Transactions of the Korean Nuclear Society Spring Meeting
Gwangju, Korea, May 30-31, 2013

Verification of a Subgroup Generation Method for Thorium Fuel Assemblies

Oh-Sung Sim and Myung-Hyun Kim
Department of Nuclear Engineering, Kyung Hee University, Yongin-si, Gyeonggi-do, 446-701, Rep. of Korea
mhkim@khu.ac.kr

1. Introduction

A new cross section library for multi-group cross section and subgroup parameter was generated for use in the direct whole core transport code, nTRACER from the evaluated nuclear data files (ENDF , JEFF and JENDL). This cross section library consists of group-wise cross section and resonance parameters. Group-wise cross sections are obtained by NJOY that should adjust proper spectrum weight for continuous energy cross section from the evaluated nuclear data file. Resonance parameter consists of subgroup level and weight. The subgroup weight is obtained by solving the ultrafine slowing down equation and fixed source problem. That means this cross section library procedure considers conservation of the shielded cross section for pin-cell in order to obtain subgroup parameters. [1], [2]

There are some isotopes to be concerned for research such as actinides and thorium. Minor actinides(MA) are existing with very small amount in a spent fuel, but effect is not negligible in a high burnup fuel assemblies. Some MAs have high fission cross sections under thermal neutron spectrum. Thorium isotopes was not investigated as much as uranium, but it has high potential for future application.

In this study, a new cross section library to be replaced with HELIOS library was generated and compared for the assembly calculation, specially for assembly with thorium. An average capture cross section value at a certain fuel pin and multiplication factor of assembly were compared with nTRACER calculation with HELIOS library and Monte Carlo calculation of MCNP with ENDF-B/II.[3]

2. Assembly model under Investigation

2.1 Assembly model for benchmark calculation

Sensitivity of assembly calculation is dependent on weight contents of Th-232 isotope in a fuel. Choice of model was based on realistic application for PWR. In a model of WASB fuel assembly which has been suggested by MIT, Th-232 is mixed with 12.2 w/o UO_2 fuel, weight percent of Th in U+Th is 86%. The following table showed weight percent of each isotopes.

Table 1. Composition of Isotopes in a Fuel pin

	Enrichment	*w% in (U+Th232)*	*wt% in (UO2+Th232)*	*Number Density*
U-235	12.2	1.73	1.52	3.724E-04
U-238	87.8	12.27	10.88	2.345E-03
Th-232		86	75.52	1.884E-02
O-16			12.08	4.373E-02

This assembly was modeled in 2D using both MCNPX and nTRACER code. Point A in the Fig.1 is location of fuel pin cell for the evaluation of average capture cross section.

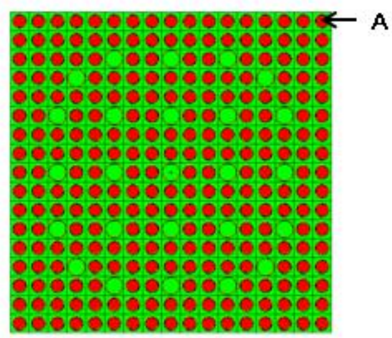

Fig. 1. 2D Model of WASB

2.2 Cross section library generation for Th232

The first step for the generation of cross section set is the generation of point-wise cross section with NJOY from ENDF-B/VII. This was done for the five temperature points (293, 500, 700, 1100, 2000 K). RMET21 code generated self-shielded cross section for 69 groups of resonance energy range and 10 design conditions. RMET21 solves neutron slowing down equation for a heterogeneous 1D cylindrical geometry on an ultra-fine energy grid provided by GEXCO. 10 conditions were determined for wide range of fuel densities (4 cases), moderator densities (4 cases) and pitches (2 cases). With the help of subroutine nTRACER-FSP, background cross sections and subgroup parameters were evaluated. The subgroup parameters can be determined by GENOME utility which carries out the method of Lagrange multiplier by solving a constrained minimization problem. Group-wise cross sections for 190 groups were calculated by GROUPR module in NJOY. LIBDEC organize group-wise cross section and GUARDIAN integrates group-wise cross section with subgroup parameter into one file for the use in nTRACER code.

