Generation of Multigroup Cross Section Library with Different Energy Group Structures

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1. Introduction

Direct whole core transport or lattice transport calculation requires multigroup cross section library data consisting of groupwise reaction cross sections and resonance parameters. A cross section library with more energy groups would allow better accuracy at the expense of increased computing time. It is therefore necessary to check the sensitivity of error and efficiency of transport calculation on the energy group structure. The purpose of this work is to establish and examine a procedure to generate multigroup cross section library with various energy group structure based on an earlier work by Kim[1] which assumed only a preset group structure.

2. Group Structures

We used three energy group structures - 47, 177 and 190 energy group structures. The 47- and 190- energy group structures are the same as the HELIOS libraries and and the 177-group structure is a modified structures which involves several merged groups in the resonance range of the 190-group structure. Figure 1 shows the U-238's absorption cross sections in the resonance energy range for the three group structures.

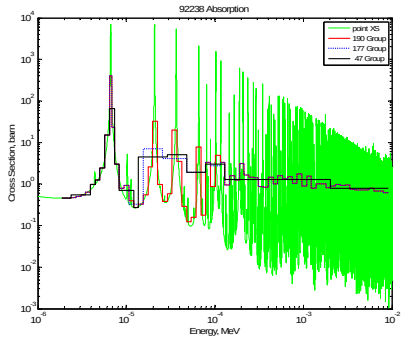

Figure 1. Group -averaged cross sections of U-238 absorption for three group structures.

3. Multigroup Xsec Generation Procedure

Three steps should be taken to generate a multigroup cross section library as shown in Figure 2. Here the input file for GenP – 'genplib.fmt' has the basic data to generate subgroup parameters. The first step is the generation of subgroup parameters while the second step is the generation of groupwise cross sections. Finally, GadXS collects the subgroup parameters and groupwise cross sections into one multigroup cross section library.

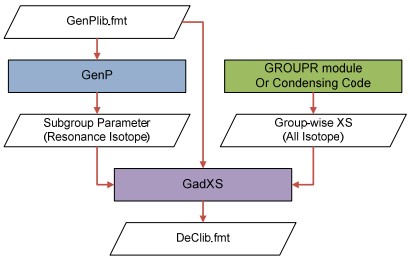

Figure 2. The flowchart of library generation.

3.1 Subgroup parameters

In the previous generation procedure, the code GenP to calculate subgroup parameters had a dependency on the HELIOS library because GenP was written for 47 and 190 energy group structures. So it was not able to generate a multigroup cross section library having an arbitrary energy group structure. To solve this problem, we implemented a new input format to replace the HELIOS library and modified GenP and DeCART to read the new input format. Now, the subgroup parameters of any energy group structure we want can be generated.

3.2 Groupwise cross sections

3.2.1 GROUPR module

GROUPR module of NJOY computes group-averaged cross sections using the spectrum given in the input by collapsing pointwise cross section from ENDF/B in the specific energy range. A spectrum in 190G was generated for 4.95w/o enriched fuel pin cell using MCNP. The groupwise cross sections generated by GROUPR contain all kinds of possible reactions, so a post-processing is needed to refine output. LIBDEC converts the GROUPR output to the specific format of DeCART.

3.2.2 Energy group condensing

If there are finer multigroup groupwise cross sections, they can be used generate condensed groupwise cross sections according to the following equations:

$$\sigma_{a,G} = \frac{\sum_{g=gm}^{gn} \sigma_{a,g}\phi_g}{\sum_{g=gm}^{gn} \phi_g} [gm \le G \le gn] \qquad (1)$$

$$\sigma_{s,G\to G'} = \sum_{g'=gm'}^{gn'} \left(\frac{\sum_{g=gm}^{gn} \sigma_{s,g\to g'}\ \phi_g}{\sum_{g=gm}^{gn} \phi_g} \right) \left[gm \le G \le gn,\ \ gm' \le G' \le gn' \right] (2)$$

This method has limitation that the energy group boundaries should be the same as the base one. In this examination, condensed groupwise cross sections were generated based on 190G data.

