Material transport model development and integration in the System Analysis Module (SAM) code

PI: Wei Ji, Rensselaer Polytechnic Institute

Collaborators: Ling Zou – Argonne National Laboratory

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ABSTRACT:

The System Analysis Module (SAM) code currently under development at Argonne National Laboratory (ANL) is quickly becoming the workhorse for advanced non-light water reactor analysis at the system level. Although not exhaustive, SAM is suited for analyzing a variety of advanced reactor designs including salt cooled reactors, which include Molten Salt Reactors (MSRs) and Fluoride High Temperature Reactors (FHRs), and metal cooled reactors, which include Sodium Fast Reactors (SFRs) and Lead Fast Reactors (LFRs). Due to the design requirements of these advanced reactor types, a number of material transport related phenomena need to be accurately modeled since they are either present during normal reactor operation or become significant during a reactor accident scenario where source term evaluation becomes critical. Some important material transport examples would be insoluble fission product behavior and deposition in MSRs during normal reactor operation, fission product release in an FHR from a failed fuel-pebble, fission gas venting or gas plenum failure in an SFR, and corrosion product creation, precipitation, and deposition in salt cooled reactors during extreme salt redox potential transients. Currently, a general species transport framework exists within SAM, but advanced material models detailing the sink, source, and interaction terms for specific species of interest are still lacking. Resolving these sink and source terms correctly at the system level using lumped parameter models can be challenging due to the complicated physics that is occurring at the mesoscale. It is important to understand the correct space and time frame of these terms in determining the magnitude and impact material transport will have on the reactor system. Additionally, in several cases of interest, it is possible for species to interact with one another which heightens the complexity of the transport problem and can create unexpected multiphysics effects in the reactor.

In this project, we propose to develop and implement models for SAM which accurately characterize the sink, source, and interaction terms of key material species that are or may be present in various advanced reactor designs. The objectives of the project are to provide end users with an ability to utilize SAM in analyzing various material transport problems by (1) developing and implementing material production and transport models, (2) developing and implementing interaction models at phase boundaries and interfaces, and (3) demonstrating and validating the material transport and interface models against system level data sets and showing their utility for safety analysis of advanced reactors.