
Characterizing fast reactor fuel failure mode through separate effect and prototypic tests

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ABSTRACT:

The development of Liquid Metal-Cooled Fast Reactor (LMFR) has been on-going since the inception of nuclear electrical production and is now back at the forefront of the research and commercial deployment. In 2020, because of the renewed interest in advanced reactor technology and the search to produce clean energy, the Department of Energy, with the support of Congress, has launched the Advanced Reactor Demonstration Program to accelerate the development and construction of selected reactor design with the goal of a demonstration prototype operating by 2027. One awardee, the Natrium™ reactor designed by TerraPower LLC and GE-Hitachi leverages this LMFR technology. In the meantime, the U.S. Nuclear Regulatory Commission is moving forward with the development of the new 10CFR50.53 rule applicable to Licensing and Regulation to Advanced Nuclear Reactors. Within this context, a renewed interest has risen to accelerate the experimental validation of improved model capability that have been developed continuously since the late 60s, to assess safety of LMFR in normal and abnormal operating condition. One of the assessment tools is the SASSYS/SAS4A code developed at Argonne National Laboratory. It has been through continuous development and validation over the last decades and has been applied to both sodium and lead cooled fast reactor. In the recent years a new module, the Clad Damage Propagation (CDAP) module, has been developed to properly predict the evolution of a pin failure event. The data available for the validation of the model, however, are limited. The proposal will focus on obtaining data representative of some of the complex physical phenomena separately model in the CDAP code for transient condition encountered during Unprotected Transient Over Power or Loss Of Flow event.

The project objectives are:

- Develop the necessary instrumentation to support design of prototypic test. It is planned to use distributed sensor technology in prototypical bundle geometry to spatially resolve temperature during the simulated pin failure event.
- Create a database by conducting separate effect tests with well-characterized initial and boundary condition. To this effect, various test facility will be used with different fluid (oil, water, sodium) and prototypical geometry. Effort will be put to evaluate the distortion through scaling analysis.
- Perform comparison between the experimental data and the prediction obtained from the model developed in SASSYS/SAS4S
- Train undergraduate and graduate students on both the experimental and code development aspect with regards to the LMFR industry.

The proposal will also benefit from the strategic partnership with ARDP awardee Terrapower LLC and the SASSYS/SAS4S code development team at Argonne National Laboratory.