Application of the Heterogeneous Thorium Fuel Core for Enhanced Proliferation Resistance and Fuel Cycle Economy

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Abstract

A heterogeneous thorium-based seed and blanket core design is suggested for a conventional pressurized light water reactor (PWR) and evaluated to enhance the proliferation resistance potential and fuel cycle economics. In this paper, a core loaded with optimized seed and thorium blanket assembly were suggested and examined for the neutronic and thermal hydraulic characteristics. KTF core has more negative MTC value due to lower boron concentration by 200 ppm than that of reference PWR over the whole cycles. MDNBR is 1.36 at 2^{nd} reload cycle under the 118% over-power transient condition in spite of high pin power peaking. Maximum cladding temperature is predicted to 973K in a LBLOCA simulation and guaranteed metal fuel integrity at severe accidental condition. Bare critical mass is 30.36 kg and thermal generation is 45.22 watts/kg that 1.5~2 times higher than those of the conventional PWR. Blanket has a higher radio-toxicity than seed and PWR assemblies owing to high burnup. The fuel cycle cost of KTF core is 4.96 mills/kWe-hr, which is cheaper than 5.23 mills/kWe-hr of the reference UO_2 fuel. It is noted that KTF core has good competitiveness in fuel cycle economics and proliferation resistance as well as neutronic and thermal hydraulic performances.