Scenarios for Minor Actinides Transmutation in the Frame of the French Act for Waste Management

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Abstract

In the frame of the French Act for waste management, options of minor actinides (MA) transmutation are studied, based on several scenarios of Sodium Fast Reactor deployment. Basically, one of these scenarios considers the deployment of a 60 GWe SFR fleet in two steps (20 GWe from 2040 to 2050 and 40 GWe in addition from 2080 to 2100). For this scenario, the advantages and drawbacks of different transmutation options are evaluated:

- transmutation of all minor actinides or only of americium.

- transmutation in homogeneous mode (MA bearing fuel in all the core or just in the outer core) or in heterogeneous mode (MA bearing radial blankets).

Scenarios have been optimized to limit the impacts of MA transmutation on the cycle:

- reduction of the initial MA content in core in the case of transmutation in homogeneous mode to reduce the impact on reactivity coefficients.

- reduction of the number of rows of blankets and the fuel decay heat in the case of transmutation in heterogeneous mode.

The sensitivity of transmutation options to cycle parameters such as the fuel cooling time before transportation is also assessed. Thus, the transmutation of only americium in one row of radial blankets containing initially 10 wt% Am and irradiated during the same duration than the standard fuel assemblies appears to be a suitable solution to limit the transmutation impacts on fuel cycle and facilities.

A comparison of results obtained with MA transmutation in dedicated systems is also presented with a symbiotic scenario considering ADS (Accelerator Driven System) deployment to transmute MA together with a SFR fleet to produce energy. The MA inventory within the cycle is higher in case of transmutation in ADS than in case of transmutation in SFR.

Considering the industrial feasibility of MA transmutation, it appears important to study “independently” the SFR deployment and the MA transmutation. Consequently, scenarios of progressive introduction of MA options are assessed:

- beginning of MA partitioning and transmutation once the SFR fleet is totally deployed, which comes to transmuting only the MA produced by the SFR fleet at equilibrium,

- no MA transmutation at the beginning of SFR deployment, then introduction of MA transmutation in radial blankets, and finally in homogeneous mode at the SFR fleet equilibrium. A similar scenario with only americium transmutation is also considered.

Results of these progressive scenarios in terms of MA inventory in waste and in cycle are found to be intermediate between those of scenarios dedicated to each transmutation option. The MA inventory in waste is function of the date of the beginning of MA partitioning.