

## MINOR ACTINIDE TRANSMUTATION IN A GAS-COOLED FAST REACTOR

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### Abstract

The gas-cooled fast reactor (GFR) is one of the six reactor designs under investigation in the Generation IV initiative and is specifically dedicated to minor actinide (MA) transmutation and nuclear waste reduction. This paper summarizes the work done on the CEA designed GFR600 model in order to assess its MA burning capabilities using the SCALE code system.

A parametric study was performed with cores containing various amounts of minor actinides with distinct spatial distributions and of different origin. The results show that the addition of MAs to the fuel greatly reduces the reactivity loss during burnup. Moreover, the higher the MA content of the core, the higher fraction of the loaded MAs is fissioned; however, the more the safety parameters deteriorate. During single cycle irradiation only the quantity of neptunium and americium isotopes can be significantly reduced, curium isotopes accumulate. This makes reprocessing challenging as Cm isotopes are the most significant sources of both neutrons and heat in the irradiated GFR fuel.

Multiple consecutive cycles were also investigated with two refuelling strategies. Adding only depleted uranium to the reprocessed actinides (pure DU feed strategy) can reduce the total initial minor actinide content by up to 70% in the first 5 cycles of 1300 effective full power days. Moreover, the reactor can be made critical during this time if the initial MA content of the core is higher than 3%. When MAs are also added (constant MA content strategy) the reactivity has a continuous increase from cycle to cycle, primarily due to the  $^{238}\text{Pu}$  breeding from  $^{237}\text{Np}$ . Unfortunately the safety parameters deteriorate in both strategies during the cycles.

The effects of the origin of MAs and plutonium were also investigated. Despite the considerably different MA and Pu vectors characteristic to the spent fuel of traditional western type pressure water reactors and Russian type VVER440 reactors, no major difference was found in the overall MA transmutation. However, the Pu isotopic composition showed a strong effect on the reactivity and the delayed neutron fraction in the first cycles.

Finally, cores having non-uniform MA content were investigated. Though the MA destruction is significantly more efficient in the center of the core than at the edge due to the harder spectrum, it was found that moving some of the minor actinides from the outer regions to the inner zone only results in minor improvement in transmutation. However, the spectral changes due to the rearrangement increase the reactivity and enable reaching higher burnup and minor actinide destruction. At the same time some of the safety parameters of the reactor further degrade.