DeCART 　　　　　　　　　　　　　　HELIOS/MASTER

Estimation of Reactor Core Calculation by HELIOS/MATER at Power Generating Condition Through DeCART, Whole-Core Transport Code

,　　　　,　　　　,　　　　,

305-353　　　　　　　　　　150

DeCART 　　　　　　　　　　　　　　HELIOS/MASTER
　　　　　　　　　.　　　　　　　　　PWR
tableset 　　　　　　2　　　　　　　　　　　　　　　.　　　　　　　　　　　　　　　HELIOS
2　　　　　　　　　　　　　　　MASTER 3　　　　　　　　　　　　　　,　　　　,
　　　　　3　　　　　　　　　　　.
　　　　　DeCART 　　　　　　　　　,　　　　　　,　　　　　　　　　　　　,
　　　,　　　　　　,　　　　　　　　　　　　　　.　　　　　　　　　　　,　　　　　　　,
　　　　,　　　　　　　　HELIOS/MASTER　　　　　　　100~300 pcm, 3%,
2%　　　　　　　　DeCART　　　　　　　　　.
15%　　　　　　　　　　　　.

Abstract

The reactivity and power distribution errors of the HELIOS/MASTER core calculation under power generating conditions are assessed using a whole core transport code DeCART. For this work, the cross section tablesets were generated for a medium sized PWR following the standard procedure and two group nodal core calculations were performed. The test cases include the HELIOS calculations for 2-D assemblies at constant thermal conditions, MASTER 3D assembly calculations at power generating conditions, and the core calculations at HZP, HFP, and an abnormal power conditions. In all these cases, the