The Performance of CSAM SAM when Cycle Length is extended

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1. Introduction

OPR1000 and APR1400 have CPCS (Core Protection Calculator System). It consists of independent four Channels (A, B, C, D) which various constants are installed. SAM (Shape Annealing Matrix) is constant made up nine elements and type of 3x3matrix. It is the constant that corrects ex-core detector signals based on signals of In-Core Instrumentation (ICI). Generally, it is calculated just one time in BOC to install in CPCS after the calibration of ex-core detector, which should be assured maintaining linearity, is performed based on ICI. In order to verify validation of that, CPC Axial Power Distribution is compared with Axial Power Distribution based on ICI every week. The difference between CPC Axial Power Distribution and Axial Power Distribution based on ICI increases according as fuels are burned. It is called CPC Axial Power Distribution Root Mean Square Error (CPC RMS Error). SAM and calibration of ex-core detector are important factors influencing the magnitude of the difference. According to vendor, the difference is limited by 8%. Otherwise, CPC penalty increases as many as difference increase. Therefore, KHNP developed Constrained Simulated Annealing Method (CSAM)[1][2], which has better performance than that of Least Square Method (LSM), to calculate SAM constant. The CSA SAM contributed largely to maintain CPC operating margin.

Somewhat, KHNP is developing the technology to be able to operate nuclear power plants for 24 month to optimize their efficiency. This paper shows trends of CPC RMS Error in a case of 24 months operation. Trends are based on data of a few OPR1000s under operation. It is data of OPR1000s that CSA SAM is applied. Also, future work and consideration required in CPCS to develop 24 months operation technology is described in this paper.

2. Analysis of CPC RMS Error

Reactor engineers continuously check CPC RMS Error to verify reliability of CPC every week. Operation data and assumption need to expect CPC RMS Error in a case of 24 months operation because KHNP has no experience for 24 months operation. In this paper, one cycle data Least Square Method was applied and five cycle data CSAM was applied are used to analyze trend of CPC RMS Error. Also, assumptions are like follows;

① CPC RMS Error varies linearly according as fuels are burned.

② OPR1000 is operated with full power for 24 months

Figure1 shows CPC RMS Error trend of plant cycle operated with LSM SAM.

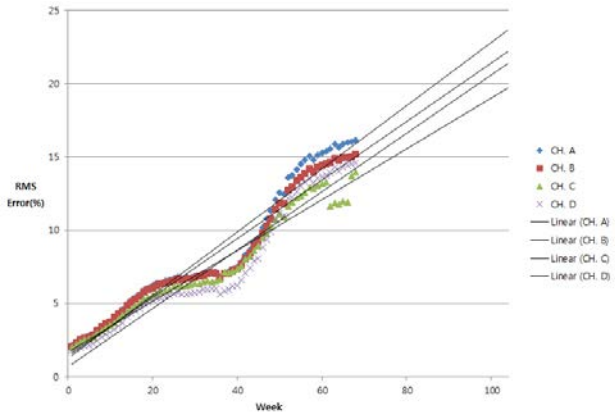

Figure 1 CPC RMS Error Trend by LSM SAM

The maximum value of CPC Axial Power Distribution Error in figure1 is 23.7% in CH.A. If OPR1000 is operated with a way like fiure1 for 24 months, big penalty will be applied in CPC. It will be about 15% in a case of figure1. Apart from operation margin of 15%, above case will become a big problem in reliability of CPC.

Figure 2 ~ 6 show CPC RMS Error trend of plant cycles after CSAM SAM is applied.

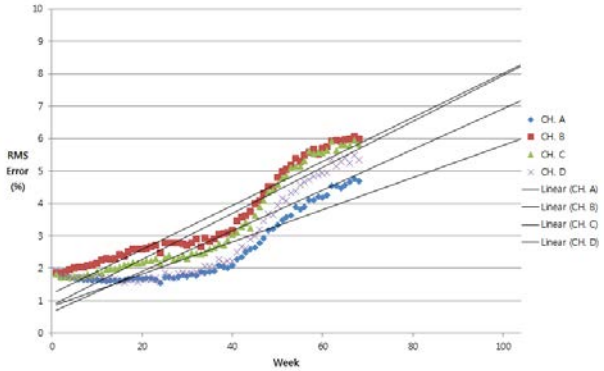

Figure 2 CPC RMS Error trend by CSAM SAM (1st Cycle)

The maximum value of CPC Axial Power Distribution Error in figure2 is 8.3% in CH.B.

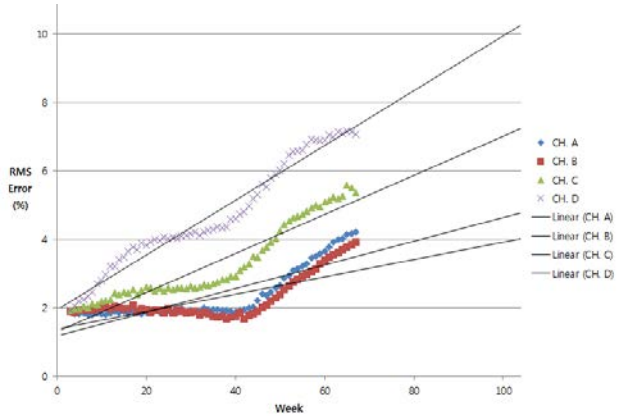

Figure 3 CPC RMS Error trend by CSAM SAM (2nd Cycle)

The maximum value is 10.3% in CH.D.

