NEUP Nuclear Energy University Programs

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Project Title

Studies of Lanthanide Transport in Metallic Nuclear Fuels

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Program: Fuel Cycle, FC-2.1 Advanced Fuel

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ABSTRACT:

One of the key concerns of using metallic fuels is the cladding degradation due to fuel-cladding chemical interactions (FCCI). The major contribution to FCCI arises as Ln migrates to the periphery of the fuel and due to swelling eventually contacts the cladding. The lanthanide interaction with clad in metallic fuels is recognized as a long-term, high-burnup cause of the clad failures. Therefore, it is important to understand the redistribution of lanthanide fission products and migration to the fuel surface. However, there is relatively little knowledge of the fundamental behavior of alloys containing lanthanides and the mechanisms by which lanthanides migrate to the clad are uncertain. We propose to study experimentally and analytically the mechanisms of lanthanide transport in metallic fuels based on the novel interpretation of 'liquid-like' transport mechanism which was developed based on post-irradiation examination (PIE) of EBR-II fuels. The proposed research will be performed using an integral approach: (1) experimental studies for measurements of key parameters and first principles calculations to determine, for example, lanthanide solubility in liquid cesium, sodium and cesium-sodium alloy; (2) theoretical model development for lanthanide transport in a non-isothermal single pore and porous medium to understand the observed behavior (deposition, dissolution and migration) in a single closed or open pore and porous medium; (3) further development of the multi-phase/physics BISON model. The key goal of the proposed research is to develop fundamental understanding of the lanthanide fission product migration and redistribution in advanced metallic nuclear fuels, and then to provide fundamental theory/data for mitigating FCCI of advanced metallic fuels. The proposed research directly addresses the NEUP topic FC-2.1: Advanced nuclear fuel.

The proposed research will be led by The Ohio State University (OSU) with two collaborating organizations (i) Los Alamos National Laboratory (LANL) and (ii) Idaho National Laboratory (INL). The three institutes have facilities for conducting the proposed research, and on-going projects at LANL and INL directly funded by DOE-NE programs will benefit the proposed research. The experiences and expertise of the four PIs are highly complementary, and in addition, the four PIs are well acquainted from having worked together before under DOE-NE programs such as NEAMS and FCR&D. This research is not directly related to any other DOE NEUP proposal for which the success of one project would depend on activities of the other project