NUCLEAR ENERGY UNIVERSITY PROGRAMS

Prediction and Monitoring Systems of Creep-Fracture Behavior of 9Cr-1Mo Steels for Reactor Pressure Vessels

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Abstract

A recent workshop on next-generation nuclear plant (NGNP) topics underscored the need for research studies on the creep fracture behavior of two materials under consideration for reactor pressure vessel (RPV) applications: 9Cr-1Mo and SA-5XX steels. This research project will provide a fundamental understanding of creep fracture behavior of modified 9Cr-1Mo steel welds for through modeling and experimentation and will recommend a design for an RPV structural health monitoring system. Following are the specific objectives of this research project:

- Characterize metallurgical degradation in welded modified 9Cr-1Mo steel resulting from aging processes and creep service conditions.
- Perform creep tests and characterize the mechanisms of creep fracture process.
- Quantify how the microstructure degradation controls the creep strength of welded steel specimens.
- Perform finite element (FE) simulations using polycrystal plasticity to understand how grain texture affects the creep fracture properties of welds.
- Develop a microstructure-based creep fracture model to estimate RPVs service life .
- Manufacture small, prototypic, cylindrical pressure vessels, subject them to degradation by aging, and measure their leak rates.
- Simulate damage evolution in creep specimens by FE analyses.
- Develop a model that correlates gas leak rates from welded pressure vessels with the amount of microstructural damage.
- Perform large-scale FE simulations with a realistic microstructure to evaluate RPV performance at elevated temperatures and creep strength.
- Develop a fracture model for the structural integrity of RPVs subjected to creep loads.
- Develop a plan for a non-destructive structural health monitoring technique and damage detection device for RPVs.