NUCLEAR ENERGY UNIVERSITY PROGRAMS

Mechanisms Governing the Creep Behavior of High Temperature Alloys for Generation IV Nuclear Energy Systems

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Abstract

This project will combine the study of the effects of microstructure (grain size, grain boundaries, second phases) with detailed testing, atomic-scale characterization, quantitative analysis, and modeling of high-temperature Alloys 617 and 800H. The purpose is to develop a mechanistic understanding of the low-stress, high-temperature creep behavior of these materials, which are candidates for use as components (e.g. intermediate heat exchangers) in the Next Generation Nuclear plant (NGNP). Through the results obtained from this integrated experimental and modeling study, new insight will be gained into how changes take place in atomic configurations during high-temperature creep of these alloys, as well as associated thermodynamic, kinetic, microstructural, property, mechanistic, modeling, and design features.

The research will focus on Alloy 617 and Alloy 800H, with an emphasis on the effects of grain size, grain boundaries, and second phases on creep properties; the mechanisms of dislocation creep, diffusional creep, and cavitation; the onset of tertiary creep; and theoretical modeling for long-term predictions of materials behavior and for high-temperature alloy design. The research program includes the following key elements: 1) thermomechanical processing of Alloys 617 and 800H to obtain a range of grain sizes; 2) determination of the creep properties and phenomenology over a range of temperatures and stresses from low to high, covering the diffusional and dislocation creep regimes, respectively; 3) characterization of the samples' microstructure before and after creep using modern techniques to understand the microstructural mechanisms associated with creep deformation and damage; and 4) determination of the parameters in the creep equations and modeling to allow predictions of long-term creep behavior for design and ASME code case purposes.