U.S. Department of Energy

Development of Hydrogen Transport Models for High Temperature Metal Hydride Moderators

PI: Prof. Jeffrey King,
Colorado School of Mines

Collaborators: Dr. Alexander Long, Los Alamos National Laboratory
Dr. Erik Luther, Los Alamos National Laboratory

Program: Reactor Concepts

ABSTRACT:

Recent developments in nuclear reactor technology have renewed research interest in microreactors for a variety of applications both on Earth and in space. While some of the terrestrial microreactor concepts are based on existing light water reactor technologies, many of the proposed microreactor designs rely on advanced materials to reach higher operating temperatures and improved power conversion efficiencies (which, in turn, lead to longer operating lifetimes without refueling). Most terrestrial microreactor applications are limited to the use of Low Enrichment Uranium (LEU) (uranium enriched to less than 20 wt% uranium-235) in response to safeguards and non-proliferation concerns. In these cases, it will likely be necessary to incorporate a moderator into the reactor core to reduce the average neutron energy and increase the effective fission cross-section, enabling the design of compact reactor cores. As a result, many microreactor concepts rely on metal hydride moderators to enable high temperature operation with compact, LEU-fueled, cores.

Thus, understanding the fabrication, incorporation, and performance of high temperature metal hydride moderators is an enabling technology for the development of future microreactors. This project will develop computational methods to predict the short- and long-term reactor performance impacts from thermally-driven hydrogen transport in two candidate metal hydride moderators (namely, zirconium-, and yttrium-hydrides).

The Colorado School of Mines (Mines), in collaboration with researchers at the Los Alamos National Laboratory, proposes to use the neutron imaging techniques developed on FP5 at LANSCE to derive temperature-dependent diffusion coefficients for the transport of hydrogen in zirconium and yttrium hydride. The project will the develop finite element models for the spatial distribution of hydrogen in the moderator materials as a function of time and temperature based on the experimentally-derived diffusion coefficients, with a primary goal of demonstrating the ability to accurately predict the time-, temperature, and geometry-dependent transport of hydrogen within the metal hydride moderator materials. Coupling the resulting hydrogen transport models to neutronics and thermal-hydraulics models of the reactor core will allow the prediction of reactor behavior as a function of hydrogen transport over time. Understanding the impact of hydrogen transport in the moderator materials on the performance of the reactor is a key capability for the future deployment of microreactors that use high temperature metal hydride moderators.