
Scaling Studies for Advanced High Temperature Reactor Concepts

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ABSTRACT:

The objective of this proposed work is to expand the utilization of the Oregon State University High Temperature Test Facility (HTTF) to the validation of design and safety thermal-hydraulics methods developed for a broader range of advanced high temperature reactors and events. While HTTF was built for a prismatic block High Temperature Gas Reactor (HTGR), it can be expanded to other advanced gas-cooled reactors as well as key safety aspects of other high temperature reactors such as molten salt and even sodium cooled reactors.

The HTTF is based on a ¼-scale model of an HTGR with the capability for both forced and natural circulation flow through the prismatic core with an electrical heat source. The peak core region temperature capability is 1600°C. The facility can be modified to simulate safety-related passive natural circulation core cooling with heat rejection to air as well as passive containment cooling. Both these features are essential to several advanced high temperature reactor concepts including advanced gas-cooled fast reactors (e.g. EM²), molten salt reactors (e.g. AHTR and FHR) and sodium cooled reactors (e.g. PRISM). Although the fluids may be different, the computation methods for flow distribution, coupled natural circulation loops and direct heat rejection to air are similar. This latter aspect is an important safety feature of advanced high temperature reactors in that their safety cooling systems reject heat to air through a heat exchanger rather than by evaporative cooling which requires water replenishment within 72 hrs. (e.g. AP1000). Figure 1 shows a schematic of a generic passive natural circulation core cooling system as applied to the current test facility.

In addition, there are several advanced gas reactor designs that are radically different in both geometry and operation from the prismatic block HTGR. Two such examples include the pebble bed core type gas reactor and the General Atomics Energy Multiplier Module (EM²) reactor. There were several accident scenarios identified in the DOE and NRC gas reactor Phenomenon Identification and Ranking Tables (PIRT) that were not addressed in the original scaling analysis for this test facility. These include reactivity-induced transients, steam-water ingress events and process plant coupling events.

It is proposed under this work that the scaling analysis of the HTTF be revised to add a detailed scaling analysis of (1) a passive natural circulation core cooling system, (2) the two advanced gas reactor concepts mentioned above as well as (3) the utilization of the test facility for transients that were not included in the original scaling analysis. It is not expected that the test facility will be able to provide high-quality data for these designs and transients as currently configured and thus this work will also include the development of a set of design requirements, required modifications and a feasibility study for each of these different scaling sets.