Analysis of HTTR Core with Different Hexagonal Discontinuity Factors

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1. Introduction

In the nodal diffusion calculation, few group equivalent constants are generated by multi-group neutron transport theory. Especially, in the nodal calculation, not only a homogenized group constants but discontinuity factors are needed. In this study, whole core transport calculation is performed by DeCART code [1] to generate equivalent group constant and assembly discontinuity factor (ADF). Then the nodal diffusion calculations are carried out by CAPP code [2] with the generated parameters and ADF. In this study, the calculations are applied to the High Temperature Engineering Test Reactor (HTTR) core [3, 4].

2. Calculation Methods and Results

In this section, the HTTR model is described first, and the calculation procedure and results are presented.

2.1 HTTR Model

The HTTR is a graphite moderated and helium gas cooled reactor with an outlet temperature of 950 °C and thermal output of 30 MW. The HTTR core is composed of hexagonal blocks 580 mm in height and 360 mm in width: fuel blocks, control rod guide blocks, replaceable reflector blocks, and instrumentation blocks. The main specifications are shown in Table I.

Table I: HTTR Specifications

Thermal Power	30 MW
Outlet Coolant Temperature	850/950 °C
Inlet Coolant Temperature	395 °C
Core Structure	Graphite
Equivalent Core Diameter	2.3 m
Effective Core Height	2.9 m
Average Power Density	2.5 W/cm3
Fuel	UO2
Enrichment	3 to 10 wt.% 6 wt.% (average)
Fuel Type	Pin-in-Block Type Coated Fuel Particles
Burn-Up Period (EFPD)	660 days
Fuel Block	Graphite Block
Coolant Material	Helium Gas
Number of Fuel	Downward
Assemblies	150
Number of Fuel Columns	30
Number of Pairs of Control Rods	
In Core	7
In Reflector	9

2.2 Calculation Procedure

The overall calculation procedure is shown in Fig. 1. First, the DeCART code performs transport calculation to generate homogenized few-group cross sections and ADF. Then the PXS_GEN [5] converts the cross sections to the format of the CAPP. Finally, the CAPP performs core calculations with provided cross-section set and ADF. The HTTR 2-D model for DeCART calculation is shown in Fig. 2.

In the DeCART calculation, the surface flux discontinuity factor (SDF) and corner point flux discontinuity factor (CDF) are calculated. Here, three kinds of solution options of CPB (corner point balance) equation are considered [6]:

Case 1: No assumptions.

Case 2: Boundary CDF is 1.0.

Case 3: Boundary CDF is 1.0 and all the negative CDF at any corner is 1.0.

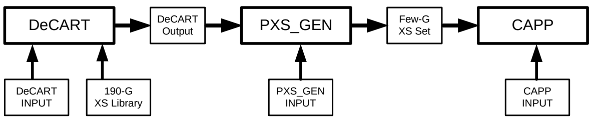

Fig. 1. Calculation procedure.

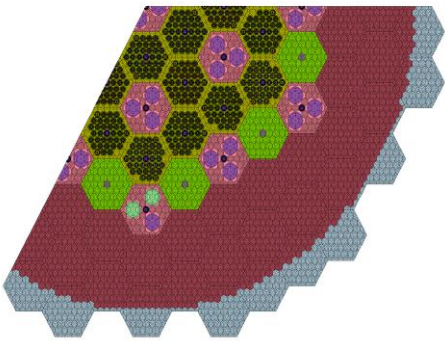

Fig. 2. 2-D 1/3 symmetry HTTR core model.

2.3 Calculation Results

As shown in Table II, The differences in k-effective for 30-column core are 88 and 702 pcm for case 1 and case 2, respectively. For case 1, the differences of 24 and 18-column cores are 77 and 71 pcm. However, for case 2, the differences increase up to 905 and 1084 pcm for 24 and 18-column core, respectively.

Table II: Comparison of k-effective

		DeCART	CAPP	Diff.(pcm)
30-column core	Case1	1.26671	1.26759	88
	Case2	〃	1.27373	702
	Case3	〃	1.27373	702
24-column core	Case1	1.23840	1.23917	77
	Case2	〃	1.24745	905
	Case3	〃	1.24745	905
18-column core	Case1	1.16105	1.16176	71
	Case2	〃	1.17189	1084
	Case3	〃	1.17189	1084

The relative power distributions of the 30-column core are shown in Fig. 3. The maximum differences of the block power are 0.38 and 0.93% for case 1 and 2, respectively. For 24- and 18-column core, the trends of deviations of the power distribution are also similar to those of the 30-column core.

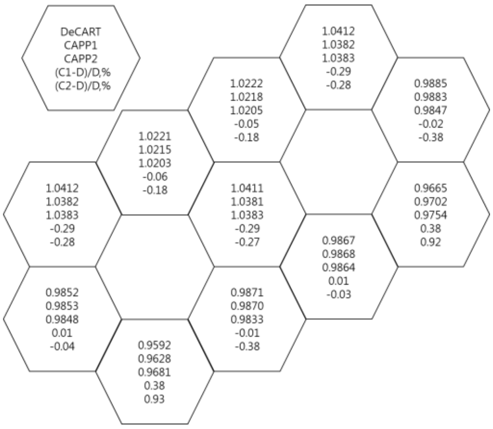

Fig. 3. Comparison of relative power distribution (30-column core).

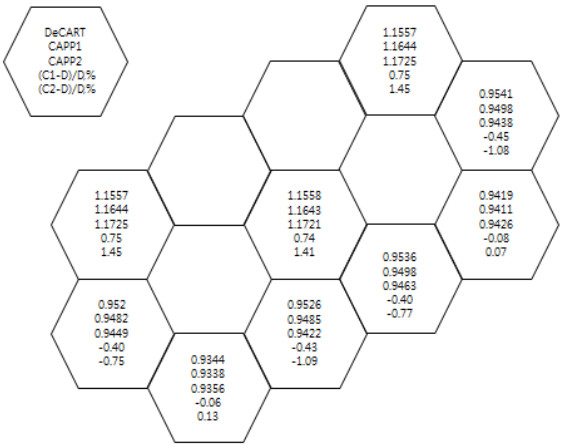

Fig. 4. Comparison of relative power distribution (24-column core).

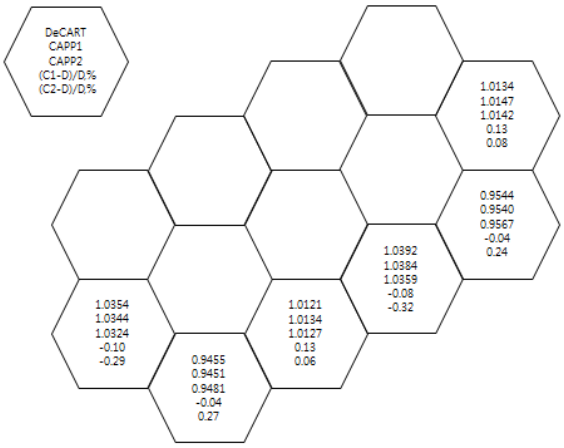

Fig. 5. Comparison of relative power distribution (18-column core).

3. Conclusions

The diffusion nodal calculations with different ADF option have been applied to the HTTR 2-D core analysis. From the calculation results, the discontinuity factor calculation option 1 shows small difference in k-effective. Also, the difference in the relative power distribution is small with case 1 option. In future, the detailed discontinuity factor will be analyzed with different calculation options.

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