NUCLEAR ENERGY UNIVERSITY PROGRAMS

Graphite Oxidation Simulation in HTR Accident Conditions

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Project Number: 09-830

Initiative/Campaign: Gen IV/Methods

Abstract

Massive air and water ingress, following a pipe break or leak in steam-generator tubes, is a design-basis accident for high-temperature reactors (HTRs). Analysis of these accidents in both prismatic and pebble bed HTRs requires state-of-the-art capability for predictions of: 1) oxidation kinetics, 2) air–helium gas mixture stratification and diffusion into the core following the depressurization, 3) transport of multi-species gas mixture, and 4) graphite corrosion. This project will develop a multi-dimensional, comprehensive oxidation kinetics model of graphite in HTRs, with diverse capabilities for handling different flow regimes. The chemical kinetics/multi-species transport model for graphite burning and oxidation will account for temperature-related changes in the properties of graphite, oxidants (O_2, H_2O, CO), reaction products (CO, CO_2, H_2, CH_4) and other gases in the mixture (He and N_2). The model will treat the oxidation and corrosion of graphite in geometries representative of HTR core component at temperatures of 900°C or higher. The developed chemical reaction kinetics model will be user-friendly for coupling to full core analysis codes such as MELCOR and RELAP, as well as computational fluid dynamics (CFD) codes such as CD-adapco. The research team will solve governing equations for the multi-dimensional flow and the chemical reactions and kinetics using Simulink, an extension of the MATLAB solver, and will validate and benchmark the model's predictions using reported experimental data.

Researchers will develop an interface to couple the validated model to a commercially available CFD fluid flow and thermal-hydraulic model of the reactor , and will perform a simulation of a pipe break in a prismatic core HTR, with the potential for future application to a pebble-bed type HTR.