results of the DeCART code in which pinwise thermal feedback effects are incorporated are used as the reference. The core reactivity, assemblywise power distribution, axial power distribution, peaking factor, and thermal feedback effects are then compared. The comparison shows that the error of the HELIOS/MASTER system in the core reactivity,
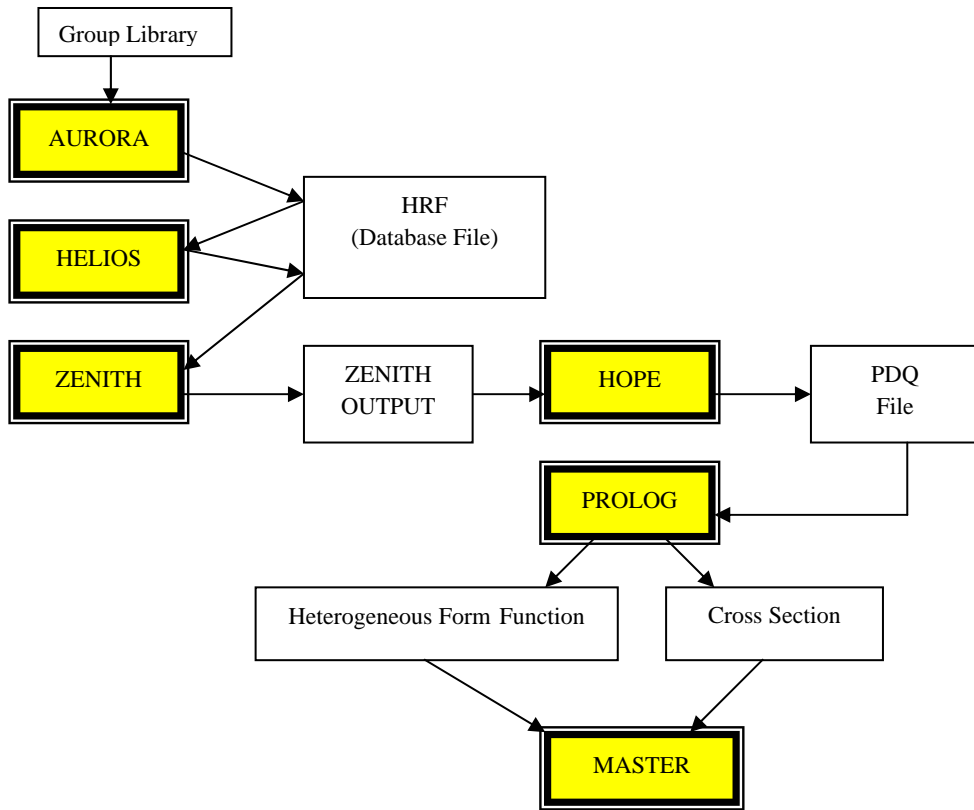
assemblywise power distribution, pin peaking factor are only 100~300 pcm, 3%, and 2%, respectively.   As far as the detailed pinwise power distribution is concerned, however, errors greater than 15% are observed.
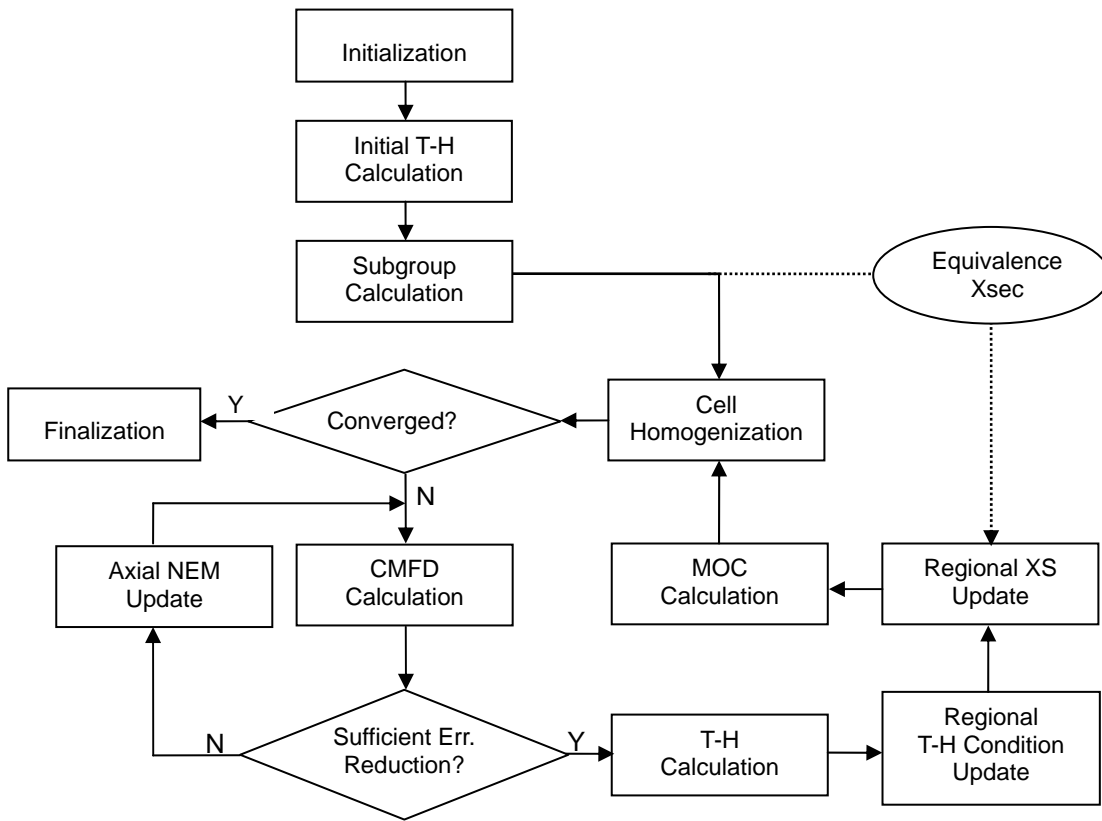

1

,

HELIOS[1]

3   MASTER[2]

,   3   DeCART[3,4]   .

HELIOS   STUDSVIK   ,   2

.

.   HELIOS

ENDF-IV   190   48

.   HELIOS   [5]

, Surface Angular Current

.

MASTER   KAERI

(PWR)   (BWR)   3   2

.

DeCART

3   .   2

(method of characteristics : MOC)   1

(nodal expansion method : NEM)   (coarse mesh finite

difference : CMFD)   3   . DeCART   (40

)   .

DeCART   PWR

HELIOS/MASTER   .   2

, 3

.

2

HELIOS/MASTER

PWR   .   17×17   57

200cm   330Mwt   .   HELIOS/MASTER

DeCART   .   1   2   HELIOS/MASTER

DeCART   .

