Core Operating Analysis of PLUS 7 Lead Test Assembly Loaded in UCN-3 Cycle 5

B.C. Baek and C.K. Lee
Korea Nuclear Fuel Co., Ltd 493 Deokjin-Dong, Yuseong-Gu, Daejon, 305-353
e-mail : bcbaek@knfc.co.kr

1. Introduction

The nuclear reactor operation with 4 LTAs (Lead Test Assemblies) loaded in UCN-3 cycle 5 was terminated at the measured accumulated burnup of 17,109 MWD/MTU. The LTAs are improved Korea standard nuclear fuel called PLUS7. Using the measured operating data, the key nuclear physics data processed by CECOR code[1] are evaluated and compared with those predicted by ROCS code[2]. The 4 LTA(HAs) location in full core load map are shown in Figure 1.

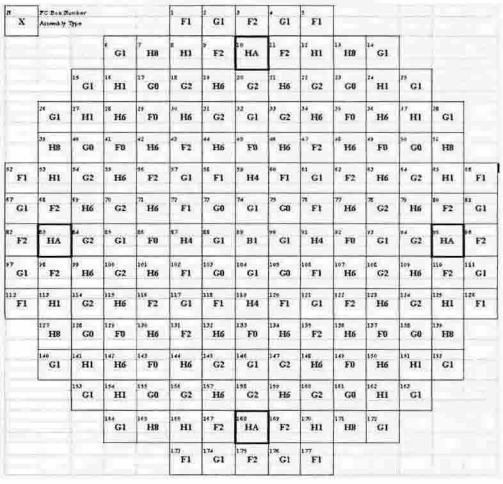

Figure 1. 4 LTAs Location of Full Core Load Map

2. Trends of Operating Parameters

Figure 2 show the trends of measured core power level and measured critical boron concentration (CBC) since reactor startup until EOC. As shown in the figure, there are no reactor trips or transients such a core power reduction and full power operation is maintained during the cycle. The rundown of measured boron concentration is agreed well with the predicted values except near EOC.

Figure 3 shows the core ASI (Axial Shape Index) vs. burnup. ASI is defined as follows:

$$ASI = \frac{P_B - P_T}{P_B + P_T}$$

where P_B is bottom half of active core power, and P_T is top half of active core power.

As shown in the figure, the measured ASI shows a good agreement with those of ROCS .

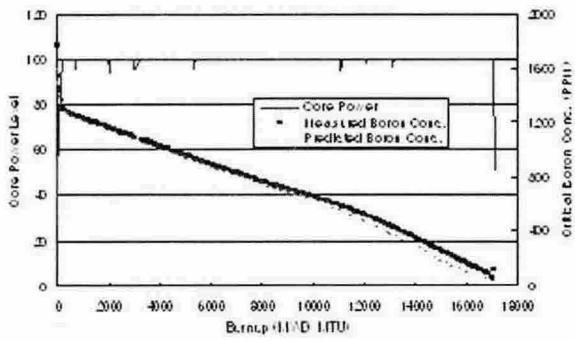

Figure 2. Trends of Core Power Level and CBCs

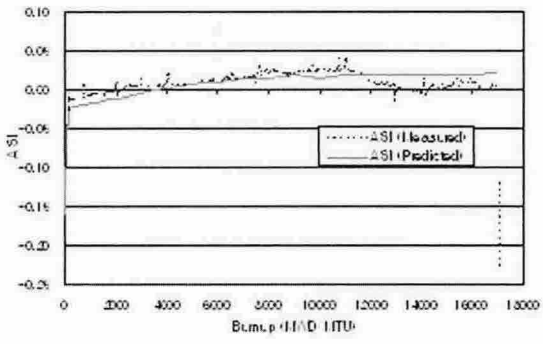

Figure 3. Trends of Predicted and Measured ASIs

3. Core Power Distribution Evaluation

3.1 Core Radial and Axial Power Distribution

The radial and axial power distributions are evaluated by RMS errors. RMS error is defined as follows:

$$RMS = SQRT\left(\sum_{i=1}^{N} (\Delta RPD)_i^2 / N\right)$$

As shown in Figure 4, the radial RMS errors are almostly less than 1.5% throughout the cycle, whereas the axial RMS errors are increasing vs. burnup and the maximum errors reached at ~6.8% near EOC. These large errors are caused by CECOR axial synthesis to minimize Fz instead of axial power distribution. It is a typical trends observed in KSNP.

