An Idea of 20% test of the Initial Core Reactor Physics

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1. Introduction

Many tests have been performed on the OPR1000 and APR1400 before commercial operation. Some of these tests were performed at reactor power levels of 20% and 50%. The CPC (Core Protection Calculator) power distribution test is one of these tests. It is performed to assure the reliability of the Core Protection Calculator System (CPCS). Through this test, SAM1 is calculated using the snapshots2. The test takes about nine hours at a reactor power level of 20% and about thirty hours at a reactor power level of 50%. SAM used at each reactor power level is as follows:

1. Reactor power of 0% ~ 20%: Designed SAM (D-SAM)
2. Reactor power of 20% ~ 50%: SAM calculated (C-SAM) at a reactor power of 20%
3. Reactor power 50% ~ End of Cycle : SAM calculated at a reactor power of 50%

As mentioned earlier, SAM is calculated and punched into CPC to assure the reliability of CPCS. Therefore, CPC is operated having penalties with D-SAM until3 reaching a reactor power of 20%. That is, the penalty of CPC will be removed when SAM is calculated and punched into the CPC at a reactor power of 20%. But these penalties are considered to be removed after a reactor power of 50% test in order to maintain the conservatism of the CPC. This is done because the final values calculated using C-SAM, in contrast to those calculated using SAM, a reactor power of 50%, are not correct. This paper began from an idea, "If so, what would happen if we removed the CPC power distribution test at a reactor power of 20%?"

2. Methods and Results

To remove the CPC power distribution test at a reactor power of 20%, the confirming of the safety of the CPC is required prior to the removing of the test. By comparing the CPC axial power shape RMS error between C-SAM and D-SAM, the safety of the CPC will be confirmed.

2.1 Current procedure

According to the SKN 1&2 Test Procedure [1], in the cases in which acceptance criterion 1, or both criteria 2 and 3, are met, SAM/BPPCC need not be determined at a 20% power plateau. Acceptance criteria 1, 2, 3 are as follows:

1. The comparison of the measured core average axial power distribution displayed by CEFAST4 with the core average axial power distribution calculated by each CPC channel shall satisfy the following expression.

$$S^x = \sqrt{\frac{\sum_{i=3}^{18} (EFZ_i^x)^2}{16}} < 5\%$$

2. The error between the measured core average axial peak displayed by CEFAST and the core average axial peak calculated by each CPC channel shall be within the range of -3.0% ~ 5.0%
3. The error between the measured core average axial shape index (ASI) and the core average ASI calculated by each CPC channel shall be within the range of -0.05 to +0.02

2.2 Status of performance of the 20% test

Table1. Status of performance of the 20% test

Shin-Kori unit 1	Performed
Shin-Kori unit 2	Not performed
Shin-Wolsong unit 1	Performed
Shin-Wolsong unit 2	Not to be performed
Shin-Kori unit 3, 4	Under construction
Shin-Ulchin unit 1, 2	Under construction

The above procedure is applied only to plants in the same site. Unfortunately, it is not clear whether the 20% test can be performed for plants of other sites. Therefore, the 20% test was not performed in Shin-Kori unit 2

[1] Shape Annealing Matrix: This is a constant comprised of nine elements. It corrects the ex-core detector signal and is punched into the CPC. Also, it is used to calculate the CPC Power distribution.

[2] The data file having the information on the signal of the in-core detector and the ex-core detector, and so on.

[3] Reliable snapshots can't be obtained until a reactor power of 20%

[4] CEFAST: The computerized code that is used to calculate the CPC axial power shape RMS error.

according to the above procedure but it was performed in Shin-Wolsong unit 1. If the above procedure had been applied in plants at other sites, the 20% test of the Shin-Wolsong unit 1 would not have been performed.