1. HELIOS/MASTER

```
Group Library
      │
      ▼
  ┌────────┐
  │ AURORA │ ──────┐
  └────────┘       ▼
  ┌────────┐    ┌─────────────────┐
  │ HELIOS │ ◄──│      HRF        │
  └────────┘    │ (Database File) │
  ┌────────┐    └─────────────────┘
  │ ZENITH │ ──────┘
  └────────┘
```

1. HELIOS/MASTER

Flow:
- Group Library → AURORA
- AURORA → HRF (Database File)
- HRF (Database File) → HELIOS
- ZENITH → HRF (Database File)
- ZENITH → ZENITH OUTPUT → HOPE → PDQ File
- PDQ File → PROLOG
- PROLOG → Heterogeneous Form Function
- PROLOG → Cross Section
- Heterogeneous Form Function → MASTER
- Cross Section → MASTER

2. DeCART

Flow:
- Initialization → Initial T-H Calculation → Subgroup Calculation
- Subgroup Calculation ⋯⋯ Equivalence Xsec
- Subgroup Calculation → Cell Homogenization
- Cell Homogenization → Converged?
- Converged? → Y → Finalization
- Converged? → N → CMFD Calculation
- Axial NEM Update → CMFD Calculation
- CMFD Calculation → Sufficient Err. Reduction?
- Sufficient Err. Reduction? → N → Axial NEM Update
- Sufficient Err. Reduction? → Y → T-H Calculation
- T-H Calculation → Regional T-H Condition Update → Regional XS Update → MOC Calculation → Cell Homogenization
- Equivalence Xsec ⋯⋯ Regional XS Update

2. DeCART

2.1

17×17 PWR . 1

17×17 PWR .

2m . 3

3 .

.

PWR (~60%). ,

. PWR (~30%).

4 . shroud

. .

, . ,

B1 60cm . Al_2O_3

.

1.

, cm			
Cell Pitch	1.2660	Nominal Assembly Power, MW	5.79
Fuel Pellet Diameter	0.8050	System Pressure, MPa	15.0
Clad Outer Diameter	0.9518	Inlet Temperature, °C	270
GT Outer Diameter	1.2260	Mass Flow Rate per Assembly, Kg/sec	24.24

Type A
T		B1	T			T		
				G			B1	
B1								
T			T			T		
	G			G			B1	
					T			
T			T				B1	
	B1			B1		B1		

Type B
T			T			T		
		B2				B2		
T			T			T		
				G				
						T		B2
T		B2	T					
					B2			

Type C
T			T			T		
					B3			B3
T			T			T		
		B3		G				
						T		B2
T			T					
		B3			B2			

	UO₂ Rod with 4.95 w/o U	B1	B_4C Rod with 0.011 g/cm Boron-10
T	Guide Tube	B2	B_4C Rod with 0.0159 g/cm Boron-10
G	Gd Rod, 4% Gadolinia	B3	B_4C Rod with 0.029 g/cm Boron-10

4.

HELIOS/MASTER

.

.   ,   ,

.   2

.   2

.   2   4   HELIOS

.   HELIOS

tableset   MASTER   .

2.

Problem ID	Geometry			
FA2REF-A, B, C	2D Fuel	290 °C		Reference Condition
FA2LCT-A, B, C	Assembly	270 °C	480°C	Low Coolant Temperature
FA2HCT-A, B, C	for Each	310 °C		High Coolant Temperature
FA2LFT-A, B, C	Type	290 °C	380°C	Low Fuel Temperature
FA2HZP-C	2D FA C	270 °C	270 °C	2D Assembly @ HZP
FA2HFP-C	2D FA C	~290 °C	~480 °C	2D Assembly @ HFP
FA3HZP-C	3D FA C	270 °C	270 °C	3D Assembly @ HZP
FA3HFP-C	3D FA C	Varying	Varying	3D Assembly @ HFP
NC-HZP	3D Core	270 °C	270 °C	Normal Core @HZP
NC-HFP		Varying	Varying	Normal Core @HZP
NC-P50				Normal Core @50% Power
PC-P50				Perturbed Core @50% Power

2.2 HELIOS/MASTER   DeCART

HELIOS/MASTER   HELIOS
5   (3   2 Al_2O_3
)   2   .   5   C
HELIOS   .

HELIOS

.   190   (48   )
45   (18   )
.   , DeCART
,

.   , surface angular current
surface angular current
collision probabilities   (k=0)   .
.

,   9
.   ,   ,   Dancoff
(RES:999999999).
2   4   , 1   2
.   (assembly
discontinuity factor)   .

k=0
0.01mm
.   40pcm
.   /   .
MASTER   ,   4   ,
.
4   COBRA   .
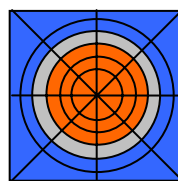(30%)   (70%)   .
DeCART   ,   .   ,   ,   ,
.

