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Core Follow Analysis for Yonggwang Unit 3 Cycle 1

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Abstract

This paper presents the results of the core follow analysis for Yonggwang Unit 3 Cycle 1. The values of peaking factors (Fxy, Fq, Fr and Fz) and core power distributions measured and processed by CECOR code[1] are compared with those predicted by ROCS code[2]. The measured boron rundown is also compared with the predicted values. As results, the comparisons of peaking factors, radial and axial power distributions and boron rundown between the measured and the predicted show good agreement throughout the cycle. Additionally, assembly burnup differences between CECOR and ROCS at EOC1(13650 MWD/MTU) are within 5% of core average burnup.

1. Reactor Operating History

Yonggwang Unit 3 Cycle 1 achieved initial criticality on October 14, 1994. After that low power physics test and power ascension test were performed during various power plateaus. On February 20, 1995 the unit was shut down for maintenance and returned to commercial operation on March 20, 1995. During the normal operation period, the reactor has been operated at essentially full power except four reactor trips. Fig.1 shows the Yonggwang Unit 3 Cycle 1 core power history during commercial operation. As shown in Fig.2, Yonggwang Unit 3 Cycle 1 was operated with Part Strength Control Element Assembly (PSCEA) inserted while maintaining full power from the burnup of ~9000 MWD/MTU to the end of cycle in order to control xenon oscillation after the middle of cycle.

The difference between measured and predicted boron concentrations at Hot Full Power (HFP) and All Rods Out (ARO) is plotted in Fig.3. As shown in this figure, the boron difference of hot-leg is smaller than that of boronometer until the first half of the cycle, but the two boron concentration readings agree with each other during the second half of the cycle. Furthermore, the boron concentration difference between hot-leg and boronometer is very small (~10 PPM) which is below the acceptable limit of ±50 PPM provided by Ref.[3].

2. Comparisons of Peaking Factors

The comparisons of peaking factors are shown in Fig.4. As shown in these figures, the tilt amplitude is small throughout the cycle indicating that the core is azimuthally symmetric, and each measured value shows good agreement with that of predicted value except Fq and Fxy near 5500 MWD/MTU. The maximum difference occurs at burnup of 5576 MWD/MTU, and the relative differences of Fq and Fxy are 6.7% and 2.9%, respectively. These differences are introduced by the large pin-to-box factor fit errors caused by using the two different CECOR coefficient sets which are divided by applicable burnup range. Actually, the cut-off burnup point for Cycle 1 CECOR coefficient library was 6000 MWD/MTU. So, the fitted pin-to-box factor at the core average burnup of about 6000 MWD/MTU are incorrectly extrapolated for the local exposures. This results in the large Fq and Fxy differences between the measured and the predicted. However, this difference is within the limit of ±10% which was used in the acceptable criteria of pin peaking factor during Steady State Core Performance Test (SCPT)[4].

3. Comparisons of Radial and Axial Power Distributions

Fig.5 shows the maximum and minimum assembly power differences between the measured and the predicted at all detector levels. As shown in this figure, the power differences of detector levels 1 and 5 which have relatively low flux levels and large noises are greater than those of levels 2,3 and 4. The axially integrated difference, however, is less than 5% during full power operation. The large difference at the beginning of cycle is caused by the use of low power snapshot. Fig.6 shows that the Root Mean Square errors (RMS) are less than 2% which is within the acceptable limit of 5% that is used in Cycle 1 SCPT[4].

The core average axial power distribution at three typical burnup points of 3000 (IOC), 8000 (MOC), and 13650 MWD/MTU (EOC1) are plotted in Fig.7. As shown in these figures, the measured axial power distributions agree well with the predicted values.

4. Comparisons of EOC Exposures

The maximum assembly burnup difference between the measured and the predicted of all assemblies at EOC1 is estimated by 395 MWD/MTU. This discrepancy is 2.9% of the core average burnup which is within the normally acceptable limit of 5%.