4. Results

The multigroup cross section libraries with 47G, 177G and 190G were generated according to the generation procedure described above. The MCNP5 cross sections were generated also for each group from ENDF 7.The Rowland pin cell problem was solved by DeCART and MCNP5 to verify the performance of libraries. Results are given in Table 1 and Figure 3.

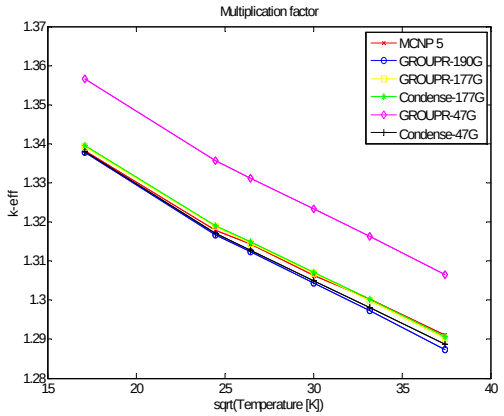

Figure 3. Multiplication factor versus Fuel Temperature

In these results, the MCNP5 cases are considered the most accurate one. As shown in Figure 3. The differences from the MCNP cases are about 100 pcm with other cases except for the 47 group case directly generated from the GROUPR module, not collapsed from 190G one. Both 177 group cases show better performance than the 190 group case. The error is reduced by about 100 pcm. There are large differences in the 47 group cases according to the method of generating groupwise cross sections. The results indicate that energy group condensing method is more accurate than directly using GROUPR module when the number of energy groups is small.

The flux weighted resonance absorption cross sections of U-238 are shown in Table 2. It is noted that the absorption reaction of U-238 has strong effect on the total reactor reactions. The error of 47G GR case is more than double of the other cases. This is due to one of the main factors of the error shown in Table 1.

Table 2. Flux weighted cross section in the resonance range

	190	177GR	177EC	47GR	47EC
U-238 Absorption	0.95452	0.95067	0.95031	0.93969	0.95249
Rel. Err., %	0.644	1.045	1.083	2.188	0.856

- Reference value by MCNP 5: 0.96071

5. Conclusion

The method for generating the multigroup cross section library data with various energy group structure was established and examined and DeCART libraries were generated with 47, 177 and 190 group structures. The group condensing scheme for obtaining the 47 G library is better than using the 47G in the GROUPR stage. The 177 group structure shows better accuracy than 190G because it employs more appropriate structure in the resonance energy range.

REFERENCES

[1] Gwan Young Kim and Han Gyu Joo, "Consistent Generation and Verification of 190 Group Cross Section Library Data for Primary Nuclides", Transactions of the Korean Nuclear Society, Spring Meeting, Korea, May, 2008.
[2] L. Pogosbekyan, H. G. Joo, C. H. Kim, and K. S. Kim, "Generation of Subgroup Weights Employing Shielded Cross Section Conservation Principle for Representative Pin Cells", M&C + SNA 2007, Monterey, California, April 15-19, 2007, on CD- ROM.

Table 1. Comparison of Multiplication factors with different energy group.

Parameter	Group	Fuel temperature (K)					
		293	600	700	900	1100	1400
Multiplication Factor	MCNP 5	1.33824	1.31779	1.31433	1.30638	1.30018	1.29097
	190	1.33772	1.31673	1.31241	1.30443	1.29732	1.28742
	Error (pcm)	-29.05	-61.09	-111.31	-114.43	-169.56	-213.60
	177GR	1.33925	1.31881	1.31461	1.30685	1.29993	1.29027
	Error (pcm)	56.35	58.69	16.21	27.53	-14.79	-42.02
	177EC	1.33954	1.31911	1.31492	1.30717	1.30027	1.29061
	Error (pcm)	72.52	75.94	34.14	46.26	5.32	-21.61
	47GR	1.35659	1.33559	1.33123	1.3233	1.31625	1.30659
	Error (pcm)	1010.77	1011.35	965.89	978.75	939.02	926.03
	47EC	1.33805	1.31702	1.31276	1.30503	1.29817	1.2887
	Error (pcm)	-10.61	-44.37	-90.99	-79.19	-119.09	-136.45

- GR : Results with groupwise cross section generated by GROUPR module
- EC : Results with groupwise cross section generated by energy group condensing