Development of Nuclear Data Transmittal System for Real Time Core Analysis of PWR Simulator

,   ,   ,

150

, ARCADIS (ANC and ROCS Cross-section And Discontinuity factor Interface System)   .   1   15

3   7   ,

,   212 pcm

,   1.0   2.7 %   ,

1.2 %   ARCADIS   .

Abstract

ARCADIS (ANC and ROCS Cross-section And Discontinuity factor Interface System) program was developed for the automatic generation of group constants for the real time core analysis of PWR simulator using nuclear design systems. In order to verify the ARCADIS program, core reactivities, radial power distributions and control bank worths of Yonggwang unit 1 cycle 15 and Yonggwang unit 3 cycle 7 were calculated by the simulator core model and compared with the results by the nuclear design system. The maximum differences of the core reactivity of 212 pcm, the radial power distribution of 2.71 % and the individual bank worth of 1.2 % were estimated. These results imply that the group constant interface by ARCADIS is established appropriately.

1.

, (FDM - Finite Difference Method)

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. ,

4

FDM

3

.

,

MASTER   MARS
[1], MASTER   RETRAN
[2].   ,

[3]   .

Westinghouse
ABB- CE   DIT /ROCS[4,5]   Westinghouse
PHOENIX/ANC[6]   .

3

,

.

ARCADIS (ANC and ROCS Cross- section And Discontinuity factor Interface
System)   1   (Westinghouse   ) 15   3   (   ) 7

.

2. ARCADIS

2.1

.

$$\Sigma = \Sigma(B_0, T_{f0}, D_{m0}) + \frac{\partial \Sigma}{\partial B} \Delta B + \frac{\partial \Sigma}{\partial \sqrt{T_f}} \Delta \sqrt{T_f} + \frac{\partial \Sigma}{\partial D_m} \Delta D_m \qquad (1)$$

, B, T_f, D_m ,   .

.

$$\Sigma = \hat{\Sigma}(B_0, T_{f0}, D_{m0}) + \frac{\partial \hat{\Sigma}}{\partial B} \Delta B + \frac{\partial \hat{\Sigma}}{\partial \sqrt{T_f}} \Delta \sqrt{T_f} + \frac{\partial \hat{\Sigma}}{\partial D_m} \Delta D_m$$

$$+ \Delta\Sigma_{CR}(B_0, T_{f0}, D_{m0}) + \frac{\partial \Delta\Sigma_{CR}}{\partial B} \Delta B + \frac{\partial \Delta\Sigma_{CR}}{\partial \sqrt{T_f}} \Delta \sqrt{T_f} + \frac{\partial \Delta\Sigma_{CR}}{\partial D_m} \Delta D_m$$

$$+ N_B \left[\sigma_B(B_0, T_{f0}, D_{m0}) + \frac{\partial \sigma_B}{\partial B} \Delta B + \frac{\partial \sigma_B}{\partial \sqrt{T_f}} \Delta \sqrt{T_f} + \frac{\partial \sigma_B}{\partial D_m} \Delta D_m \right] \quad (2)$$

$$+ N_{Xe} \left[\sigma_{Xe}(B_0, T_{f0}, D_{m0}) + \frac{\partial \sigma_{Xe}}{\partial B} \Delta B + \frac{\partial \sigma_{Xe}}{\partial \sqrt{T_f}} \Delta \sqrt{T_f} + \frac{\partial \sigma_{Xe}}{\partial D_m} \Delta D_m \right]$$

, B Xe B^{10} ,

$$\hat{\Sigma} = \Sigma - N_B \sigma_B - N_{Xe} \sigma_{Xe}$$

$$\Delta\Sigma_{CR} = \Sigma(rodded) - \Sigma(unrodded)$$

.

ARCADIS (2)

,

.

2

2 12

.

Westinghouse

ABB- CE DIT/ROCS Westinghouse

PHOENIX/ANC .

ARCADIS

. ROCS ANC

.

2.2

. Doppler

. ROCS

ANC

.

.

.

. ARCADIS

(gap conductance)

gap conductance   .   gap conductance

                                                       . <   1>   1

3   gap conductance   .   1.0

                    .

3.

ARCADIS   ROCS   ANC

3

. ARCADIS

(ICCC : Interface Coupling Coefficient Correction)

.

.   ,

. ARCADIS   <   2>   .

[3]

3

.   3

.   ,

                                                                      DHCGEN   .

            DHCGEN   ARCADIS

    ANC   ROCS   .