5. Results and Discussion

The core follow analysis of Yonggwang Unit 3 Cycle 1 has been performed by comparing the measured values with the predicted values. The comparisons of boron rundown, peaking factors, core power distributions, and EOC1 burnup distribution are performed. The following items summarize the results of core follow analysis for Yonggwang Unit 3 initial core:

1) The slight over prediction of core reactivity during the first half of the cycle is reduced and the core reactivities agrees within 10 PPM as the core burnup progresses.
2) The radial box power comparison between the measured and the predicted shows good agreement. The relative difference of axially integrated assembly power is less than 5% and RMS error is less than 2% throughout the cycle.
3) The maximum burnup difference for all assemblies at the end of the cycle is 395 MWD/MTU. This difference is only 2.9% of the core average burnup, which is acceptable.
4) Relatively large difference (~6.7%) of Fq is shown at 5576 MWD/MTU which is near the end point (6000 MWD/MTU) of the first half of CECOR coefficient library. As described above, the error is introduced by dividing the application burnup range into two in CECOR coefficient library. Therefore, the excessive extrapolation of pin-to-box factors near 6000 MWD/MTU results in large pin-to-box fitting error. This error would be decreased by using the extended burnup points in fitting the pin-to-box factors at the first half of CECOR coefficient library or/and by using the all instrument level-wise 1-pin factors to be used in pin peaking synthesis in CECOR. Note that this sort of fitting error in CECOR would not occurred at reload cycle which uses a unique CECOR coefficient library file.

References

[1] ABB-CE, "User's Manual for CECOR," CE NPSD-104 Rev 8, August, 1994.
[2] ABB-CE, "User's Manual for ROCS," CE-CES-4 Rev-8P, March, 1994.
[3] "Reload Startup Physics Tests for PWR's," ANS/ANSI-19.6-1-1985, ANS,1985.
[4] KAERI, "Steady-state Core Performance Test Procedure for YONGGWANG NUCLEAR POWER PLANT UNIT 3," 10587-SE-TP152-03, Rev.01, March 31, 1994.

