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Influence of Nuclear Data Files on the Analyses of Metallic Uranium Fueled BFS Critical Assemblies

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1. Introduction

The uncertainty of nuclear data occupies a considerable portion in the fast reactor analysis compared with other uncertainties coming from methodologies, geometrical approximation, and so on. This uncertainty mainly comes from a lack of evaluated nuclear data of TRU nuclides, especially minor actinides.

An analysis of fast reactor has been carried out with KAFAX-E66[1] derived from ENDF/B-VI.6 nuclear data file. Several nuclear data files have been released since 2002. The study is to figure out the characteristics of each nuclear data file and to evaluate the influences on the results of BFS critical assemblies.

2. Brief Descriptions of BFS critical assemblies

BFS-73-1[2] and BFS-75-1[3] critical experiments were carried out by international cooperation with IPPE to verify early KALIMER-150 core analysis, which is metallic uranium fueled core. BFS-73-1 has a single enrichment core of ~18.5wt%, while BFS-75-1 has two enrichment zones, low enrichment zone (LEZ), high enrichment zone (HEZ). Both BFS assemblies are surrounded by thick radial blanket rings and axial blankets in both sides.

BFS-73-1 critical experiment had done in 1997 but the critical assembly was recomposed to measure reaction ratios of several minor actinides that had not measured in previous experiment. For the benchmark specification of BFS-73-1 assembly, several corrections were made to effective multiplication factor and spectral indices to be consistent between real BFS-73-1 geometry and benchmark geometry, which was about 250 pcm including unit cell heterogeneity effect, control rod removal, core boundary simplification. The cell heterogeneity effect was dominant as about 150 pcm.

Unit cell heterogeneity effect of BFS-75-1 was evaluated as 0.00615 in k-effective by using TWODANT in this study.

3. Methods and Results

Three new nuclear data files, ENDF/B-VII.0, JEFF-3.1, and JENDL-3.3 are used for the evaluation. The nuclear data files are converted into MATXS format by NJOY code. This work is contributed by nuclear data evaluation laboratory in KAERI.

All analyses are carried out based on the K-CORE system, which has been developed by KAERI for fast reactor analysis. Effective cross sections for each zone of BFS critical assemblies are processed by TRANSX[4] with narrow resonance approximation. Nuclear parameters, effective multiplication factor, spectral indices, and reactivity worth for each assembly were calculated by TWODANT[5] (S_N) and DIF3D[6] (FDM or Hex-Z nodal) with R-Z Hex-Z geometrical approximation and with various neutron energy group structures.

3.1 k-effective

Figure 1 and Figure 2 show C/E values of k-effective with respect to nuclear data files used. The dot lines in the figures are boundaries of experimental uncertainties. For BFS-73-1 assembly, the calculated k-effective is in good agreement with measured value within measurement uncertainty except for the JENDL-3.3. JENDL-3.3 tends to always underestimate k-effective. There is no significant difference by geometrical approximation and neutron energy group structures; however, 6g energy structure tends to largely overestimate the k-effective.

Calculated k-effective for BFS-75-1 agrees well with measured value within uncertainty for the ENDF/B-VII.0 and JEFF-3.1. ENDF/B-VI.6 tends to overestimate while JENDL-3.3 tends to underestimate. This tendency is kept through BFS-73-1 and BFS-75-1 critical assemblies.

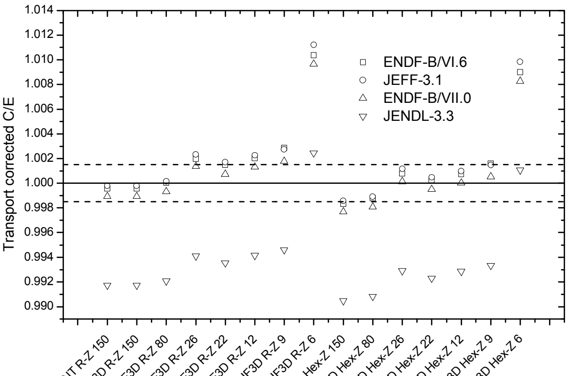

Figure 1 Comparison of effective multiplication factors for BFS-73-1 critical assembly

