Benchmark Testing Calculations for ^{232}Th

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【abstract】 *The cross sections of ^{232}Th from CNDC and JENDL-3.3 were processed with NJOY97.45 code in the ACE format for the continuous-energy Monte Carlo Code MCNP4C. The K_{eff} values and central reaction rates based on CENDL-3.0, JENDL-3.3 and ENDF/B-6.2 were calculated using MCNP4C code for benchmark assembly, and the comparisons with experimental results are given..*

Introduction

Because of the shortage of energy resource and the lack in reserve of traditional nuclear fuel, the research for the generation and waste transmutation by using intermediate energy proton accelerator driven radioactive clean nuclear system (ADS) has attracted internationally considerable attention. New concepts of nuclear technology for power production are being investigated to satisfy these needs. Thorium-based nuclear fuel cycle offers many advantages: a) Neutron capture in ^{232}Th yields ^{233}U, which is a highly efficient nuclear fuel. A thermal breeder (or near-breeder) reactor concept based on thorium fuel is feasible. b) World reserves of thorium are much more than reserves of uranium. c) Thorium fuel is more proliferation-resistant due to highly radioactive constituents, which can not be separated out by chemical means.

Based on the above advantages there is a rising interest in innovative fuel cycle concepts based on thorium fuel. Therefore the quality of nuclear data for ^{232}Th is very important. The data of ^{232}Th were evaluated in China Nuclear Data Center using the newest experimental data and UNF [1] code, which calculates nuclear reaction cross sections with advanced theoritical method. In order to test the reliability of these data, it's necessary to do benchmark tests. Monte Carlo code MCNP4C[2] was used to do the calculation of k_{eff} values and central reaction rates, and the comparisons were given with experimental results and the results of JENDL-3.3, ENDF/B-6.2.

1 Data Processing

The ENDF60 library[3], which is generated in LANL(Los Alamos Laboratory) with ENDF/B-6.2 was used in the calculations. The data of ^{232}Th from CNDC and JENDL-3.3 were processed with the NJOY97.45 code[4] in ACE-format for the MCNP4C code. The thinning tolerances reconstructing and Doppler broadening of cross section data were 0.2%, and the tolerance for thinning distributions was 0.

2 Benchmark Calculations

The benchmark calculations were performed using the Monte Carlo code MCNP4C. The k_{eff} values and central reaction rate ratios were calculated. Table 1 gives out the description for the benchmark assembly[5]. In this calculation, the calculated results of ENDF/B6 were based on ENDF60 library, and the ACE format files for ^{239}Pu, ^{240}Pu, ^{241}Pu and Gallium were also from ENDF60 library.

Table 1 The description of the benchmark assembly used

Isotope/Element	Atom Density (atoms/barn-cm)
Plutonium Core	
^{239}Pu	3.6049*10
^{240}Pu	1.9562*10
^{241}Pu	1.1459*10
Gallium	1.3338*10
Thorium reflector	
^{232}Th	$3.0054*10^{-2}$

3 Results and Discussions

The k_{eff} values and central reaction rate ratios were calculated, and the comparisons with the experimental results were given for different evaluated data libraries. Table 2 and Table 3 give out the k_{eff} values and central reaction rates, respectively.

Table 2 The calculated results for k_{eff} values

Assembly	Experiment	Present	ENDF/B6[*]	JENDL-3.3
One-dimension	1.000(～0.001)	1.00661	1.00581	1.00969
Two-dimension	1.000(～0.001)	1.00495	1.00433	1.00682

*: The data library is from ENDF60 library.

Table 3 The results for central reaction rate ratios

Reaction	Experiment	Present	ENDF/B6[*]	JENDL-3.3
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	0.195±0.003	0.1735	0.1723	0.1727
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	0.92±0.02	0.8352	0.8277	0.834
$\sigma_f(^{232}Th)/\sigma_f(^{238}U)$	0.26±0.01	0.2565	0.2472	0.25
$\sigma_{n,\gamma}(^{238}U)/\sigma_f(^{235}U)$	0.083±0.003	0.074	0.0735	0.074
$\sigma_{n,2n}(^{238}U)/\sigma_f(^{238}U)$	0.053±0.003	0.055	0.055	0.0546
$\sigma_{n,\gamma}(^{232}Th)/\sigma_{n,\gamma}(^{238}U)$	1.20±0.06	1.22	1.29	1.2
$\sigma_{n,2n}(^{232}Th)/\sigma_{n,2n}(^{238}U)$	1.04±0.03	1.13	1.09	1.001

*: The data library is from ENDF60 library.

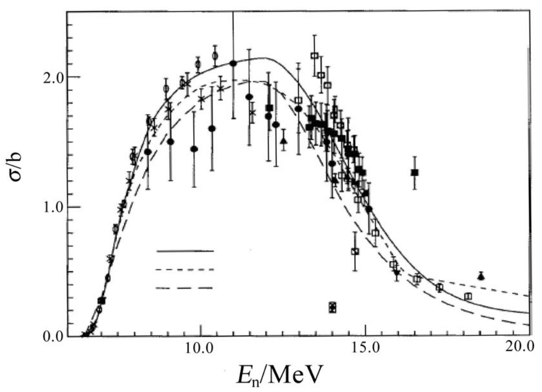

Fig.1 The comparisons of (n,2n) cross-section for ^{232}Th

Table 2, the calculated k_{eff} values based on present data, ENDF/B-6.2 and JENDL-3.3 are overestimated and compared with the experimental results, and it can be seen that the results based on present data are close to ENDF/B-6.2.

Table 3 show that the fission reaction rate ratios of ^{232}Th ($\sigma_f(^{232}Th)/\sigma_f(^{238}U)$) and the capture reaction rate ratio of ^{232}Th ($\sigma_{n,\gamma}(^{232}Th)/\sigma_{n,\gamma}(^{238}U)$) based on present data are in better agreements with the experimental results, but the $\sigma_{n,2n}(^{232}Th)/\sigma_{n,2n}(^{238}U)$ value are higher than the experimental one and the results from ENDF/B-6.2 and JENDL-3.3. According to the testing results, the (n,2n) reaction cross sections of present ^{232}Th data should be decreased. In Fig.1 is given the comparisons of the (n,2n) cross sections. It can be seen that the present (n,2n) reaction cross section is actually larger than those of ENDF/b6 and JENDL-3.

Reference

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