Comparative Analysis of Isotopic Composition of Spent Fuel from Takahama-3 PWR PIE database using TRIPOLI-PEPIN Code

Yi-Kang Lee[*1]

1 CEA/Saclay – DEN/DM2S/SERMA/LEPP, 91191 Gif sur Yvette Cedex, France

Abstract

Evaluation of isotopic composition of spent nuclear fuel is essential for reactor physics and fuel cycle backend applications. A TRIPOLI-PEPIN coupled depletion code, TR4PEP, has been developed to meet these requirements. It combines the continuous-energy Monte Carlo transport code, TRIPOLI-4.3 [1] and the point depletion code, PEPIN-2 [2], to perform the burnup dependent material data calculation.

The depletion calculation flow of TR4PEP code has been presented on a previous study. Its application on PWR UO_2 and MOX spent fuel has been validated against several international numerical benchmarks. Compared to industry standard deterministic cell codes and other Monte Carlo based depletion codes, TR4PEP deep-burn depletion calculations have shown satisfactory results. [3]

In addition to the numerical benchmarks, the analysis of available post irradiation examination (PIE) results by TR4PEP is also important. The PIE results at fuel assembly level are accessible only from spent fuel reprocessing plant and these data are not easy to use for code validation due to the dissolution of several assemblies in the same time. The PIE results at fuel pellet level depend not only on the method for the isotopic measurements but also on the irradiation environment and history.

A free access PIE database on isotopic composition of spent nuclear fuel is obtainable from OECD/NEA. [4] Both PWR and BWR PIE data at fuel pellet level are taken into account in this database but the only 17 x 17 type PWR fuel available in this database is from Takahama-3 PIE results.

To validate TR4PEP with Takahama-3 PIE results, two irradiated UO_2 samples, SF95-4 from fuel assembly NT3G23 and SF97-5 from NT3G24, are considered in this study. Both samples have an initial ^{235}U enrichment of 4.11 wt% and their burnup are respectively 36.69 and 47.03 GWd/t.

Comparative analysis of isotopic composition from SF95-4 and SF97-5 including 19 actinides from ^{234}U to ^{247}Cm and 18 important fission products has been carried out. This paper reports the C/E values between TR4PEP calculated result and Takahama-3 PIE measurements and also the comparison results between the TR4PEP calculations of this study and previous MVP-ORIGEN2 calculations. [5]

As the axial distribution of moderator density is not available from the PIE database, a sensitivity study of isotopic composition on moderator density will be also presented. [6]

KEYWORDS: Monte Carlo depletion, TRIPOLI-PEPIN, Takahama-3, Post Irradiation Examination, moderator density

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[*] Corresponding author, Tel. 33-1-69-08-84-79, Fax. 33-1-69-08-45-72, E-mail: yklee@cea.fr

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