Speaker: Adrianna E. Lupercio

Presentation Medium: Talk and Poster Presentations

Title: Fracture Behavior of Traditional UO_2 Fuel Pellets for Light Water Reactors

Authors: Adrianna E. Lupercio, Cayden Doyle, Ehsan Moshkelgosha, Mahmood Mamivand, Andrew T. Nelson, Brian J. Jaques

Growing energy demands and climate change have spurred the need for cleaner energy. Nuclear energy emits zero greenhouse gases during operation and provides nearly 20% of the electricity generated in America. Enhanced nuclear fuel economy and performance necessitates the extension of uranium dioxide (UO_2) fuel operation lifetime and the implementation of Advanced Technology Fuels (ATFs). To meet these needs, separate effects data are critical to the modeling and simulation efforts for the prediction of fuel performance. Baseline experimental data to understand the mechanical behavior, such as transverse rupture strength (TRS), of traditional fuels and ATFs is essential, as it is a primary driver for fuel performance.

Fracture data for irradiated and unirradiated UO_2 are limited and fracture data at production levels is virtually non-existent which is critical to their licensing and implementation in nuclear reactors. This knowledge-gap is partly due to challenges in machining radiological materials into traditional, high tolerance bend bar test specimens. Consequently, obtaining sufficient data to understand the stochastic fracture behavior of ceramic materials becomes difficult. Alternatively, the biaxial flexure test method requires simple pellet geometries representative of nuclear fuel, minimal surface preparation, and avoids edge defects, reducing time and cost of sample production.

This study used a ball-on-ring biaxial flexure technique, validated in previous work, to establish the fracture behavior of traditional UO_2 fuel pellets. The UO_2 pellets fabricated specifically for this work have an average grain size of 6.7 µm and a theoretical density >94%. Tested UO_2 pellets resulted in a TRS between 106 – 171 MPa, Weibull characteristic strength of 164 MPa, and Weibull modulus of 8.9. Results from fracture data indicate the ball-on-ring test method is reliable for obtaining TRS of oxide nuclear fuels to provide baseline fracture data for the improvement of nuclear fuel performance predictions.

Conference: Future Net-Zero Innovators Student Symposium