Improvement of Core Analysis of High Temperature Engineering Test Reactor Using McCARD Code

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1. Introduction

A core analysis for the High Temperature Engineering Test Reactor [1-3] (HTTR) was performed using the Monte Carlo McCARD [4] code.

In this study, the two types of cross section library were used for benchmark calculations: ENDF-B/VII.0 and ENDF-B/VII.1 libraries. Also, the new impurity data of the graphite block were used. The calculation results are compared with those of the experiments.

2. Analysis Model

Fig.1 shows the HTTR core model. The HTTR core is an annular type form. The reactor core component is arranged in the reactor pressure vessel, which has a 13.2 m height and 5.5 m diameter. The core consists of 30 fuel columns and 7 control rod guide columns with an active core height of 290 cm and a 230 cm effective diameter. An additional 9 control rod columns are located in the outer reflector region. The replaceable reflector region adjacent to the active core consists of 9 control rod columns, 12 replaceable reflector columns, and 3 irradiation columns. There are 2 top reflector blocks, 5 fuel blocks, and 2 bottom reflector blocks in each fuel column Table I gives main specifications of the HTTR.

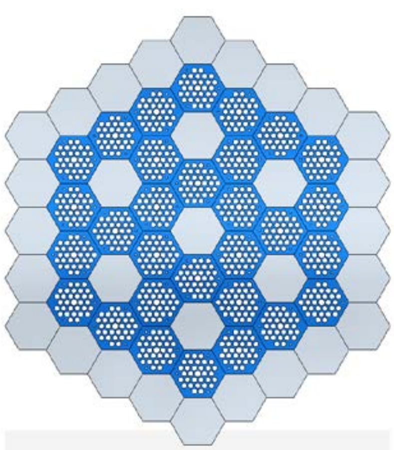

Fig.1 HTTR core model

Table I: Specification of the HTTR

Parameter	Value
Thermal power	30 MW
Outlet coolant temperature	950°C
Inlet coolant temperature	395°C
Equivalent core diameter	230 cm
Effective core height	290 cm
Uranium enrichment	3 to 10 wt%
Number of fuel blocks	150
Number of fuel columns	30
Number of control rod block	
In core	7
In reflector	9

3. Results and Discussion

The experiment and results with ENDF-B/VII.1 give very similar k-effective values with loaded fuel columns. The first criticality is obtained with 19 fuel columns for both the experiment and calculations with ENDF-B/VII.1, and the k-effective values are 1.0152 and 1.0145, respectively, whereas the calculation with ENDF-B/VII.0 gives the first criticality with 18 fuel columns, and the difference in k-effective value from the experiment is 1582 pcm. From the results, it can be seen that the calculations with ENDF-B/VII.1 give a very small deviation in k-effective values between -380 and 280 pcm, while the ENDF-B/VII.0 gives a maximum discrepancy of ~1600 pcm.

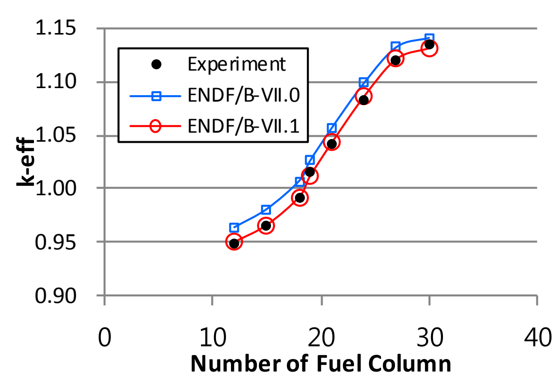

Fig. 2 Comparison of k-effective value

The control rod (CR) positions at the criticality were evaluated for various fuel columns. The control rod position is the distance from the bottom line of the fuel region. In the calculation, the flat standard (FS) condition was applied for all core conditions. In the FS condition, all of the control rods move simultaneously. The results are shown in Table VII and Fig. 4. From these results, McCARD gives a slightly higher position than the experiment.

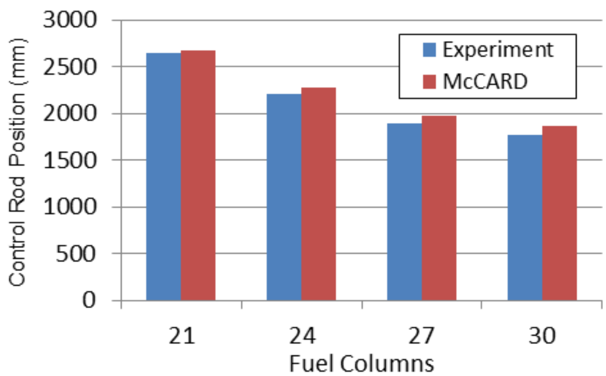

Fig. 4 Critical control rod position

The scram reactivity is evaluated for the following conditions:

- Fully loaded core (30 fuel column) and
- Fresh core

The following two cases are investigated for the scram reactivity evaluation: first, the scram reactivity of the reflector CRs (CR in Region2 and Region3), and second, the scram reactivity of all of the CRs.
The reactivities of the first and second scrams are compared in Table 6. The differences are -26 and 4% for the first and second scram, respectively.

Table II: Scram reactivity

Scram	Experiment ($\Delta k/k$)	Calculation ($\Delta k/k$)	C-E (%)
First Scram	0.12±0.012	0.09±0.0009	-26
Second Scram	0.46±0.046	0.44±0.0004	-4

4. Summary

McCARD gives the first criticality with a 19-fuel column loaded core, which is same as that of the experiment. For the criticality of the other fuel column core, McCARD with ENDF-B/VII.1 gives very good agreement with the experiment. The main reason for the discrepancy of the criticality between the ENDF-B/VII.0 and ENDF-B/VII.1 libraries is known to be a capture cross-section of the graphite.

For the control rod position, the calculation results show a higher position because of a higher multiplication factor in the McCARD calculations. In addition, MCCARD with the ENDF-B/VII.1 library gives fairly good agreement with the experiment for other benchmark specifications such as the reactivity, scram reactivity, control rod positions.

From the analysis results, it can therefore be concluded that the McCARD calculations with the ENDF-B/VII.1 library give much closer results with the experiments.

REFERENCES

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