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Experiments and computations to address the safety case of heat pipe failures in Special Purpose Reactors

PI: Victor Petrov, University of Michigan

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Collaborators: Annalisa Manera – University of Michigan; Richard Martineau- Idaho national Laboratory

Abstract

Microreactors, also known as very-Small Modular Reactors (vSMRs) or Special Purpose Reactors (SPRs), are being considered for use in unique applications where other methods of megawatt level energy production are uneconomical or unavailable. These reactors produce a few MW power (typically < 20 MW), can be manufactured in a factory and then transported by track, train, plane or ship to the location of deployment. They are designed for fully- or semi-autonomous operation so that they can be used for electricity production in remote locations, military installations, for industrial applications such as desalination or hydrogen production, or for integration in micro-grids.

Development of micro-reactors is being supported by the DOE Advanced Reactor Technologies Program and several companies. Very recently, the Nuclear Energy Institute has issued a road-map (NEI, 2018) for a timely development of Micro-reactors for deployment by the U.S Department of Defense (DoD). A critical point for a timely deployment is associated to the licensing process with U.S. NRC. As identified by a recent analysis carried out by INL, the main safety concern for heat pipe reactors are the thermo-mechanical stresses on the core structure following failure of multiple heat pipes.

The proposed work is focused on addressing this main safety concern, by means of experiments and high-fidelity simulations. The SPR design recently developed within a collaboration between Idaho National Laboratory (INL) and Los Alamos National Laboratory (LANL) is taken as reference, but the conclusions and the validated computational framework resulting from the proposed workscope can be extended to all other heat-pipe micro-reactor designs. Project includes following tasks:

1. Scaling study and pre-test simulations for the design of the experimental facility;
2. Construction of the experimental facility;
3. Definition and execution of experimental campaign;
4. Validation (and further improvement) of the codes suite (Sockeye coupled to the MOOSE);
5. Development of set of recommendations for heat pipe micro-reactors safety case.

The project will leverage experimental capabilities and expertise of ECMF laboratory of the university of Michigan and expertise of INL in code development and heat-pipe reactor design.