.   ray   ,
.

6   .
3   ,   (6   )
(6   )   2   .
8   , Ray   0.5mm,   90   4
2   ray   .   ray

, 3   10cm
20   ,   1   .
6   .   45
.
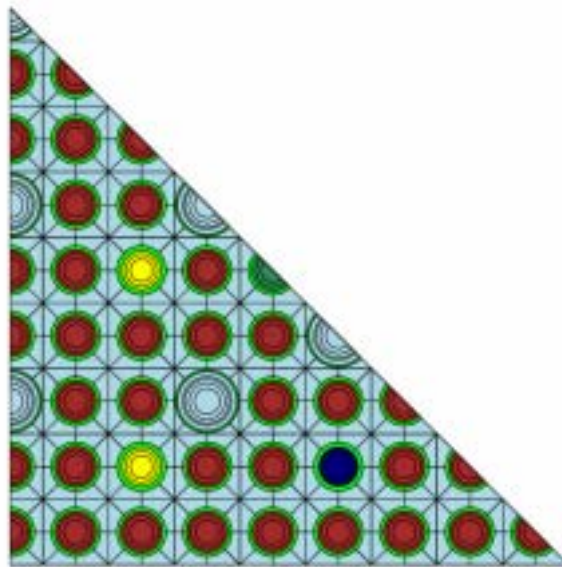
5. HELIOS   C

6. DeCART

3

HELIOS/MASTER   DeCART   2.4GHz Intel Pentium4
CPU   LINUX   .   DeCART
20   .   2
,   ,   .
3.1   2   HELIOS   DeCART
.   MASTER   DeCART   2   ,   3
3.2   .   3.3

．

3.1

4　　　　　　　　　　　　2　　　　　　　　　　HELIOS　　DeCART
　　　　．

40pcm
　　　　．　　　　　　　　　　　　　　　(FTC)　　5~9%
　　．

4. 2　　　　　　　　　　　　　　　　　HELIOS　　DeCART

Case	A1			B1			C1		
	HELIOS	DeCART	Diff.	HELIOS	DeCART	Diff.	HELIOS	DeCART	Diff.
FA2REF	1.00239	1.00359	-119	1.12519	1.12532	-10	1.05015	1.05032	-15
FA2LCT	1.01018	1.01153	-132	1.13412	1.13445	-26	1.06015	1.06053	-34
FA2HCT	0.99295	0.99398	-104	1.11415	1.11404	9	1.03792	1.03782	10
FA2LFT	1.00496	1.00595	-98	1.12809	1.12810	0	1.05285	1.05287	-2
MTC-L	-38.5	-39.1	-1.7%	-35.0	-35.8	-2.2%	-44.9	-45.9	-2.1%
MTC-H	-47.4	-48.2	-1.5%	-44.0	-45.0	-2.2%	-56.1	-57.3	-2.2%
FTC	-2.55	-2.34	9.0%	-2.28	-2.19	4.4%	-2.44	-2.31	5.7%

*　　　　　　　　　　: pcm

5
　　　．　Pin-to-box　　　　　　　1%　　　　　　　　，　　　　　　　　1.5%　　RMS
0.6%　　　．

5.　　　　　　　　HELIOS　　DeCART

Parameter	Type A	Type B	Type C
Pin-to-Box Factor	1.160	1.131	1.223
Pin-to-Box Difference	0.012	0.010	0.004
Max. Difference	0.013	0.016	0.015
RMS Difference	0.0062	0.0063	0.0059

3.2

HELIOS　　　　　　　　　　　　　　　　　　　　　　　　2　　　　　　Tableset
　　．　MASTER

.   6   HZP, HFP   2   , 3

.   2   2   HZP

                HFP   HFP   .

Tableset   HFP

                    .   HPF

                                    DeCART   .

    HFP   . 2   3   HFP

        (Tf-avg),   (Tc-avg),   (Dc-avg)

                        .   MASTER   (Tf-max)   DeCART

                    DeCART

                .

    7   ,   3   HFP   HZP

                .   /   (Fq-pin)

        2%   .

