

Feasibility Study of a Small Modular Reactor driven by a High-Energy proton Accelerator

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Abstract

The development of advanced nuclear systems with enhanced safety, fuel sustainability, and reduced long-lived radioactive waste has stimulated growing interest in accelerator-driven systems (ADS). In this study, the feasibility of a thorium-fueled small modular reactor (SMR) coupled with a high-energy proton accelerator is investigated using an integrated multiphysics simulation framework combining neutronics and linear accelerator analysis.

Monte Carlo neutron transport simulations were performed using the OpenMC simulation platform to evaluate neutron production, energy spectra, and spatial heat and flux distribution within the subcritical reactor core. High-energy proton beams with energies ranging from 600 to 1000 MeV interacting with lead-bismuth eutectic (LBE) target were simulated using GEANT4 toolkit to extract neutron energy spectrum and spatial distribution.

The results demonstrate stable reactor operation under subcritical conditions while providing significant intrinsic safety advantages compared with conventional critical reactor systems due to easy access capability to terminate the fission process immediately through accelerator shutdown.

The proposed thorium-fueled ADS-SMR exhibits strong potential as a next-generation nuclear energy system for clean electricity generation, hydrogen production, and hybrid cogeneration applications. The presented computational methodology provides a robust platform for future safety assessment, design optimization, and performance evaluation of advanced subcritical nuclear reactors.

Index Terms

Generation IV Nuclear Reactors, Linear Accelerator, Multiphysics, Sustainability