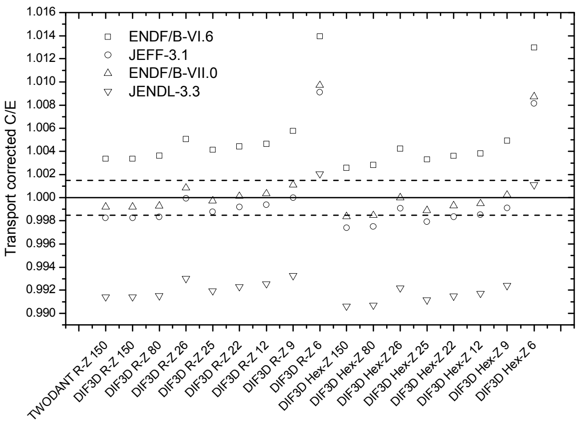

Figure 2 Comparison of effective multiplication factors for BFS-75-1 critical assembly

3.2 Spectral Indices and reaction ratio

Figure 3 and Figure 4 show C/E values of spectral indices and reaction ratio. Error bar in the figure represents measurement uncertainty for each corresponding reaction ratio. For the major nuclides the calculated values are good agreement with measured data within uncertainty, while large discrepancies are observed in reaction ratios of minor actinides. Although it does not significantly affect on nuclear performance of the current sodium cooled fast reactor because of low MA content in heavy metal, for example, 5.3% in KALIMER-600 TRU burner design, it would be necessary to reduce uncertainty involved in fuel cycle performance such as TRU and MA transmutation rate.

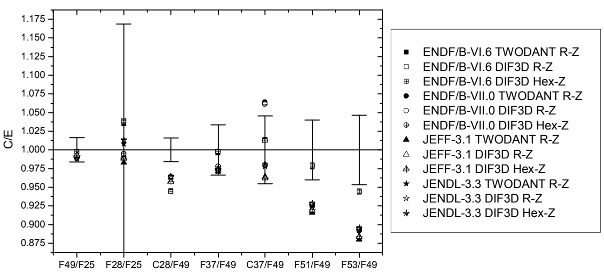

Figure 3 Comparison of spectral indices and relative reaction ratio for BFS-73-1 critical assembly

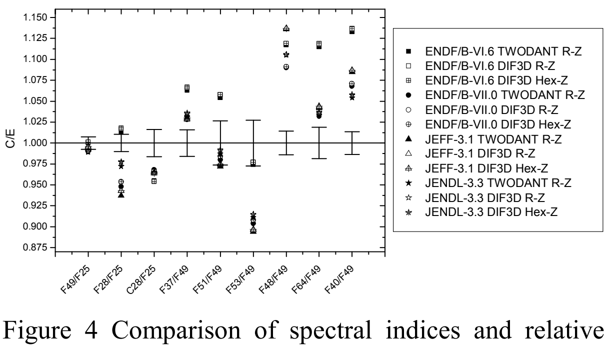

Figure 4 Comparison of spectral indices and relative reaction ratio for BFS-75-1 critical assembly

3.3 Sodium Void Reactivity

Sodium void reactivity was calculated for four cases according to voided locations and voided fraction. Only results with JEFF-3.1 shows reasonable results of sodium void reactivity through all cases.

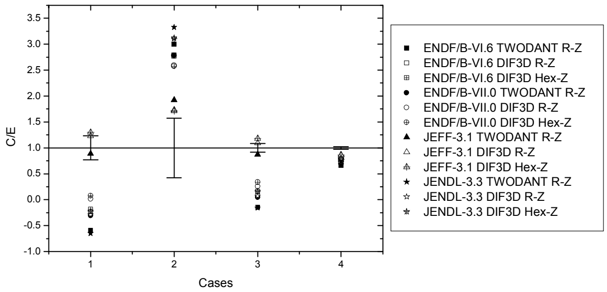

Figure 5 Comparison of sodium void reactivity for BFS-75-1 critical assembly

4. Conclusion

Two metallic uranium fueled BFS critical assemblies were analyzed by varying the nuclear data libraries, geometrical approximation, and neutron energy group structures. Calculated k-effective agreed well with the measured value except for the JENDL-3.3 but improvement is still needed for MA nuclides.

Results of this study could be used to decide the nuclear data file that will be used for Korean sodium cooled fast reactor analysis and provide fundamental data to catch the characteristics of recent nuclear data files.

ACKNOWLEDGEMENT

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