표 6.   MASTER   DeCART

Case	Code	k-eff	Tf-avg	Tf-max	Tc-avg	Tout	Dc-avg	Fq-FA	Fr-FA	Fq-pin	Fr-pin
FA2HZP-C	MASTER	1.06584	270.0	270.0	270.0	270.0	0.7808	1.000	1.000	1.258	1.258
	DeCART	1.06533	270.0	270.0	270.0	270.0	0.7808	1.000	1.000	1.231	1.231
	Difference	44.9	0.00%		0.00%	0.00%	-0.01%	0.00%	0.00%	2.18%	2.18%
FA2HFP-C	MASTER	1.04797	480.6	586.5	292.3	314.7	0.7366	1.000	1.000	1.258	1.258
	DeCART	1.04727	482.7	671.7	293.3	314.9	0.7392	1.000	1.000	1.214	1.214
	Difference	63.2	-0.44%		-0.34%	-0.08%	-0.35%	0.00%	0.00%	3.56%	3.56%
FA3HZP-C	MASTER	1.05557	270.0	270.0	270.0	270.0	0.7808	1.409	1.000	1.796	1.258
	DeCART	1.05381	270.0	270.0	270.0	270.0	0.7808	1.418	1.000	1.745	1.231
	Difference	158.1	0.00%		0.00%	0.00%	-0.01%	-0.66%	0.00%	2.88%	2.19%
FA3HFP-C	MASTER	1.03531	487.2	755.3	295.5	314.7	0.7329	1.473	1.000	1.852	1.258
	DeCART	1.03388	487.5	902.8	295.4	314.9	0.7329	1.498	1.000	1.806	1.214
	Difference	133.7	-0.04%		0.02%	-0.08%	-0.01%	-1.68%	0.00%	2.55%	3.58%

7

3.3

2   4   7   .

287pcm   .

1%   .

/   8   9   .
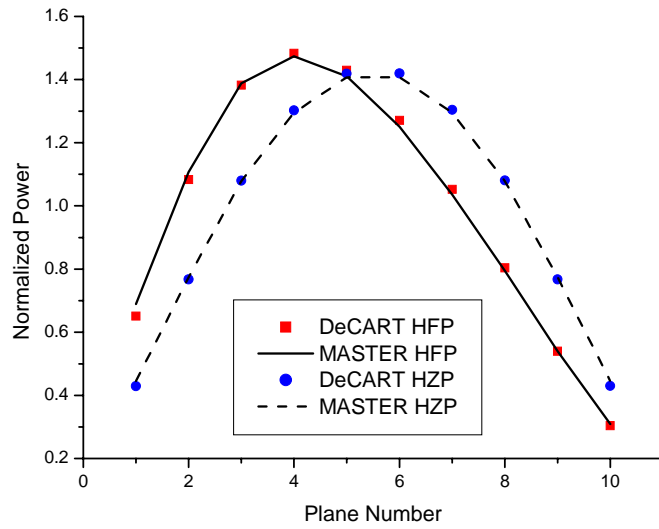
2.6%   ,

.   MASTER

.

7.   MASTER   DeCART

Case	Code	k-eff	Tf-avg	Tf-max	Tc-avg	Tout	Dc-avg	Fq-FA	Fr-FA	Fq-pin	Fr-pin
NC-HZP	MASTER	1.04855	270	270	270	270	0.7808	1.902	1.349	2.386	1.669
	DeCART	1.04541					0.7808	1.904	1.342	2.365	1.665
	Difference	286.7					-0.01%	-0.13%	0.50%	0.89%	0.25%
NC-HFP	MASTER	1.02446	488.8	937.6	295.8	314.3	0.7315	1.915	1.273	2.387	1.574
	DeCART	1.02206	490.0	1167.3	295.8	314.3	0.7314	1.962	1.272	2.400	1.549
	Difference	229.8	-0.26%		0.01%	0.01%	0.02%	-2.41%	0.04%	-0.53%	1.57%
PC-P50	MASTER	1.06629	371.6	941.5	279.5	293.2	0.7641	3.853	1.921	4.485	2.208
	DeCART	1.06507	371.7	1108.0	279.6	293.2	0.7641	3.818	1.885	4.473	2.215
	Difference	107.4	-0.02%		0.00%	0.01%	0.00%	0.91%	1.89%	0.27%	-0.31%

*   : pcm

NC-HZP

1.349	1.327	1.271	1.148	0.629
1.342	1.318	1.257	1.141	0.637
0.5	0.7	1.1	0.6	-1.3
	1.305	1.232	1.028	0.471
	1.294	1.220	1.025	0.481
	0.9	1.0	0.3	-2.1
MASTER		1.142	0.815	
DeCART		1.140	0.837	
Error,%		0.2	-2.6	