3. Verification of KHU LIBRARY

Calculation results of nTRACER code using a new cross section library (KHU LIB.) was compared with those with HELIOS library(HELIOS LIB.) and they were also compared with MCNPX results.

3.1 Average Multi-group Cross Section

Group-wise capture cross sections of Th-232 were evaluated at each fuel pins. The following figure showed the evaluated cross sections of Th-232 at a corner point fuel pin. The maximum absolute relative errors of HELIOS LIB. compared with MCNPX was 168.9% at group-122 (from 6.868eV to 6.476eV). However, the maximum absolute relative errors of KHU LIB. becomes small to 19.4% at the same energy group.

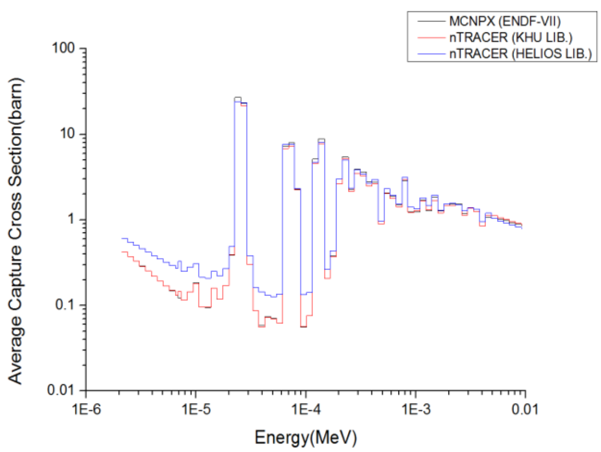

Fig. 2. Average Capture Cross Sections of Th232

3.2 Multiplication Factor of Assembly

The multiplication factors were calculated at the various temperature points and compared with MCNP results as shown in Fig. 3. At 293 K, the reactivity difference of KHU LIB. compared with MCNPX was about 64 pcm whereas one of HELIOS LIB. showed 2,507 pcm. It is interestingly found that the nTRACER with KHU LIB. showed smaller error at the lower temperature range when compared with MCNPX. However, existing HELIOS library in nTRACER code was not good for the application for thorium fuels.

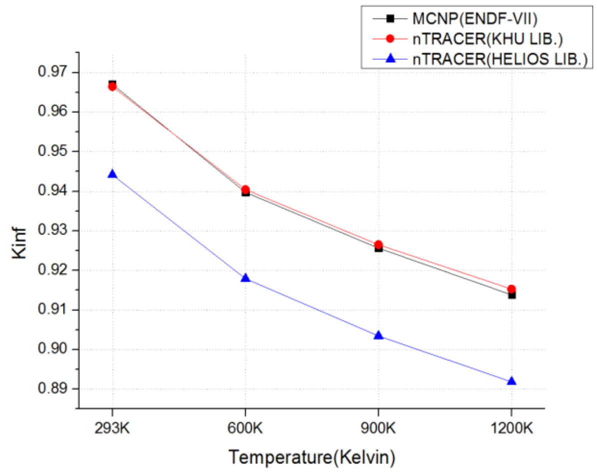

Fig 3. Variation of K-eff to Temperature

4. Conclusions

The accuracy of library data generated for thorium isotope in nTRACER calculation was tested for WASB model. There was a great improvement in K-eff and capture cross section for this assembly compared with old library, HELIOS library. The same kinds of improvement are expected for minor actinides and some other isotopes which were not interested before. This work is now on going and results will be addressed near future.

REFERENCES

1. H. G. Joo, G. Y. Kim, L. Pogosbekyan "Subgroup weight generation based on shielded pin-cell cross section conservation," Ann. Nucl. Energy 36, pp 859-868, (2009).
2. Aung Tharn Daing, Myung Hyun Kim and Han-Gyu Joo, "Subgroup Data Generation by Conserving Self-Shielded Cross Sections for PWR Fuel Cell with Am-241," Trans. Am. Nucl. Soc., Vol.105, (2011).
3. Y.S. Jung, S.W. Park and H.G. Joo, "Implementation and Verification of Quadratic Depletion Method in Direct Whole Core Calculation Code nTRACER," Proc. of KNS 2012 Spring Mtg., Jeju, Korea, (2012).