NUCLEAR ENERGY RESEARCH INITIATIVE

Detailed Reaction Kinetics for CFD Modeling of Nuclear Fuel Pellet Coating for High Temperature Gas-Cooled Reactors

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Collaborators: None

Related Program: AFCI

Project Description

High-temperature gas-cooled nuclear reactors are being adapted to produce a safe, effective, and economic source of energy. The fuel source for the reactors is from small uranium pellets coated to trap and retain radioactive fission products from escaping into the environment. Spouting fluidized beds, in which a central jet of gas fluidizes particles so they circulate in a regular pattern, are used to uniformly coat the fuel pellets. However, issues such as agglomeration, attrition, and breakage of particles need to be resolved to produce the highest quality particle coating. Further studies are required to improve the chemical vapor deposition (CVD) process to produce quality mixing and reactions for coating. While additional experimental data are necessary, direct measurements can be difficult to obtain. A complementary approach is to use computational fluid dynamics (CFD) to predict the CVD process.

The objective of this research is to conduct a state-of-the-art computational study of the chemical vapor deposition process in a spouting bed in order to validate and improve computational fluid dynamics models for the reaction kinetics to coat uranium fuel pellets with carbon and silicon carbide. This project will take a complementary approach using CFD to model the CVD process and apply it as a tool for reactor design, scale-up, and optimization. The work will validate the computations with experimental data for the multiphase fluid mechanics and species chemistry predictions required to describe the CVD process.

Work Scope

- Use computational chemistry to develop detailed reaction kinetics models of the gas-phase and surface molecule interaction, with a goal of predicting surface coating rates.
- Implement the reaction kinetics using in-situ adaptive tabulation for complex chemistry and couple to the MFIX computer code.
- Implement a polydispersity model in MFIX to account for effects of particle size distribution.