NC-HFP

1.272	1.260	1.229	1.148	0.679
1.272	1.257	1.219	1.140	0.682
0.0	0.2	0.8	0.7	-0.4
	1.247	1.200	1.041	0.517
	1.241	1.191	1.037	0.524
	0.5	0.8	0.4	-1.3
MASTER		1.136	0.857	
DeCART		1.134	0.878	
Error,%		0.2	-2.4	

PC-P50

1.175	1.327	1.578	1.331	0.675
1.170	1.318	1.567	1.320	0.679
0.4	0.7	0.7	0.8	-0.6
	1.307	1.868	1.234	0.513
	1.299	1.885	1.231	0.520
	0.6	-0.9	0.2	-1.3
MASTER		1.198	0.883	
DeCART		1.196	0.900	
Error,%		0.2	-1.9	

8.

9.

3   .   10

  HZP

(15%   ).

,

.   11

10%   .   8   /

.

,   1.0   .
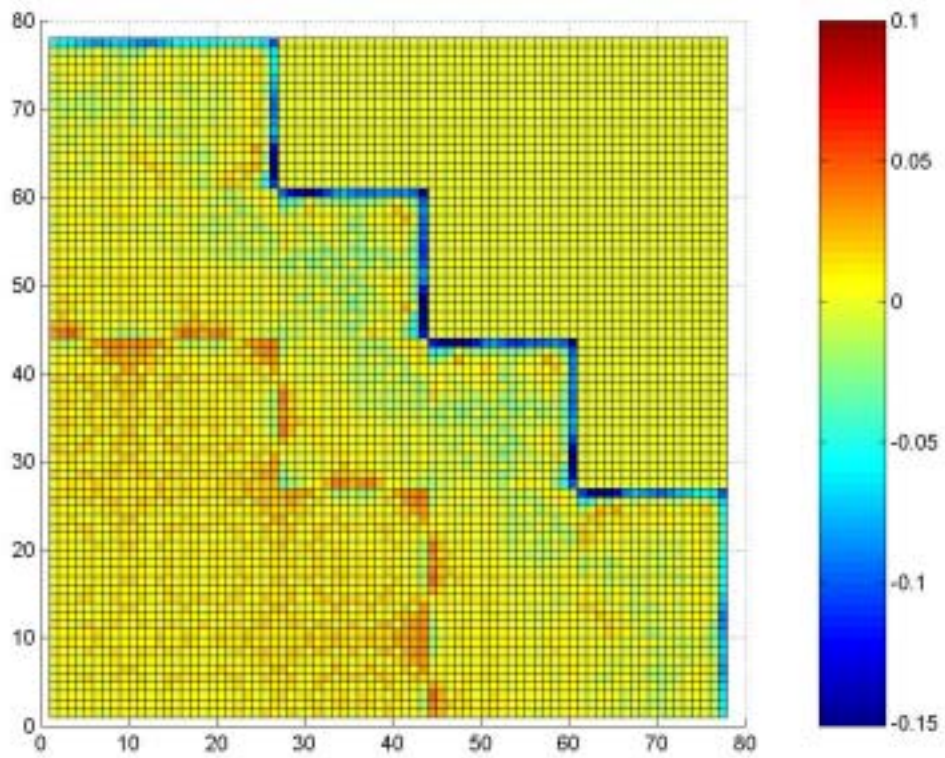
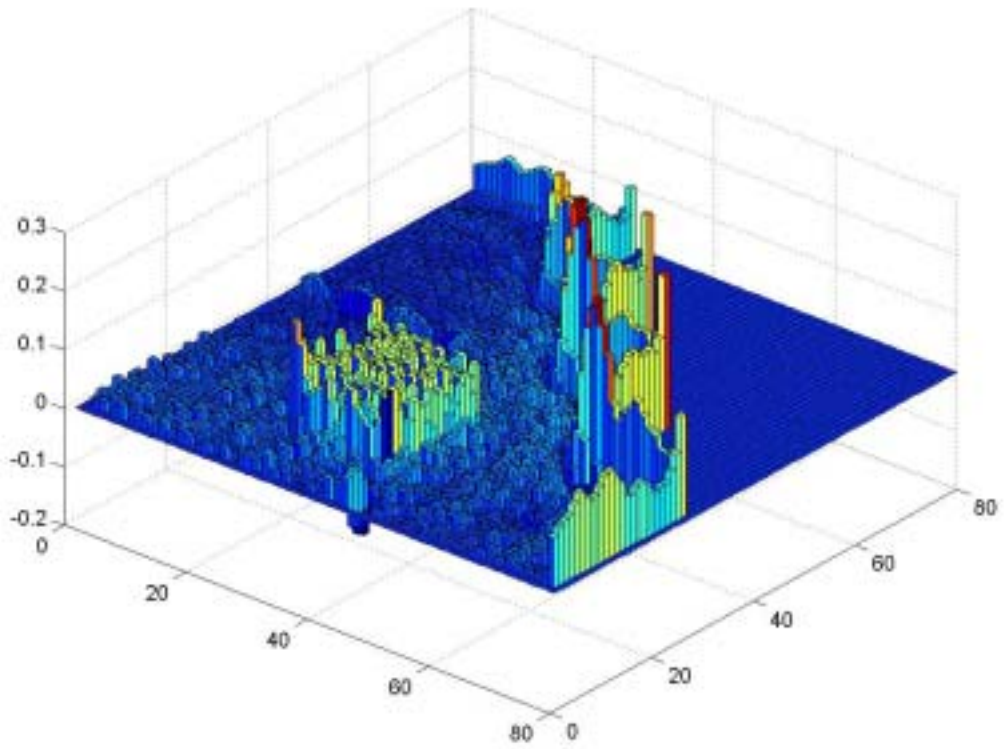RMS   .
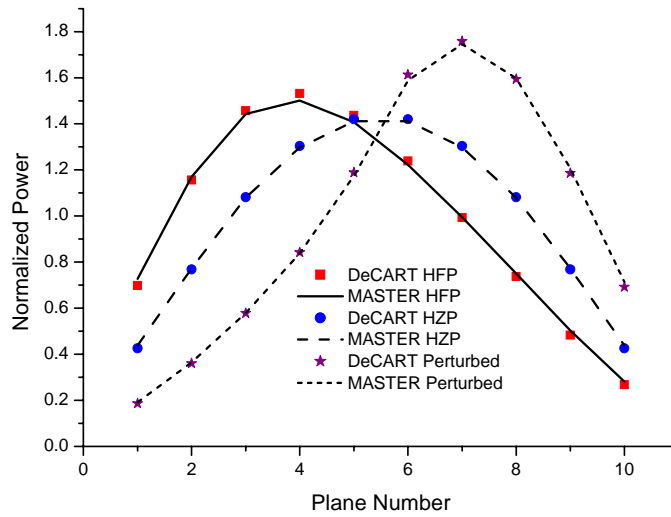
  10. HZP   (MASTER-DeCART)