                                                                                500 pcm,

        1.0   5%   10%   .

3.1   1   15

　　1　　　　　　　ANC　　　　　　　　. ANC

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　.

　　　　　　　ANC　　　　　　　　　　　　ARCADIS

　　　　　　　　　　　　　　　　　　　3　　　　　　　　　　　.

　　ANC

　　. <　1>, <　2>

　　　　　　　　　　　　　ANC　　　　　　　　　.

　　　<　3>　　　　　　.　　　　　　　　　　　1.0

　　　　　　　　　1.1%　　　　　　　　　　　　　.

　　　50%　　　　　　　　D　50%　　　　　　　　　　　　<
4> < 　5>　　　　　　　　　　　<　　6> <　　7>　　　.

　　　　　　　　56.5 pcm,

　1.0　　　　　　　　　　0.5%　　　　50%　　　　　　　　D
50%　　　　　　　　　54.2 pcm,　　　1.0

　　　　　　　1.1%　　　　　.

3.2   3   7

　　3　　　　　ROCS　　　　. ROCS

　　　　　　　　　　　　　　　　　　　　　　　　.

　　　　　ROCS

　　<　3>, <　4>　　　　.
<　8>　　　.　　　　　　　1.0

　　　2.7%　　　　　　　　　　　.

　　　　　　　　　　　50%

5　50%　　　　　　　　<　　9> <　　10>
　　<　11> <　12>　　　.

　31.1 pcm,　　　　　　　　1.0

0.3%　　50%　　　　5　50%

30.2 pcm,　　1.0

0.3%　　　.

4.

PHOENIX/ANC　DIT/ROCS

ARCADIS (ANC and ROCS Cross- section And Discontinuity factor Interface System)   .

,

. ARCADIS   ROCS   ANC

albedo   .

ARCADIS   ANC   1   15   ROCS

3   7

,   ANC   ROCS

212 pcm   ,   1.0

2.7%   ,   1.2 %   .

500 pcm   ,   5%

10%   ARCADIS

.

5.

,   1   ,   3

.

6.

[1] J. J. Jeong et al., "MARS/MASTER Solution to OECD Main Steam Line Break Benchmark Exercise III," J. Korean Nucl. Soc., 32, 214 (2000).

[2]   , "RETRAN- MASTER- TORC   ," KAERI/TR- 2292/ 2002.

[3]   , "

," 2003   , , 2003. 10.

[4] "User's Manual for DIT – Discrete Integral Transport Assembly Design Code," CE- CES- 11 Rev. 3- P, 1994.

[5] "User's Manual for ROCS – Coarse and Fine Mesh Advanced Diffusion Theory Code for Reactor Core Analysis," CE- CES- 4 Rev 11- P, 1996.

[6] T. Q. Nguyen et al., "Qualification of the PHOENIX- P/ANC Nuclear Design System for Pressurized Water Reactor Cores, WCAP- 11596- P- A, 1988.

<表 1>　　　　　　　　　　　　　ANC

	ANC	ICCC	(pcm)
	1.09202	1.09201	- 0.9
(1000 ppm)	1.05584	1.05568	- 14.1
(1 ppm)	1.13148	1.13154	4.6
1.0	1.07998	1.08002	3.5
2.0	1.07343	1.07346	2.8
320	1.08102	1.08069	- 28.3
250	1.09974	1.10013	32.6
180	1.10432	1.10542	90.6
100	1.10503	1.10698	159.9
27	1.10473	1.10733	212.0

<表 2>　　　　　　　　　　　　　　　ANC

	(pcm)		(%)
	ANC	ICCC	
	7721.9	7688.3	- 0.4
(1000 ppm)	7752.9	7726.7	- 0.3
(1 ppm)	7680.9	7643.5	- 0.5
1.0	7925.6	7796.0	- 0.4
2.0	7873.8	7844.2	- 0.4
320	8215.4	8204.8	- 0.1
250	7237.7	7188.0	- 0.7
180	6699.9	6642.0	- 0.9
100	6297.6	6243.0	- 0.9
27	6065.5	5991.9	- 1.2

< 3>   ROCS

	ROCS	ICCC	(pcm)
	1.06074	1.06073	- 1.3
(1000 ppm)	1.01846	1.01851	- 5.2
(1 ppm)	1.10768	1.10758	- 7.8
2.0	1.05452	1.05447	- 4.8
	1.07035	1.07043	7.1
320	1.05195	1.05179	- 14.5
250	1.07033	1.07035	18.1
180	1.07679	1.07731	45.4
100	1.08069	1.08155	73.6
27	1.08292	1.08398	91.0