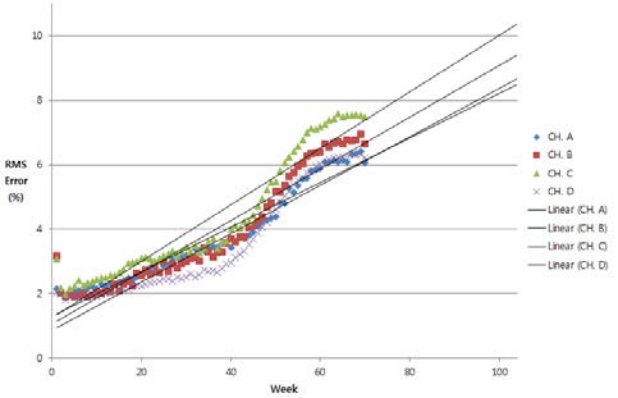

Figure 4 CPC RMS Error trend by CSAM SAM (3rd Cycle)

The maximum value is 10.4% in CH.C.

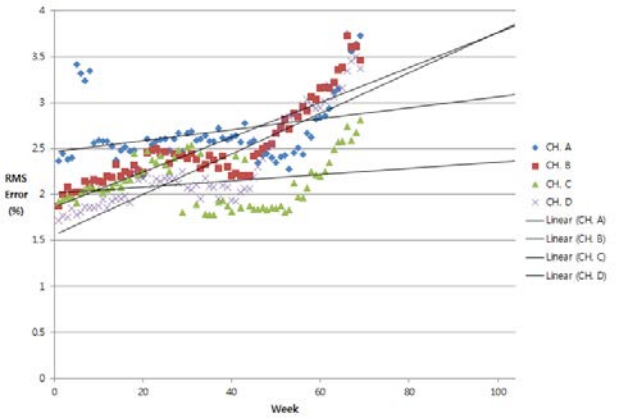

Figure 5 CPC RMS Error trend by CSAM SAM (4th Cycle)

The maximum value is 3.9% in CH.D.

The maximum value of CPC Axial Power Distribution Error in figure6 is 4.6% in CH.D. According to Figure2-6, CPC RMS Error of plant operated with CSAM SAM exists between 3.9% and 10.4%. More cases need to be analyzed because CPC Axial Power Distribution RMS Error for only six cases is considered to analyze trend of that.

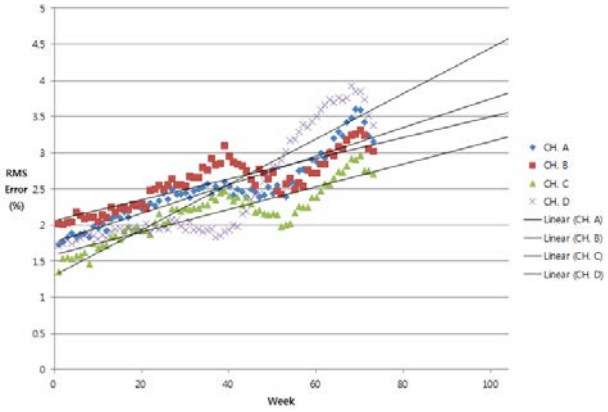

Figure 6 CPC RMS Error trend by CSAM SAM (5th Cycle)

Nevertheless, CPC Axial Power Distribution RMS Error in some cases exceeds 8%. That is, CPC operation margin will be decreased as many as increase of CPC Axial Power Distribution RMS Error if cycle length is extended to 24 month which is longer than current cycle length. Therefore, KHNP should prepare for 24 months operation technology by improving the method to calculate SAM or renormalization of ex-core detector calibration [3].

3. Conclusion and Future Work

KHNP is developing the technology to extend operation cycle length in order to optimize the operation efficiency of OPR1000. To verify effect of extended operation cycle length on CPC, CPC Axial Power Distribution RMS Error in a case of 24 months operation was expected using operation data of six cycles in OPR1000. According to the method, which is CSAM or LSM, to calculate SAM, it exists between 4% and 23%. But cases that CPC Axial Power Distribution RMS Error exceeds 8% exist under all circumstances. 8% is a threshold limited by vendor. In cases that CPC Axial Power Distribution RMS Error exceeds threshold, operation margin is decreased due to CPC penalty. To prevent CPC operation margin from being decreased, improved method to calculate SAM or to calibrate ex-core detector is required. KHNP will consider the way to maintain CPC operation margin along with 24 month operation technology development, hereafter.

Reference

[1] Kyung Ho Roh, Sun Kwan Hong, Solution of ill-posedness Using Constrained Simulated Annealing, KNS, 2008

[2] Sang Rae Moon, Sung Tae Yang, Ki Young Kim, Verification of Advanced SAM Using Constrained Simulated Annealing, KNS, 2008

[3] Korea Electric Power Cooperation, Renormalization method of excore detector, US20100104059, 2010