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A methodology for determining the transmutation efficiency of minor actinides in nuclear reactors

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The long-lived minor actinides (MAs); americium, neptunium, and curium are the major contributors, after a few centuries, to the long-term radiotoxicity of spent fuel. Therefore, the transmutation of these MAs is considered as an alternative way to the direct disposal. Up to now no definite internationally recognized quantitative criterion of MAs transmutation efficiency was worked out, although this would be highly desirable. The absolute and relative total mass reduction of MAs are completely inadequate because they ignore the accumulation of higher radiotoxic long-lived MAs from the transmuted nuclide. In the current work, we introduce a new criterion for transmutation efficiency of MAs in nuclear reactors and demonstrate its efficiency on the Single-fluid Double-zone Thorium-based Molten Salt Reactor (SD-TMSR). The proposed criterion takes into account the mass of all useful MAs, short-lived MAs, and short-lived fission products (FPs). In contrast, the mass parameters calculate the reduction in the MAs mass regardless of the produced nuclides. We introduce a new approach to load MAs into the SD-TMSR. The proposed approach merges the advantages of both homogeneous and heterogeneous approaches. The overall change in the actinides and FPs mass during the irradiation has been calculated using direct SERPENT-2 calculations. The results show that the transmutation efficiency of Am-241, the prime candidate for transmutation, in the SD-TMSR reaches 82.6 % after 1500 days of radiation.

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