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Modeling of a 1/20th Scaled-down Gas Reactor Using MOOSE-based Application Pronghorn

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Introduction

University of Idaho (UI) designed and built a 1/20th scaled-down HTGR system to examine the mixing and venting of helium and reactor cavity air after a loss-of-coolant, also known as LOCA, due to a break in the reactor pressure vessel. Computational fluid dynamics (CFD) models of the system were developed, but their computational cost is high for modeling long transient accident scenarios.

A numerical approach is needed to have a better understanding of the physics phenomena that takes place following a LOCA event, and it can guide plant designers to design parameters for the development of mitigation techniques. This scenario is applicable to all HTR designs including the pebble bed reactor concept.

University of Idaho 1/20th Scaled-down HTGR.

Objectives

The objective of the project is divided into the following tiers:

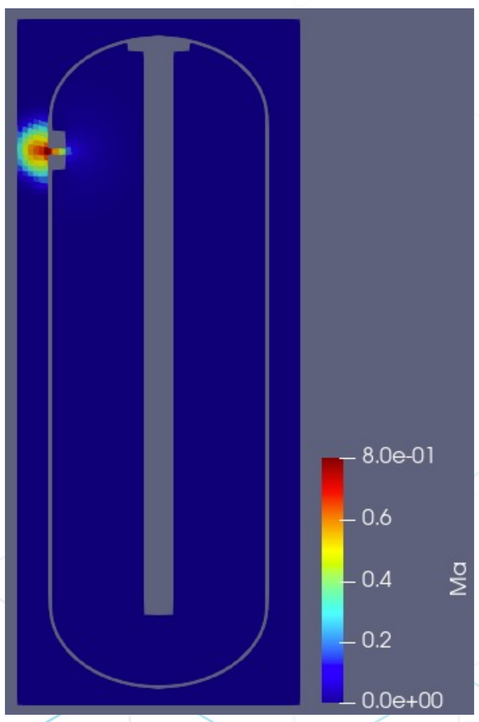
- develop a simulation of the scaled-down system using the MOOSE-based application Pronghorn,
- perform a verification analysis using experimental data gathered from UI, and
- compare numerical results against the commercial CFD software Star-CCM+.

The final product will be published in the Virtual Test Bed (VTB) repository to serve as a reference for other users to develop similar models using MOOSE.

Methodology

The modeling of a LOCA event is divided into two sections, where the first section focuses on the blowdown, while the second part focuses on the natural circulation.

This is meant to use specific settings to resolve phenomena of interest (e.g., shock wave during blowdown). The results from the the blowdown simulation will be used for the natural circulation simulation.



Break in the reactor pressure vessel: helium flowing into the containment cavity. Forced circulation due to the helium jet.

Depressurization complete: Pressure within the pressure vessel matches the pressure in the containment cavity.

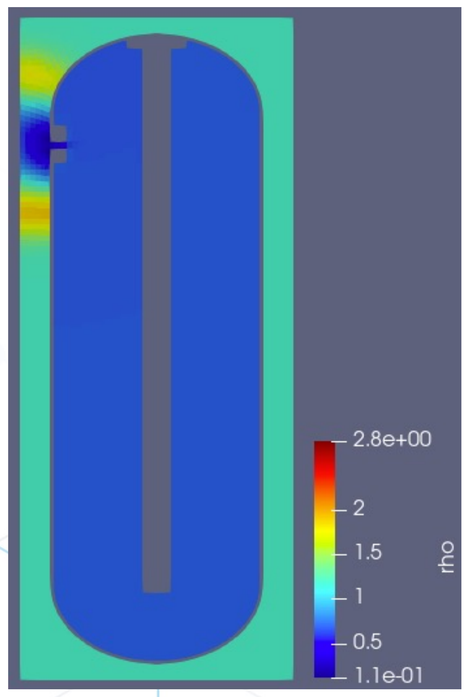
Natural circulation: Due to large temperature difference within the system, the air/he flow switches from forced to the natural circulation regime

Results

Simulations of the reactor pressure vessel with its respective containment were completed successfully. The blowdown and natural circulation simulations achieve convergence, and they provide results in a timely manner.

Future Work

Verification analysis efforts are underway. Two species model will be tested to analyze the helium/air mixing.



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