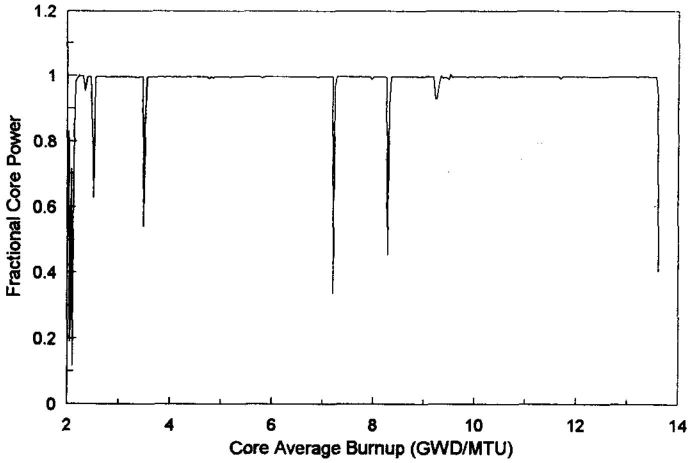


Fig.1 YGN-3 CY-1 Core Power History

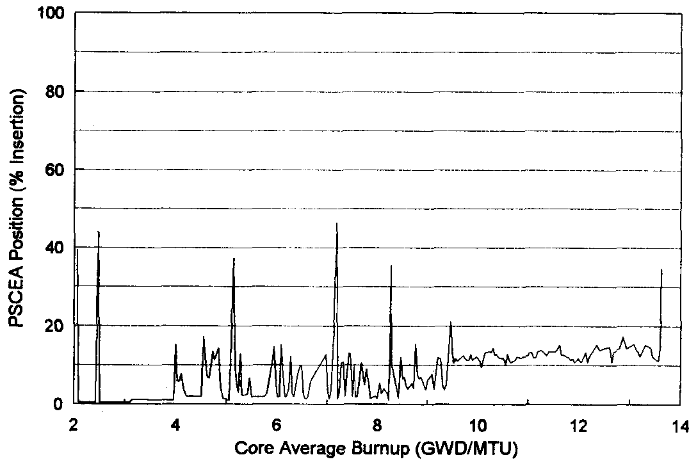


Fig.2 YGN-3 CY-1 PSCEA Operating History

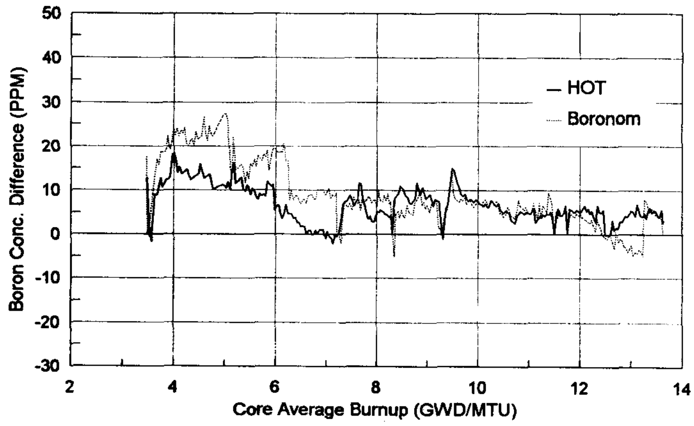


Fig.3 YGN-3 CY-1 PPM Differences
(Predicted - Measured)

