conditions. This is achieved through leveraging imaging techniques combined with a customized high temperature furnace mounted on a flexible dynamic mechanical testing system. Such capability currently does not exist at a research reactor with commercial-level flux and would clearly be invaluable for the nuclear community to improve the design and the operation of current and future nuclear reactors. To this end, an upgrade of our current diagnostics and thermomechanical testing is required.

In the past few years, our fuel performance group has developed data driven models for Accident Tolerant Fuel (ATF) concepts including coatings and SiC/SiC composite materials through out-of-pile experimentation. The work was supported by various DOE programs on ATF as part of the Advanced Fuels Campaign and Nuclear Energy Advanced Modeling and Simulation (NEAMS). The testing program was key in identifying the failure mechanisms not previously considered/known and identifying fuel performance modeling gaps. The proposed equipment will upgrade our out-of-pile diagnostic capability and also allow for testing of irradiated materials. The proposed Digital Image Correlation equipment and software allows strain measurement in complex topology present in many advanced fuel designs. In order to apply such a powerful diagnostic technique, a versatile furnace with viewing windows that can be mounted to a dynamic mechanical servo-hydraulic machine will also be acquired. By co-locating the proposed equipment within the NRL space, the requested upgrades will simultaneously significantly improve NSUF partner access to irradiation/PIE capabilities, increase the attractiveness and viability of nuclear fuel irradiation experiments at the NRL, and create a unique educational opportunity for hands-on research training and teaching of nuclear materials engineering. Both research and educational opportunities will be made available to the general scientific community through a combination of NSUF irradiation proposals through the DOE-NE office, interdepartmental collaborations with MIT faculty & staff, and educational partnerships with other universities.