High-performance and Ultra-long Life Micro-Modular Reactor Cooled by Heat Pipes

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Abstract

This paper introduces a concept of a hybrid micro modular reactor (H-MMR) aimed at autonomous operation, which integrates an MMR and renewable energy through a common thermal energy storage system (ESS). The reactor power is 12 MWth and the reactor core is comprised of 18 hexagonal fuel assemblies (FAs) and it is to be designed for continuous operation without refueling over 20 years. The H-MMR core is surrounded by a thick PbO radial-reflector and an oxide dispersion-strengthened steel (ODS) axial-reflector with a B4C shielding layer in the outer region. Reactivity control drums are located in the radial-reflector region and a secondary shutdown system is placed in the center of the core. To achieve a good neutron economy over an ultra-long core lifetime, the inverted fuel assembly concept using a UN (U nitride) fuel is adopted in this work. A unique feature of the H-MMR is that it is cooled by sodium heat pipes without any flowing coolant in the core during both normal and transient conditions. All of neutronics analyses and depletions were performed by continuous energy Monte Carlo Serpent 2 code with the evaluated nuclear data file ENDF/B-VII.1 library. It was found that the reactor lifetime can be over 100-years without refueling, while the reactivity swing over the whole core lifetime is less than one dollar. These findings imply that inherently safe and long-life fast reactor can be realized by utilizing UN-based inverted FA concept with proper design parameters, enabling a very efficient autonomous load-following operation without any active controls.

Keywords: *Hybrid Micro Modular Reactor (H-MMR), Solid Inverted FAs, Uranium Mono-nitride (UN) fuel, Heat Pipe, Fast Reactor*