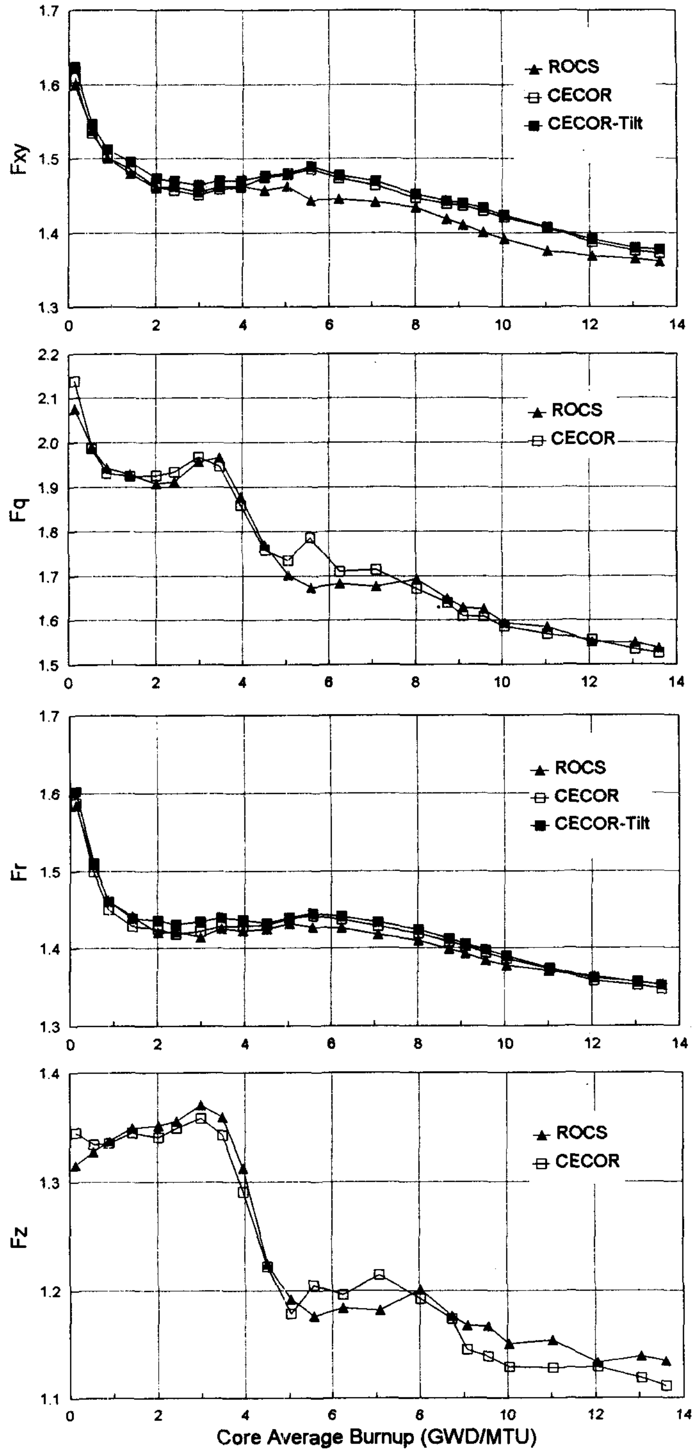


Fig.4 Peaking Factors vs. Core Average Burnup

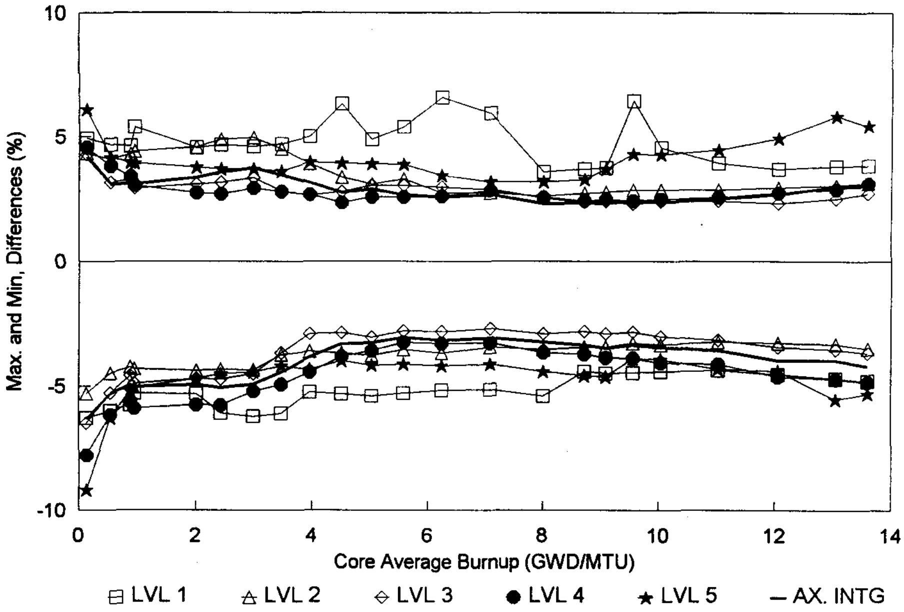


Fig. 5 Assembly Power Differences on Full Core CECOR and ROCS
YGN-3 Cycle 1

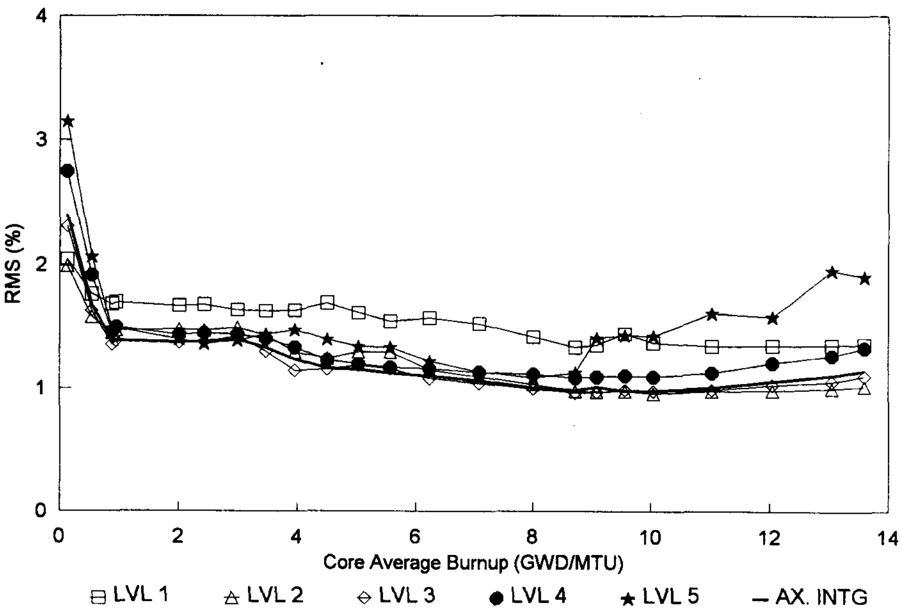
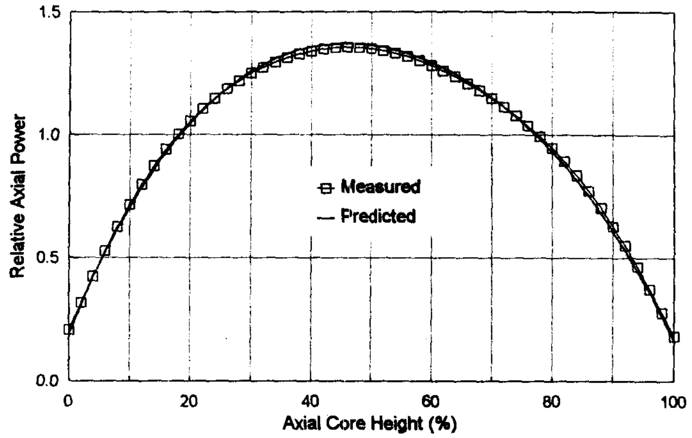
