NEUP Nuclear Energy University Program
U.S. Department of Energy

# Fragmentation and Thermal Energy Transport of Chromia-doped Fuels under Transient Conditions

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**Program**: FC-2.1

**ABSTRACT:**
The goal of this project is to provide essential data, analysis and modeling to fill a major knowledge gap in thermal energy transport relevant to transient fuel performance for high burnup accident tolerant fuels (ATF). This project will also provide a research methodology including experimental and analysis procedures and tools for future reactor testing, such as the transient reactor TREAT, of irradiated ATF fuels. Heat transfer from fuel to coolant is governed by: (1) local heat generation rate in high burnup fuels (higher rim area heat generation), (2) thermal conductivity of fuel pellets after significant microstructure change and fracture/fragmentation (significant radial variation), (3) heat conduction through the fuel-cladding interface and cladding itself, and (4) cladding-to-coolant heat transfer that involves transient boiling. Among these steps, the most critical ones are (2) heat conduction in fractured/fragmented fuel and (4) transient boiling for high burnup fuels because they are most rate-limiting and least understood. Transient boiling is currently being studied by multiple NEUP projects as well as TREAT experiments, and it is expected to be similar to medium burnup fuels. However, the thermal conductivity of fractured/fragmented high burnup ATF pellets has never been measured. It is a clear knowledge and data gap that is critically needed for the modeling effort on thermal energy transport in steady-state and transient fuel performance because it directly impacts the temperature distribution inside the fuel and heat flux though the cladding. The specific objectives of this project are:
(1) Develop a model fuel system that is representative of high burnup ATF fuels, specifically, chromia-doped UO2 with controlled grain structure, pore and porosity used for fragmentation testing and heating transfer modeling.
(2) Fracture and fragment the fuel to simulate LOCA fuel fracture/fragmentation patterns, forming as microstructure descriptor (cracking patterns) for microstructure-based thermal transport
(3) Measure fuel thermal conductively and diffusivity as functions of fuel microstructure and fracture/fragmentation characteristics and build thermophysical property correlations
(4) Model temperature transient and energy transport from fragmented fuels through cladding to the coolant, using actual and machine-learning generated fracture patterns, with BISON code and the input data from measurements to establish a science-based prediction of fuel transient performance under normal and design basis accidents
The project team represents leading expertise, experiences, and lab capabilities in ATF fuel fabrication and thermos-physical property measurement, as well an ATF fuel vendor and RIA/LOCA modeling experts. The project will build on historical data from LOCA and RIA integral tests performed by multiple countries and develop experimental and modeling capabilities to assess high burnup ATF transient performance for eventual integral testing for potential licensing needs. Extensive efforts are currently ongoing to understand cladding hydride buildup and oxidation layer growth associated with high burnup fuels, which cause a lower fuel failure enthalpy threshold in an RIA and a lower peak cladding temperature in LOCA cladding failure. This project will provide essential thermal transport data based on fuel microstructure and fracture characteristics from the best surrogate fuels for high burnup ATF fuels safety assessment, as well as methodology preparation for future reactor (TREAT) experiments.