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Preliminary Study on the Factors Affecting Safety Parameters of (Th, U)O_2 Fuel Cycle: The Basis for Choosing Three Fissile Enrichment Zones

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Abstract : The beginning of cycle transient safety parameters is paramount for smooth reactor operation. The enhanced operational safety of UO_2 fuelled AP1000 reactor being the first using three fissile enrichment zones motivated this research for (Th, U)O_2 fuel. This study evaluated the impact of fissile enrichment, soluble boron, and gadolinia on the transient safety parameters to determine the basis for choosing the three fissile enrichment zones. Fuel assembly and core model of Westinghouse small modular reactor were investigated using different fuel and reactivity control arrangements. The Monte Carlo N-Particle eXtended (MCNPX) integrated with CINDER90 burn-up code was used for the calculations. The results show that the moderator temperature coefficient of reactivity (MTC) and the fuel temperature coefficient of reactivity (FTC) were respectively negative and decreased with increasing fissile enrichment. Soluble boron significantly decreased the MTC but slightly increased FTC while gadolinia followed the same trend with a minor impact. However, the MTC and FTC respectively decreased significantly with increasing change in temperature. These results provide a guide on the considerable factors in choosing the three fissile enrichment zones for (Th, U)O_2 fuel in anticipation of their impact on safety parameters. Therefore, this study provides foundational results on the factors that must be considered in choosing three fissile arrangement zones for (Th, U)O_2 fuel.

Keywords : reactivity, safety parameters, small modular reactor, soluble boron, thorium fuel cycle
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