< 4>   ROCS

	(pcm)		
	ROCS	ICCC	(%)
	14519.5	14447.0	- 0.5
(1000 ppm)	14442.6	14371.6	- 0.5
(1 ppm)	14607.3	14533.9	- 0.5
2.0	14625.1	14554.0	- 0.5
	14352.9	14275.8	- 0.5
320	15480.4	15421.3	- 0.4
250	13273.7	13185.5	- 0.7
180	12035.7	11929.8	- 0.9
100	10998.9	10882.1	- 1.1
27	10387.5	10267.7	- 1.2

1   3
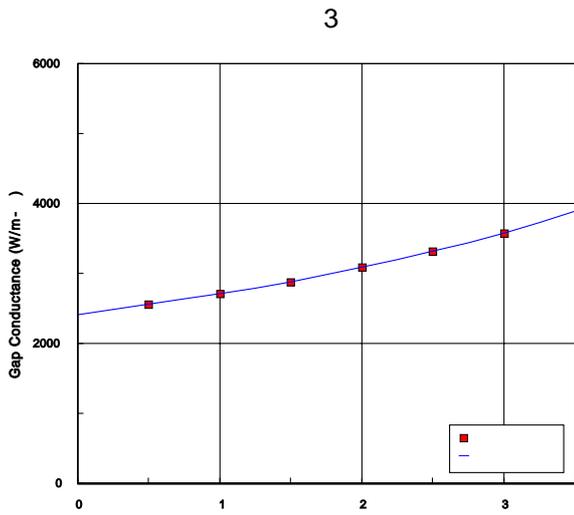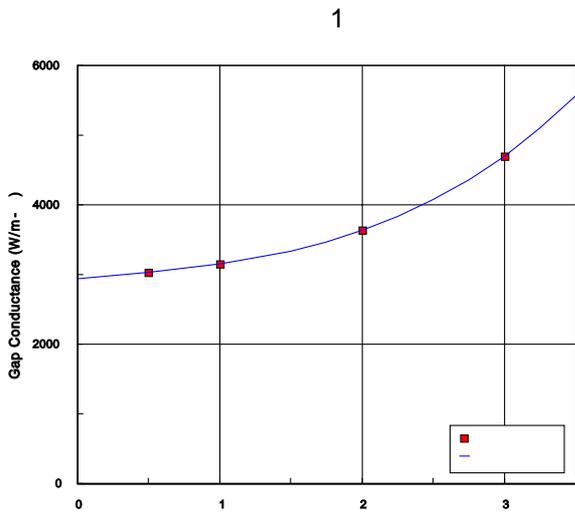
<   1>   Gap Conductance

<   2> ARCADIS

1.385 1.381 0.3	1.635 1.644 - 0.6	1.045 1.047 - 0.2	2.350 2.342 0.3	1.781 1.776 0.3	1.301 1.310 - 0.7	0.446 0.447 - 0.3	0.394 0.393 0.3
1.635 1.644 - 0.6	0.849 0.853 - 0.5	1.768 1.775 - 0.4	2.220 2.195 1.1	1.790 1.792 - 0.1	0.787 0.790 - 0.4	0.932 0.937 - 0.5	0.292 0.287 1.8
1.045 1.047 - 0.2	1.776 1.782 - 0.4	1.099 1.105 - 0.5	1.547 1.553 - 0.4	0.793 0.796 - 0.4	0.778 0.782 - 0.5	0.391 0.393 - 0.6	
2.350 2.342 0.3	2.241 2.217 1.1	1.588 1.593 - 0.3	0.735 0.737 - 0.2	0.729 0.731 - 0.3	0.305 0.307 - 0.7	0.155 0.156 - 0.8	
1.781 1.776 0.3	1.852 1.852 0.0	0.888 0.889 - 0.2	0.901 0.902 - 0.1	0.342 0.342 0.0	0.164 0.164 0.1		
1.301 1.310 - 0.7	0.847 0.850 - 0.3	1.014 1.015 - 0.1	0.790 0.774 2.0	0.265 0.264 0.5			
0.446 0.447 - 0.3	1.024 1.027 - 0.3	0.501 0.502 - 0.3	0.277 0.277 0.0				
0.394 0.393 0.3	0.315 0.310 1.7					ICCC ANC %	

< 3> 1 ICCC/ANC (ARI)

