Proposal 09-826

NUCLEAR ENERGY UNIVERSITY PROGRAMS

Understanding Fundamental Material Degradation Processes in High Temperature Aggressive Chemomechanical Environments

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Abstract

The objective of this project is to develop a fundamental understanding of the mechanisms that limit materials durability for very high-temperature applications. Current design limitations are based on material strength and corrosion resistance. This project will characterize the interactions of high-temperature creep, fatigue, and environmental attack in structural metallic alloys of interest for the very high-temperature gas-cooled reactor (VHTR) or Next–Generation Nuclear Plant (NGNP) and for the associated thermo-chemical processing systems for hydrogen generation. Each of these degradation processes presents a major materials design challenge on its own, but in combination, they can act synergistically to rapidly degrade materials and limit component lives. This research and development effort will provide experimental results to characterize creep-fatigue-environment interactions and develop predictive models to define operation limits for high-temperature structural material applications.

Researchers will study individually and in combination creep-fatigue-environmental attack processes in Alloys 617, 230, and 800H, as well as in an advanced Ni-Cr oxide dispersion strengthened steel (ODS) system. For comparison, the study will also examine basic degradation processes in nichrome (Ni-20Cr), which is a basis for most high-temperature structural materials, as well as many of the superalloys. These materials are selected to represent primary candidate alloys, one advanced developmental alloy that may have superior high-temperature durability, and one model system on which basic performance and modeling efforts can be based. The research program is presented in four parts, which all complement each other. The first three are primarily experimental in nature, and the last will tie the work together in a coordinated modeling effort. The sections are 1) dynamic creep-fatigue-environment process, 2) subcritical crack processes, 3) dynamic corrosion – crack initiation processes, and 4) modeling.