Feasibility and Safety Assessment for Advanced Reactor Concepts Using Vented Fuel

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ABSTRACT

Most nuclear reactor systems utilize a fuel design that has a primary objective of the containment all of the produced fission products in solid, liquid and gaseous forms and their retention for the life of the fuel. Over the past 45 years several high temperature gas-cooled reactor system design concepts have employed a drastically different fuel design that included the venting of the fuel into a fission product collection system to accumulate the fission product gases from the fuel elements.

Recently General Atomics proposed the Energy Multiplier Module (EM^2) reactor concept. The EM^2 concept is a helium-cooled, all ceramic fast reactor incorporating materials and a geometry that potentially gives it a very long core life, in excess of 30 years without refueling. The fuel is planned to be uranium carbide particles that are sintered into a porous fuel plate which is not expected to retain any volatile or gaseous fission products. This fuel plate is then clad by silicon carbide which will exclude fission products from getting into the main coolant. The fuel elements are vented and a small amount of the main coolant and the gaseous and volatile fission products are collected into a collection system. The vent system will collect a small side stream of main coolant helium that goes through the fuel plates and sweeps virtually all the fission product gases and collects them on a multi-element filter system. The fission product collection filters will be removed from the system and sent to waste storage at a regular time interval. This should allow the on-site source term for any core accident to be minimized.

This project will perform analyses related to better quantifying the utility of such a vented fuel system, with an aim at better understanding the safety and licensing ramifications for a plant utilizing vented fuel. This study will include:

- An extensive literature review of past vented fuel concepts and their safety analysis , fission product release models in UC fuels, methods of fission product mobility in fuel, coolant and gas purge systems, and safety analysis methods.
- Design and systems analysis studies, using Aspen Plus, MELCOR and other tools to characterize the issues for vented fuel concepts.
- Development of numerical models and other tools for the simulation of fission product diffusion and release in UC fuels, fission product transport in a vented fuel plate, and fission product source terms and transport into a vented fuel collection system.
- Limited-scope PRA analysis to understand the implications of vented fuel technology and concepts.
- A detailed technology gap analysis for vented fuel safety assessments.
- Preliminary design of research reactor testing.