2.3 Comparison of CPC power distribution by C-SAM and D-SAM of Shin-Wolsong unit 1

First of all, C-SAM and D-SAM of Shin-wolsong unit 1 were compared. The results are as follows:

Table2. Design SAM

Channel A			Channel B		
6.1853	-2.9862	0.3486	6.1853	-2.9862	0.3486
-2.3971	6.9130	-2.6077	-2.3971	6.9130	-2.6077
-0.7882	-0.9269	5.2581	-0.7882	-0.9269	5.2581
Channel C			Channel D		
6.1853	-2.9862	0.3486	6.1853	-2.9862	0.3486
-2.3971	6.9130	-2.6077	-2.3971	6.9130	-2.6077
-0.7882	-0.9269	5.2581	-0.7882	-0.9269	5.2581

Table3. SAM calculated at reactor power of 20%

Channel A			Channel B		
3.3222	1.2406	-2.2891	3.5467	0.8774	-2.0379
0.9042	1.5652	1.0615	1.0490	1.3214	1.2453
-1.2264	0.1942	4.2277	-1.5957	0.8013	3.7925
Channel C			Channel D		
3.0751	1.7230	-2.6617	3.3468	1.2802	-2.3473
1.0851	1.2785	1.2415	1.0404	1.3405	1.1807
-1.1602	-0.0014	4.4202	-1.3871	0.3793	4.1667

The calculated SAM is not physically correct in comparison with the D-SAM.

In sequence, the CPC power distribution by C-SAM is compared with that by D-SAM. The results are as follows:

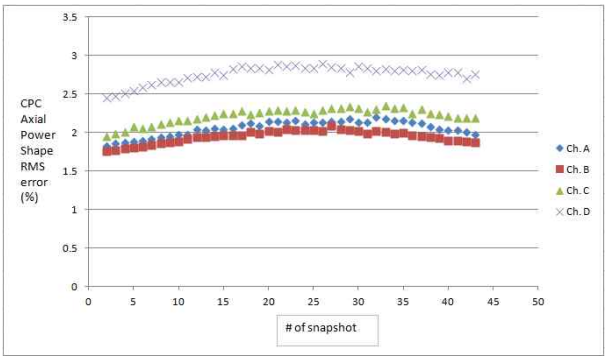

Figure1. CPC axial power shape RMS error by C-SAM

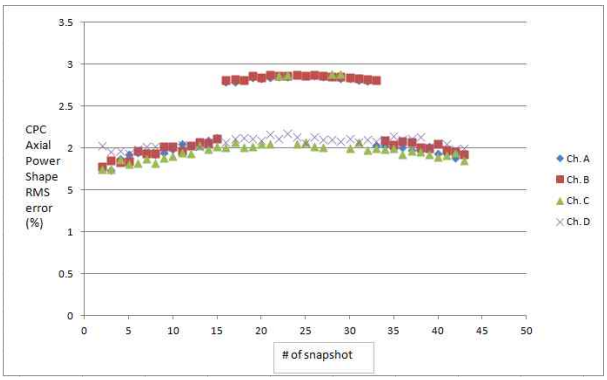

Figure2. CPC axial power shape RMS error by D-SAM

CPC axial power RMS error calculated by C-SAM is similar to that calculated by D-SAM.

3. Conclusions and recommendations

The difference between D-SAM and C-SAM is compared using operation data of Shin-Wolsong unit 1. Also, the CPC axial power shape RMS error calculated by C-SAM and D-SAM is compared. On the CPC power distribution side, D-SAM may be used at a reactor power level of 20%~50%. However, such a use it means that only the above case is without problems in terms of CPC operation. In the case of important changes, such as using other types of fuel or making large changes to the loading pattern, detailed safety analysis and discussion with related companiesy and regulatory body will be required prior to application. Finally, Shin-Kori units 3, 4 and Shin-Ulchin units 1, 2, and so on, are under construction. The content of this paper will have to be considered for the follow-up unit.

REFERENCES

[1] 9S-I-000-15 (CPC Power Distribution Measurement Test, Rev.01, 2011.08.19), SKN 1&2 Test Procedure by KHNP