NUCLEAR ENERGY UNIVERSITY PROGRAMS

Multiaxial Creep-Fatigue and Creep-Ratcheting Failures of Grade 91 and Haynes 230 Alloys Toward Addressing Design Issues of Gen IV Nuclear Power Plants

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Abstract

This project will develop systematic sets of uniaxial and multiaxial data, including creep fatigue and creep ratcheting, at high temperatures (850-950°C) for Alloy 617, a primary candidate material for the intermediate heat exchanger (IHX) in The Next-Generation Nuclear Plant (NGNP). Researchers will develop and validate a unified constitutive model (UCM) based on these experimental results. Validation of the UCM for both the uniaxial and multiaxial fatigue failures will ensure robustness of the ASME-NH design-by-analysis methodology.

As components must be designed against both creep fatigue and ratcheting failure at high temperatures, this project will scrutinize the experimental responses of Alloy 617 in order to quantify the influences of creep and dynamic strain aging (DSA) on fatigue and ratcheting failures. Developing such a UCM will require incorporation of various modeling features, such as strain-range dependence, erasure of memory, back stress shift, cross-effect, DSA, and various nonproportionality and multiaxial modeling features. However, these features are not available in ANSYS and ABAQUS, which severely limits simulation and design capabilities. Toward achieving a robust UCM, the project will gradually improve the Chaboche nonlinear kinematic hardening model by incorporating new and recently proposed modeling features. The improved model will have a large number of interdependent parameters, which are difficult to determine manually. Hence, the team will develop an automated genetic algorithm-based parameter optimization scheme to facilitate the UCM's use by designers and regulators. Finally, the UCM will be implemented into ANSYS and ABAQUS for high-temperature nuclear plant design applications.