NUCLEAR ENERGY RESEARCH INITIATIVE

Validation and Enhancement of Computational Fluid Dynamics and Heat Transfer Predictive Capabilities for Generation IV Reactor Systems

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Project Number: 05-160

Collaborators: Fluent, Inc; Idaho National Laboratory

Related Program: Gen IV

Project Description

Currently, two primary approaches exist for computational fluid dynamics (CFD) modeling of reactor systems. Thermal/hydraulic analysis codes, such as RELAP, model the entire plant using coarse nodes but cannot predict small-scale flow details. Traditional CFD codes, such as FLUENT, are most adept at detailed flow and temperature predictions over specific regions. However, there are many unanswered questions regarding the ability of traditional codes to accurately model and predict complex flow patterns inherent in nuclear reactors, particularly turbulence. Turbulence is modeled either through direct numerical simulation (which is not practical for engineering design), large eddy simulation (which combines direct and empirical subgrid scale calculations), or Reynolds-averaged Navier-Stokes (RANS) equations (which is viable for complex geometries). Because no single model can handle all geometries, research is needed to validate, modify, and improve CFD predictive capabilities for the Generation IV reactors.

This project will validate and improve CFD predictive methods for Generation IV nuclear reactor systems. Researchers will assess the ability of large eddy simulation and RANS closure models, which are available in the FLUENT code, to predict flows for specific, fundamental geometries inherent in Next Generation Nuclear Plant reactors. Based on the results of the assessment, researchers will modify the closure models to improve predictive capabilities and obtain experimental data for relevant geometries to support code validation.

Work Scope

- Design and conduct experiments for parallel jets, crossflow, and crossflow cylinder array configurations.
- Perform a systematic validation study solving RANS equations in FLUENT using the above configurations, and determine necessary modifications to the turbulence model.
- Perform a systematic validation study using large eddy simulations to verify subgrid scale models in FLUENT and determine necessary modifications.