TRANSMUTATION AND BURNING OF MAs IN LWRs, MTRs AND ADSs

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Abstract

The paper examines the neutron-induced evolution of MAs irradiated in LWRs, MTRs and ADSs as calculated with current codes and nuclear data libraries, for realistic targets. The reactors considered are, in particular, as LWR a typical 1000 MWe MOX-fuelled PWR, as MTR the high flux materials testing reactor BR2 (60 to more than 100 MWth) located at SCK•CEN, and as ADS the prototype MYRRHA (about 30 MWth) in its present development stage at SCK•CEN, described in another paper of this workshop [1]. The transformation of the actinides by (n,γ) reactions (neutron capture) into higher isotopes ("transmutation") and their disappearance out of the actinide family by (n,f) reactions (actinide fission or "burning") are discussed in detail for the three reactor types. While fast spectrum systems such as the proposed ADS immediately burn the MAs, but at relatively low rates because of the small cross-sections, thermal spectrum systems, with large (n,γ) cross-sections, first transmute the MAs into higher isotopes, some of which ultimately are also fissile in the thermal energy range. In the case of MTRs, in which high (thermal) fluxes prevail, large fractions of MAs are thus transmuted and ultimately burnt in relatively short times, nevertheless at the cost of several neutron captures before fission occurs and therefore with bad neutron economy.

The present study is a continuation of work presented at the 6th Information Exchange Meeting on Actinide and Fission Product Partitioning and Transmutation on December 11-13 at Madrid [2], now further extended to PWR irradiations. In addition, attention is paid to the neutron spectrum variations occurring in the targets and hence to the variations of the neutron-spectrum-averaged microscopic fission and capture cross-sections, as a function of time, as more and more MAs disappear and other actinides and fission products are produced. Also the neutron economy aspects will be addressed.

A comparison between fast reactors and ADSs as to their transmutation and burning capacities was made in [3].

[1] H. Aït Abderrahim, P. Kupschus, Ph. Benoit, E. Malambu, K. Van Tichelen, B. Arien, F. Vermeersch, Th. Aoust, Ch. De Raedt, S. Bodart, P. D'hondt, "MYRRHA, a Multipurpose ADS for R&D. Pre-design Phase Completion", to be presented at this workshop.
[2] Ch. De Raedt, B. Verboomen, Th. Aoust, A. Beeckmans de West-Meerbeeck, H. Aït Abderrahim, E. Malambu, Ph. Benoit , L. H. Baetslé, "MA and LLFP Transmutation in MTRs and ADSs. The Typical SCK-CEN Case of Transmutation in BR2 and MYRRHA. Position with Respect to Global Needs", Sixth Information Exchange Meeting on Actinide and Fission Product Separation and Transmutation", Madrid, Dec. 11-13, 2000.
[3] Ch. De Raedt, L.H. Baetslé, E. Malambu, H. Aït Abderrahim, "Comparative Calculation of FR-MOX and ADS-MOX Irradiations", International Conference on Future Nuclear Systems, GLOBAL'99, Jackson Hole (Wyo.), Aug. 30 - Sept. 2, 1999.