INTERNATIONAL NUCLEAR ENERGY RESEARCH INITIATIVE

Experimental Validation of Stratified Flow Phenomena, Graphite Oxidation, and Mitigation Strategies of Air Ingress Accidents

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Project Abstract

Previous studies have identified an air ingress event following reactor depressurization as an important accident scenario for the very high temperature reactor (VHTR). Consequently, the development of validated advanced air ingress-related models is a high priority for the Next Generation Nuclear Plant (NGNP), which will incorporate VHTR technology.

The major goal of this project is to upgrade the GAMMA code to reliably predict the consequences of air-ingress in the NGNP. To accomplish that, researchers will conduct experiments to understand important phenomena that occur during air-ingress accidents. These experiments will measure the following: 1) the effects of air ingress induced by a density-driven stratified flow into the reactor core, 2) the internal pore area density of nuclear grade graphite—which is an important parameter for determining the oxidation rate, 3) the oxidation and density variation in terms of graphite oxidation in the bottom reflector, and 4) the effects of the graphite oxidation on the structural integrity of the bottom reflector.

Accurately estimating safety margins in the VHTR design requires precise experimental data and tools, including accurate multi-dimensional thermal-hydraulic and neutronic models, a graphite oxidation model, and a fracture model. Researchers will develop a coupled neutronics and thermal-hydraulic capability in the GAMMA code, which will allow for high-pressure conduction cooldown transient simulations as well as accurate determination of initial and transient power distributions. Both of these are essential to accurately calculate safety margins.

Researchers will use the upgraded code to simulate air ingress accidents in order to evaluate various methods for mitigating the effects of air ingress. Air ingress leads to oxidation of the in-core graphite structure and fuel, which accelerates heat-up of the bottom reflector and the reactor core and eventually causes the release of fission products. The potential collapse of the bottom reflector due to graphite oxidation and the release of carbon monoxide would lead to serious safety problems.