Reactivity Impact of Difference of Nuclear Data Library for PWR Fuel Assembly Calculation by Using AEGIS Code

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1. Introduction

In 2010, the latest version of the Japanese Evaluated Nuclear Data Library (JENDL-4.0) has been released by JAEA[1]. JENDL-4.0 is major update from JENDL-3.3, and confirmed to give good accuracy by integral test for fission reactor systems such as fast neutron system and thermal neutron system [2]. In this study, we evaluated the reactivity impact due to difference between ENDF/B-VII.0[3] and JENDL-4.0 for PWR fuel assembly burnup calculation using AEGIS code[4] which has been developed by Nuclear Engineering, Ltd. in cooperation with Nuclear Fuel Industries, Ltd. and Nagoya University.

2. Methods and Results

2.1 AEGIS Code

AEGIS is a lattice code with a very detail resonance treatment in evaluation of effective cross sections based on spectrum calculation with an ultra-fine energy group structure. Two dimensional transport calculation based on the method of characteristics is performed with the XMAS energy group structure where 172 energy groups are treated. Depletion calculation is performed with a very detailed burnup-chain where approximately 200 nuclides are explicitly treated based on the Krylov sub-space method for accurate and fast calculation[5]. A novel method to improve prediction accuracy of depletion of Gadolinium in the integrated absorber rods is implemented as the projected predictor/corrector method to realize larger burnup step, which contribute to great reduction of computation time[6].

The calculation conditions of AEGIS for commercial PWR core design are 48 divisions for azimuthal direction of 2π phase space and 0.2cm of ray interval parameters (RT020AZ48) for the typical UO2 fuel assembly and 64 divisions and 0.2cm ray intervals (RT020AZ64) for the Gadolinia(Gd)-bearing UO2 fuel assembly. It is confirmed that these conditions provide good accuracy in comparisons with results by Monte-Carlo depletion calculation using by MVP-BURN[7] and reference calculation by AEGIS with a detail condition, for instance 128 divisions and 0.05cm ray intervals (RT005AZ128). The comparisons of k-infinity for UO2 fuel and Gd-bearing UO2 fuel are shown in Fig.1 and 2.

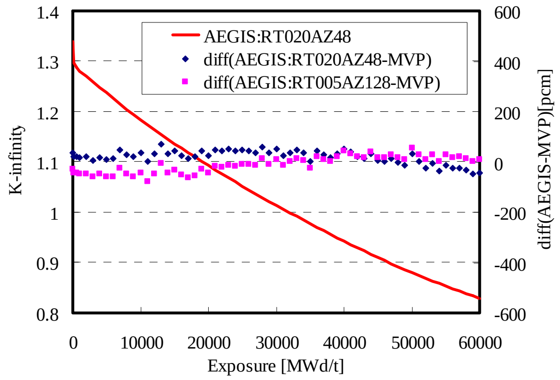

Fig.1 Comparison of k-infinity of UO2 assembly between MVP and AEGIS

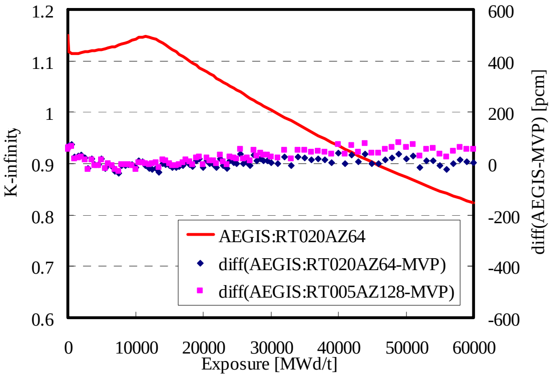

Fig.2 Comparison of k-infinity of Gd assembly between MVP and AEGIS

It confirmed that the results by AEGIS agreed with that by MVP within the range of ±100pcm throughout burnup.

2.2 Impact on Change of Cross-Section Library

In the next step, impact due to change of cross-section library from ENDF/B-VII.0 to JENDL-4.0 was examined using AEGIS for fuel assembly of UO2 and Gd-bearing UO2 as shown in Fig. 3 and 4, respectively. Results by each library agreed well for both fuel where impact on k-infinity change was in the range of approximately ±200pcm while JENDL-4.0 gives higher reactivity than ENDF/B-VII.0 at the point of 0MWd/t.