           8. MASTER 3

Pin Power Error Indicator	NC-HZP	NC-HFP	PC-P50
RMS	2.68	3.32	3.02
	-0.302	-0.336	-0.318
	-0.088	-0.106	0.209
, %	-21.0	-18.0	-17.6
, %	-7.2	7.3	7.7

그림 11. PC-P50 벤치마크 문제의 6번 핀셀에서의 (DeCART-MASTER)

4 결론

본 연구에서는 PWR 노심 해석을 위한 HELIOS/MASTER 핵설계 코드체계와
DeCART 코드를 이용하여 노심 해석을 수행하였다. 계산 결과, 임계도 측면에서,
HELIOS/MASTER 코드체계는 100~300 pcm, 3%, 2%

DeCART 코드는.
15% 정도의 차이를 보였다. HELIOS/MASTER

PWR 노심 해석에.

1. "HELIOS Program," STUDSVIK SCANDPOWER, Nov. 30, 2001.

2.   , "MASTER-2.1: User's Manual," KAERI/UM-06/2000, Korea Atomic Energy Research Institute, Sep. 2000.

3.   , "Three-Dimensional Heterogeneous Whole Core Transport Calculation Employing Planar MOC Solution," *Trans. Am. Nucl. Soc.,* 2002.

4.   , "Cell-Based CMFD Formulation for Acceleration of Whole-core Method of Characteristics Calculations," *J. Kor Nucl Soc.*, **35**, *pp.* 250-258 (2002).

5.   , "Evaluation of General 2D Geometric Transport Code, HELIOS," *Proceedings of KNS Spring Meeting, Cheju*, May 1996.