NUCLEAR ENERGY UNIVERSITY PROGRAMS

TRISO-Coated Fuel Durability Under Extreme Conditions

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Abstract

Very high-temperature reactor plant development depends on advancing the fundamental understanding of the behavior of TRISO-coated particle fuels under varied environmental and thermo-mechanical conditions. Coated particle fuel has been employed successfully in high-temperature gas-cooled reactors for several decades, and there is a significant body of work on carbides in this context, yet issues remain that relate to carbide reliability and long-term durability. This project will examine TRISO-coated particles (SiC and ZrC coatings) in an integrated two-part study, considering kinetics and mechanical behavior.

The project team will perform experiments to assess reaction kinetics of the carbides under CO-CO_2 environments at temperatures up to 1,800°C. A vacuum thermogravimetric analysis (TGA) system will be used to measure weight loss from specimens as a function of temperature and CO-CO_2 pressure, with a focus on low pressures (10^{-4} – 10^{-1} atm) where lack of protective oxide scale allows active oxidation. Researchers will first obtain data with bulk SiC and bulk ZrC, and subsequently with TRISO-coated particles, applying a kinetic model based on weight loss and structural and microstructural characterization to describe the degradation. Cesium vapors will be introduced into the CO-CO_2 mixture during elevated temperature exposure to study their interaction. Researchers will employ scanning and transmission electron microscopy to establish the chemical and microstructural evolution under the imposed environmental conditions.

The second part focuses on establishing the role of high-temperature environmental exposure on mechanical behavior, using two techniques to test TRISO-coated particles under compression . Researchers will isolate individual particles for compression with a spherical tip nano-indenter. The second technique will be to place several particles within high-precision parallel plates that are loaded in compression. This multi-particle test will produce data that may in principle be described by the failure response of a single particle.