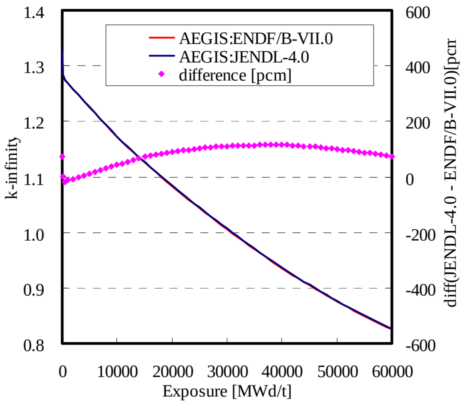

Fig.3 Comparison of k-infinity of UO2 assembly between JENDL-4.0 and ENDF/B-VII.0 by AEGIS

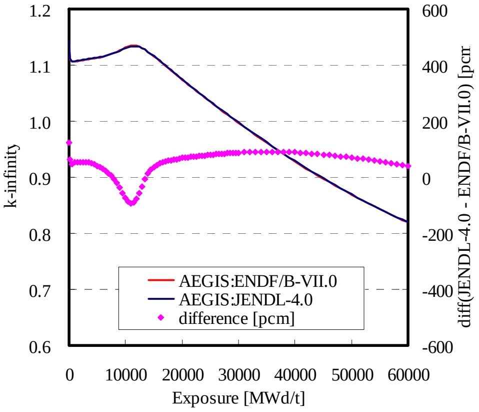

Fig.4 Comparison of k-infinity of Gd assembly between JENDL-4.0 and ENDF/B-VII.0 by AEGIS

Components of the impact on k-infinity were also examined by changing cross section data of major nuclides from ENDF/B-VII.0 to JENDL-4.0 for both assemblies. As shown in Fig.6 and 7, the impacts were caused by U-238, U-235, Pu-239, Xe-135, Gd-155, Gd-157 and summations of each Zr nuclides. The major contributor is Pu-239, in which fission cross-section is different between each cross-section data.

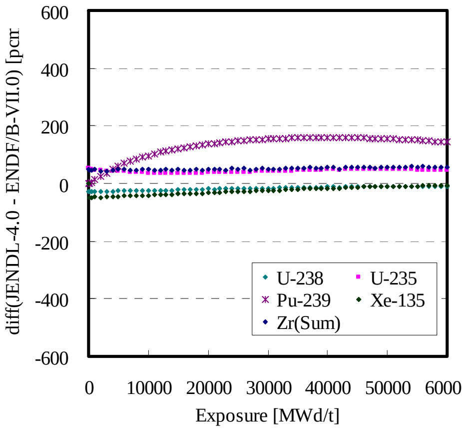

Fig.6 Impact on k-infinity of UO2 assembly

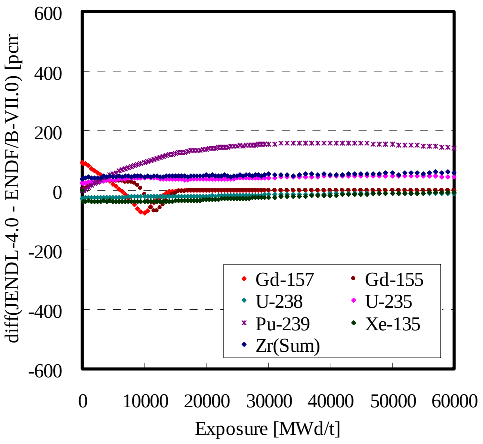

Fig.7 Impact on k-infinity of Gd assembly

3. Conclusions

In this study, the change of k-infinity was evaluated due to difference between ENDF/B-VII.0 and JENDL-4.0 in PWR fuel burnup calculations. It is found that the change is in the range of 200pcm that is small enough for design calculations. The major contributor is Pu-239, in which fission cross-section data is different especially in the resonance energy region between two libraries.

REFERENCES

[1] K. Shibata, O. Iwamoto, T. Nakagawa, *et. al.*, JENDL-4.0: A New Library for Nuclear Science and Engineering, Journal of Nuclear Science and Technology, Vol.48, No.1, p.1, 2011.

[2] G. Chiba, K. Okumura, K. Sugino, *et. al.*, JENDL-4.0 Benchmarking for Fission Reactor Applications, Journal of Nuclear Science and Technology, Vol.48, No.2, p.172, 2011.

[3] M.B. Chadwick, P. Oblozinsky, M. Herman, *et. al.*, ENDF/B-VII.0: Next Generation Evaluated Nuclear Data Library for Nuclear Science and Technology, Nuclear Data Sheets, Vol.107, p.2931, 2006.

[4] N. Sugimura, A. Yamamoto, T. Ushio, *et. al.*, Neutron Transport Models of AEGIS: Advanced Next-Generation Neutronics Design System, Nuclear Science and Engineering, Vol.155, p.276, 2007.

[5] A. Yamamoto, M. Tatsumi, N. Sugimura, Numerical Solution of Stiff Burnup Equation with Short Half Lived Nuclides by the Krylov Subspace Method, Journal of Nuclear Science and Technology, Vol.44, No.2, p.147, 2007.

[6] A. Yamamoto, M. Tatsumi, N.Sugimura, Projected Predictor-Corrector Method for Lattice Physics Burnup Calculations, Nuclear Science and Engineering, Vol.163, No.2, p.144, 2009.

[7] K. Okumura, T. Mori, M. Nakagawa, *et.al.*, Varidation of A Continuous Energy Monte Carlo Burn-up Code MVP-BURN and Its Application to Analysis of Post Irradiation Experiment, Journal of Nuclear Science and Technology, Vol.37, p.128, 2000.