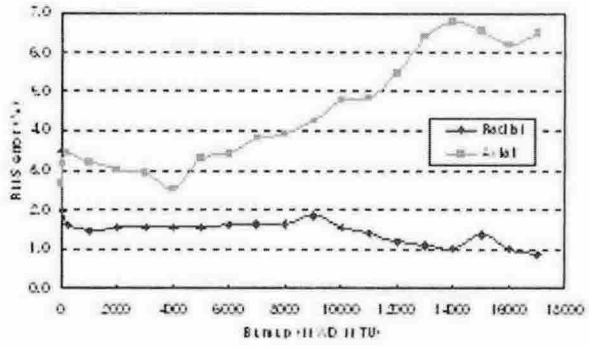

Figure 4. RMS errors of Radial and Axial Powers

3.2 Core Peaking Factors

Figure 5 shows the difference of core peaking factors between CECOR and ROCS vs. burnup. It is shown that the maximum differences of power peaking factors are within ±5% during the cycle. The BOC startup test criteria in reload test procedure [3] are 7.5% for Fxy, 10% for Fq, Fr and Fz.

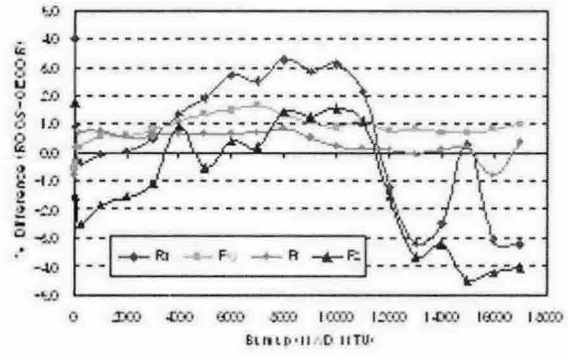

Figure 5. Comparison of Core Power Peaking Factors

3.3 LTA Power Distributions

Figure 6 illustrates the axial power peaking factor, Fz differences between 4 LTAs and LTA average vs. burunp. As shown in the figure, the maximum difference is about ±1.5% up to ~12,000MWD/MTU and less than ±0.5% after ~12,000MWD/MTU up to EOC, where the power distributions are so symmetric.

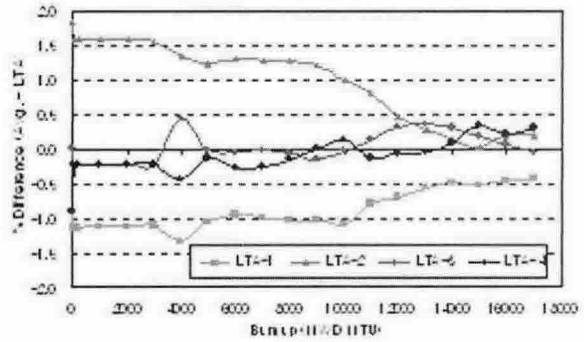

Figure 6. Each LTA Fz Difference to 4 LTA Average

3.4 Ratio of LTA Fxy and Core Fxy

Table 1 shows the ratio of LTA Fxy to core peak Fxy. As shown in table, the maximum ratio is less or equal to 0.97, which is design target estimated by LOCA analysis.

Table 1. Ratio of LTA Fxy and Core Max. Fxy

Burnup (MWD/MTU)	Core Peak Fxy	LTA Fxy	Ratio Fxy(LTA)/Fxy(CORE)
50	1.5501	1.4083	0.91
500	1.5468	1.4060	0.91
3000	1.5462	1.3893	0.90
7000	1.5375	1.3815	0.90
9000	1.5392	1.3808	0.90
11000	1.5408	1.3780	0.89
13000	1.4983	1.3843	0.92
15000	1.4682	1.3964	0.95
16000	1.4555	1.3990	0.96
17000	1.4482	1.3991	0.97

4. Conclusion

The measured nuclear data of PLUS7 LTA loaded in UCN-3 Cycle 5 was compared with those of the predicted by ROCS. The radial and axial RMS errors are less than 2% and 6.8%, respectively, and the core peaking factors are within the test acceptance criteria. The power distributions of 4 LTAs are symmetric individually and agree with those of ROCS. The ratio of LTA Fxy to core maximum Fxy is less than 0.97, which is design target value. Therefore, it is confirmed that the measured core power distributions and LTA power distributions are agreed with those of ROCS.

REFERENCES

[1] Westinghouse, "User's Manual for CECOR," CE-NPSD-104
Rev.013.
[2] Westinghouse, "User's Manual for ROCS," CE-CES-4-P Rev.151997, Supplement 1 June 1999, Supplement 2 Oct. 2002.
[3] KHNP Reload Test Procedures.