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Reduction of Plutonium Production in Heavy Water Research Reactor: A Feasibility Study through Neutronic Analysis Using MCNPX2.6 and CINDER90 Codes

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Abstract : One of the main characteristics of Heavy Water Moderated Reactors is their high production of plutonium. This article demonstrates the possibility of reduction of plutonium and other actinides in Heavy Water Research Reactor. Among the many ways for reducing plutonium production in a heavy water reactor, in this research, changing the fuel from natural Uranium fuel to Thorium-Uranium mixed fuel was focused. The main fissile nucleus in Thorium-Uranium fuels is U-233 which would be produced after neutron absorption by Th-232, so the Thorium-Uranium fuels have some known advantages compared to the Uranium fuels. Due to this fact, four Thorium-Uranium fuels with different compositions ratios were chosen in our simulations; a) 10% UO₂-90% THO₂ (enriched= 20%); b) 15% UO₂-85% THO₂ (enriched= 10%); c) 30% UO₂-70% THO₂ (enriched= 5%); d) 35% UO₂-65% THO₂ (enriched= 3.7%). The natural Uranium Oxide (UO₂) is considered as the reference fuel, in other words all of the calculated data are compared with the related data from Uranium fuel. Neutronic parameters were calculated and used as the comparison parameters. All calculations were performed by Monte Carol (MCNPX2.6) steady state reaction rate calculation linked to a deterministic depletion calculation (CINDER90). The obtained computational data showed that Thorium-Uranium fuels with four different fissile compositions ratios can satisfy the safety and operating requirements for Heavy Water Research Reactor. Furthermore, Thorium-Uranium fuels have a very good proliferation resistance and consume less fissile material than uranium fuels at the same reactor operation time. Using mixed Thorium-Uranium fuels reduced the long-lived α emitter, high radiotoxic wastes and the radio toxicity level of spent fuel.

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