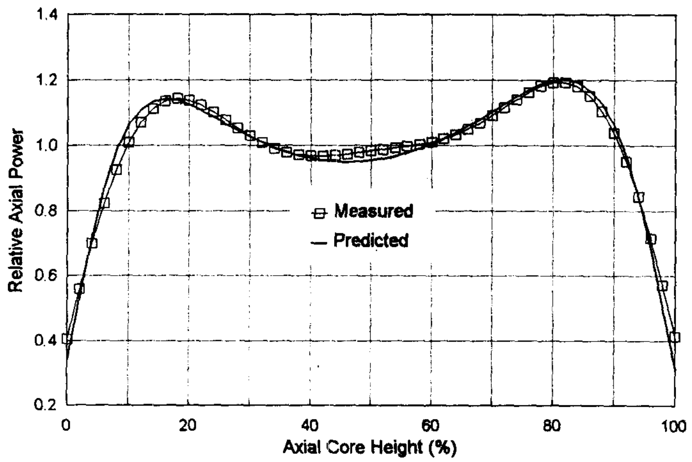


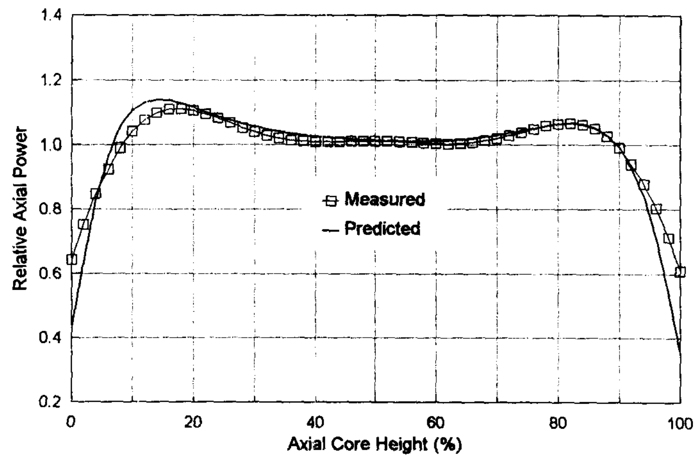
Fig. 6 RMS of Assembly Power Differences on Full Core CECOR and ROCS
YGN-3 Cycle 1



Burnup: 2989 (MWD/MTU)



Burnup : 8010 (MWD/MTU)



Burnup : 13601 (MWD/MTU)

Fig.7 Comparison of Axial Power Distribution