Sodium versus Lead-Bismuth Coolants for the ENHS (Encapsulated Nuclear Heat Source) Reactor

Ser Gi Hong, Young Gyun Kim, and Yeong Il Kim
Korea Atomic Energy Research Institute
Deokjin-dong, Yuseong-gu, Daejon, Korea
Ehud Greenspan
Department of Nuclear Engineering
University of California, Berkeley, CA, USA

Abstract

The neutronic feasibility of designing cores for the ENHS (Encapsulated Nuclear Heat Source) reactor using sodium rather than lead-bismuth coolants is investigated. The cores considered are to be of uniform composition and to have no blanket elements and solid reflectors. They are to operate up to the fuel radiation damage limit without refueling, without fuel shuffling and with bunrup reactivity swings that is lower than 0.2%. It was found possible to design once-for-life cores for the ENHS reactor that will feature nearly zero burnup reactivity swing using either Pb-Bi (Pb is essentially the same) or sodium coolants. Relative to Pb-Bi cooled cores, sodium cooled cores feature tighter lattice and therefore more compact cores, spikier power distribution and more positive coolant temperature coefficient of reactivity. Due to their larger peak-to-average power distribution, the average discharge burnup of all-sodium cooled cores is smaller by ~5% than that of Pb-Bi cooled cores. Of the sodium-cooled cores considered, the one using lead-bismuth for the secondary coolant offers flatter power distribution and significantly larger reactivity worth of the peripheral absorber.