U.S. Department of Energy

Project Title

Mechanistic and Validated Creep/Fatigue Predictions for Alloy 709 from Accelerated Experiments and Simulations

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Program: RC-3

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ABSTRACT:

As a promising candidate for fast reactor program, Alloy 709 possesses excellent high temperature thermo-mechanical properties. To support its qualification in the ASME code for Class 1 Components in Elevated Temperature Service (Section 3, Division 1, Subsection NH), we propose mechanistic methods for predicting creep and creep-fatigue deformation rates based on accelerated *in-situ* and *ex-situ* tests, and mesoscale dislocation dynamics (DD) simulations.

The research work performed in this project will have the following deliverables: (***i***) creep and creep-fatigue data on Alloy 709 with normalized stresses (σ/E) ranging from 5×10^{-3} to 10^{-5} at temperatures ranging from 450–750ºC, and with load cycles ranging from 10^3 to 10^5; (***ii***) microstructure evaluation from (*a*) *in-situ*/*ex-situ* TEM, (*b*) *in-situ* XRD using synchrotron radiation at APS/ANL and (*c*) mesoscale dislocation dynamics simulations informing creep damage mechanics (CDM) model; (***iii***) a rational framework (CDM) of generalized viscoplastic constitutive equations to reliably predict and extrapolate the results of accelerated tests to reactor operating conditions; (***iv***) validations of CDM performed through predictions that can be crosschecked and benchmarked against experimental data; and (***v***) extrapolated creep and creep-fatigue data delivered for use in ASME code development.

Three graduate students will be trained in the area of nuclear materials science; they will work closely with the laboratory partners at APS/ANL and ORNL.