0.901 0.904 0.3	1.210 1.213 0.2	1.047 1.048 0.0	1.257 1.260 0.2	1.035 1.035 0.0	1.206 1.209 0.3	0.782 0.783 0.1	0.455 0.453 - 0.4
1.210 1.213 0.2	0.958 0.960 0.2	1.232 1.230 - 0.2	1.278 1.277 - 0.1	1.291 1.293 0.2	1.265 1.264 - 0.1	1.221 1.216 - 0.4	0.347 0.345 - 0.5
1.047 1.048 0.0	1.230 1.228 - 0.2	1.272 1.271 - 0.1	1.327 1.330 0.2	1.248 1.247 - 0.1	1.168 1.172 0.4	1.011 1.006 - 0.5	
1.257 1.260 0.2	1.269 1.267 - 0.1	1.324 1.327 0.2	1.225 1.224 - 0.1	1.081 1.084 0.3	0.809 0.810 0.1	0.334 0.333 - 0.4	
1.035 1.035 0.0	1.288 1.290 0.2	1.246 1.245 - 0.1	1.079 1.083 0.4	0.746 0.747 0.1	0.315 0.314 - 0.3		
1.206 1.209 0.3	1.264 1.263 - 0.1	1.167 1.171 0.4	0.809 0.809 0.0	0.316 0.316 0.0			
0.782 0.783 0.1	1.220 1.215 - 0.4	1.011 1.006 - 0.5	0.334 0.333 - 0.3				
0.455 0.453 - 0.4	0.348 0.346 - 0.7					ICCC ANC %	

< 4> 1 ICCC/ANC (ARO)

1.385 1.381 0.3	1.635 1.644 - 0.6	1.045 1.047 - 0.2	2.350 2.342 0.3	1.781 1.776 0.3	1.301 1.310 - 0.7	0.446 0.447 - 0.3	0.394 0.393 0.3
1.635 1.644 - 0.6	0.849 0.853 - 0.5	1.768 1.775 - 0.4	2.220 2.195 1.1	1.790 1.792 - 0.1	0.787 0.790 - 0.4	0.932 0.937 - 0.5	0.292 0.287 1.8
1.045 1.047 - 0.2	1.776 1.782 - 0.4	1.099 1.105 - 0.5	1.547 1.553 - 0.4	0.793 0.796 - 0.4	0.778 0.782 - 0.5	0.391 0.393 - 0.6	
2.350 2.342 0.3	2.241 2.217 1.1	1.588 1.593 - 0.3	0.735 0.737 - 0.2	0.729 0.731 - 0.3	0.305 0.307 - 0.7	0.155 0.156 - 0.8	
1.781 1.776 0.3	1.852 1.852 0.0	0.888 0.889 - 0.2	0.901 0.902 - 0.1	0.342 0.342 0.0	0.164 0.164 0.1		
1.301 1.310 - 0.7	0.847 0.850 - 0.3	1.014 1.015 - 0.1	0.790 0.774 2.0	0.265 0.264 0.5			
0.446 0.447 - 0.3	1.024 1.027 - 0.3	0.501 0.502 - 0.3	0.277 0.277 0.0				
0.394 0.393 0.3	0.315 0.310 1.7						

ICCC
ANC
%

< 5> 1 50% ICCC/ANC (D 50%)

< 6> 1 ICCC/ANC (ARO)

<   7>   1   50%   ICCC/ANC   (D 50%   )

0.578 0.605 - 4.5	0.886 0.914 - 3.1	1.403 1.417 - 1.0	0.913 0.922 - 1.0	0.703 0.705 - 0.3	0.950 0.949 0.0	0.937 0.929 0.9	0.631 0.631 0.0
0.886 0.914 - 3.1	1.020 1.048 - 2.7	0.727 0.746 - 2.6	0.979 0.992 - 1.4	0.918 0.921 - 0.4	0.757 0.756 0.1	1.349 1.337 0.9	0.706 0.706 - 0.1
1.403 1.417 - 1.0	0.728 0.747 - 2.6	1.622 1.631 - 0.6	1.091 1.101 - 0.9	1.601 1.591 0.6	1.191 1.187 0.3	1.138 1.126 1.1	0.505 0.504 0.1
0.913 0.922 - 1.0	0.977 0.991 - 1.4	1.088 1.099 - 0.9	0.793 0.804 - 1.4	0.947 0.943 0.4	1.084 1.078 0.6	1.273 1.265 0.6	
0.703 0.705 - 0.3	0.916 0.919 - 0.4	1.598 1.589 0.6	0.947 0.943 0.4	1.252 1.226 2.1	1.362 1.339 1.7	0.636 0.629 1.1	
0.950 0.949 0.0	0.757 0.756 0.1	1.191 1.187 0.3	1.077 1.071 0.6	1.360 1.337 1.7	0.502 0.507 - 0.8		
0.937 0.929 0.9	1.347 1.335 0.9	1.137 1.125 1.1	1.270 1.262 0.6	0.634 0.627 1.1			
0.631 0.631 0.0	0.705 0.705 - 0.1	0.504 0.503 0.1					

