INTERNATIONAL NUCLEAR ENERGY RESEARCH INITIATIVE

Fully Ceramic Microencapsulated Replacement Fuel for Light Water Reactor Sustainability

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This project supports the introduction of a robust, accident-tolerant fuel that is compatible with currently operating light water reactors (LWRs). Specifically, the team will further investigate fully ceramic micro-encapsulated (FCM) fuel, a promising concept under Department of Energy development. The FCM fuel is a TRISO-based dispersion fuel consisting of ceramic-coated microspheres of low-enriched uranium embedded in a dense, uniform silicon carbide (SiC) matrix fuel pellet. Pellets can be stacked in non-zirconium cladding and fabricated into fuel assemblies compatible with existing LWR designs. The Fukushima nuclear accident has demonstrated the vulnerability of conventional uranium oxide (UO_2) LWR fuels to severe damage during station blackout events. The ceramic microspheres and ceramic compacting matrix provide additional barriers to the release of fission products.

The goal of this project is to establish FCM fuel as a feasible replacement for UO_2 ceramic fuel in the existing LWR fleet. To be viable one-for-one replacements, the FCM fuel pins must behave in essentially the same manner as UO_2 in terms of power generation, thermal-hydraulics, and neutronics. The FCM fuel must also achieve comparable levels of linear fissile density and reactivity behavior throughout its operational life in the reactor. To accomplish this, the project team will introduce high-fissile-density materials and investigate special packing techniques. Given the existing database of properties for the relevant materials, the team will evaluate performance at the fuel assembly and full-core levels, in addition to the customary neutronic and thermal-hydraulic analysis. The project consists of the following key elements:

- Selection of FCM fuel rod and assembly designs and preliminary neutronic exploration of LWR cores
- Modeling and preliminary thermal-hydraulic assessment of reference FCM cores
- Reactor systems modeling and preliminary safety assessment of FCM fueled cores
- FCM fuel qualification – manufacturing, irradiation, and performance analysis