ICCC
ROCS
%

<   8>   3   ICCC/ROCS   (ARI)

0.871 0.870 - 0.1	1.166 1.163 - 0.2	1.245 1.244 - 0.1	1.149 1.147 - 0.2	0.998 0.997 - 0.1	1.265 1.265 0.0	0.994 0.994 - 0.1	0.455 0.456 0.2
1.166 1.163 - 0.2	1.292 1.288 - 0.3	0.829 0.827 - 0.2	1.182 1.180 - 0.2	1.125 1.124 - 0.1	0.942 0.943 0.0	1.221 1.221 0.0	0.629 0.631 0.3
1.245 1.244 - 0.1	0.830 0.828 - 0.2	1.278 1.276 - 0.1	1.138 1.136 - 0.2	1.289 1.290 0.1	1.293 1.294 0.1	1.137 1.138 0.1	0.357 0.358 0.3
1.149 1.147 0.2	1.181 1.179 - 0.2	1.136 1.134 - 0.2	0.893 0.893 0.0	1.025 1.026 0.1	1.134 1.136 0.2	1.038 1.040 0.2	
0.998 0.997 - 0.1	1.124 1.123 - 0.1	1.288 1.289 0.1	1.026 1.027 0.1	1.262 1.264 0.2	1.079 1.081 0.2	0.396 0.397 0.3	
1.265 1.265 0.0	0.943 0.943 0.0	1.294 1.295 0.1	1.128 1.130 0.2	1.077 1.079 0.2	0.422 0.423 0.2		
0.994 0.994 - 0.1	1.220 1.220 0.0	1.136 1.137 0.1	1.036 1.038 0.1	0.395 0.396 0.2			
0.455 0.456 0.2	0.629 0.631 0.3	0.357 0.358 0.2				ICCC ROCS %	

< 9> 3 ICCC/ROCS (ARO)

0.841 0.837 - 0.4	1.140 1.138 - 0.1	1.206 1.207 0.0	1.072 1.069 - 0.3	0.811 0.809 - 0.2	1.217 1.217 0.0	0.996 0.995 - 0.1	0.453 0.452 - 0.1
1.140 1.138 - 0.1	1.267 1.267 0.0	0.793 0.789 - 0.4	1.134 1.133 - 0.1	1.068 1.066 - 0.3	0.923 0.921 - 0.2	1.250 1.252 0.2	0.636 0.638 0.4
1.206 1.207 0.0	0.794 0.790 - 0.5	1.260 1.261 0.1	1.126 1.125 - 0.2	1.303 1.304 0.1	1.335 1.335 0.0	1.184 1.187 0.2	0.361 0.361 0.0
1.072 1.069 - 0.3	1.133 1.132 - 0.1	1.125 1.123 - 0.2	0.891 0.889 - 0.3	1.051 1.050 - 0.1	1.186 1.186 0.0	1.093 1.096 0.3	
0.811 0.809 - 0.2	1.066 1.064 - 0.3	1.302 1.303 0.1	1.052 1.051 - 0.1	1.330 1.333 0.2	1.138 1.142 0.3	0.409 0.410 0.1	
1.217 1.217 0.0	0.924 0.922 - 0.2	1.335 1.336 0.0	1.179 1.179 0.0	1.136 1.140 0.3	0.436 0.436 0.0		
0.996 0.995 - 0.1	1.249 1.251 0.1	1.183 1.186 0.2	1.090 1.093 0.3	0.408 0.408 0.0			
0.453 0.452 - 0.1	0.635 0.638 0.4	0.360 0.360 0.0				ICCC ROCS %	

< 10> 3 50% ICCC/ROCS (5 50%)

< 　　11>　　3　　　　　ICCC/ROCS　　　　　　　　(ARO)

< 　　12>　　3　　50%　　　ICCC/ROCS　　　　　　　(　　5 50%　　)