Simulation of the Long period Core Design for WH type of KHNP

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1. Introduction

This study is to simulate of the long period core design and evaluate the risk assessment for the result.

The current core design of the reactor and the new design of long period based on ANC code are compared here targeting the unit of WH type(Westinghouse nuclear steam supply system) operated by KHNP. The reactor core is composed of 157 fuel assemblies, consisting of a 17×17 array with 264 fuel rods, 24 guide thimbles.

To investigate susceptibility of CIPS(crud-induced power shift) for long period core design, the boron mass is also calculated here.

2. Methods and Results

2.1 Method of the Core Design for long period operation

The current unit(~16 month cycle) consists of 64 feed assemblies and the rest of assemblies(once or twice burned) from previous cycles.

To extend the fuel cycle, the number of feed assembly and enrichment of the fuel are increased.

89 feed assemblies and the fuel rods of 4.95w/o uranium enrichment and 3.2w/o for Axial-blanket are used for the aimed long cycle.

For the long period core design of N+1 cycle, the core design database of the previous cycles(N-1, N) are prepared.

2.2 Core Design and the Result

For starting core design of N-1 cycle, the refueled assemblies of operated N-2 cycle and 97 feed assemblies are used. The 4.95w/o Uranium enrichment (3.2w/o for Axial-blanket) and 8w/o Gd_2O_3 for burnable absorber rods are designed for fresh fuel rods. Fig.1 shows the core loading pattern of N-1 cycle for long period. The burnup was 25136 MWD/MTU at 10ppm boron concentration and the maximum F△h *(Nuclear Enthalpy Rise Hot Channel Factor)* was 1.478 at nominal model.

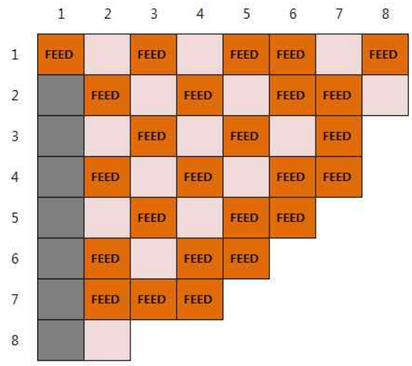

Fig. 1. The Core Design of N-1 Cycle for Long period

The F△h of current and long period cycle of N-1 is compared at Fig.2.

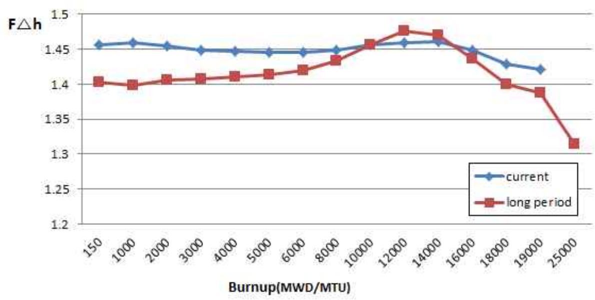

Fig. 2. F△h of Current and Long Period Cycle of N-1

For core design of N and N+1 cycle, 89 feed assemblies and same enrichment for fresh fuel rods are used. The only once-burned assemblies are reloaded. Each 1/4 core loading pattern is as follows.

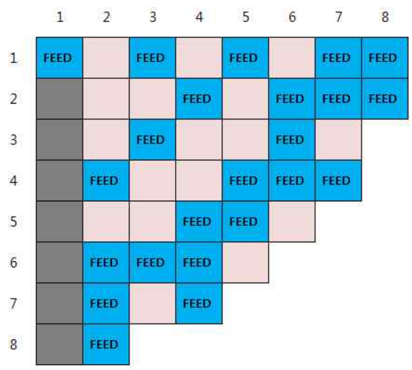

Fig. 3. The Core Design of N Cycle for Long Period

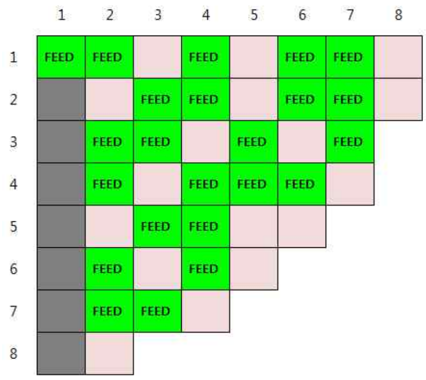

Fig. 4. The Core Design of N+1 Cycle for Long Period

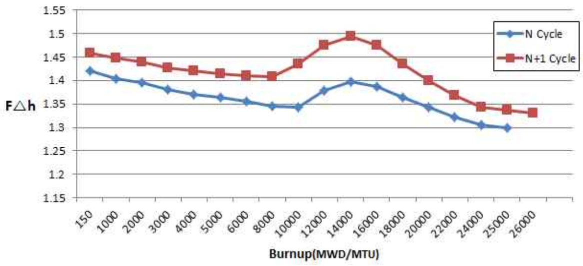

Fig. 5. Maximum F△h of N and N+1 cycle

The cycle length of long period design is increased by 6 month than the average of operated cycles. The burnup is about 26000(MWD/MTU) and maximum F△h is 1.497 at nominal model(Fig.5). Fig.6 and Fig.7 show the curve of boron concentration of N-1 and N/N+1 cycle.

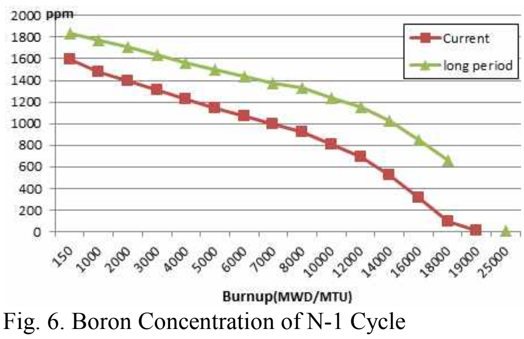

Fig. 6. Boron Concentration of N-1 Cycle

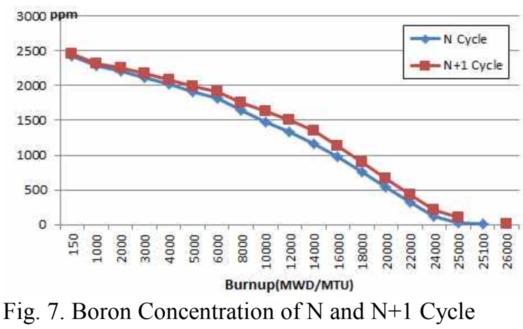

Fig. 7. Boron Concentration of N and N+1 Cycle

For the results of core design, risk assessment was performed.

The MTC at BOC, ratio of peak to average power in the assembly with hot rod, maximum average assembly power, maximum pin burnup are satisfied the criteria for the risk assessment of the core design at short (burnup - 500(MWD/MTU) at 10 ppm boron concentration), nominal (burnup(MWD/MTU) at 10 ppm) and long (burnup + 500(MWD/MTU) at 10 ppm) model.

Burndown curve is 6% deviated from the criteria, but this result is already predicted.

2.3 Risk Assessment for CIPS(crud-induced power shift)

For investigating susceptibility of crud-induced power shift, boron mass was calculated by using BOA (Boron-Induced Offset Anomaly) code of EPRI.

For analyzing N-1 long period cycle, N-3, N-2 and N-1cycle inputs and restart files for BOA code are made.

The operated N-1 cycle was tested by BOA code, and the information of the batch of assemblies, burnup, concentration of boron and Li for lone period design are applied to same environment of that cycle.

Maximum predicted core boron mass is increased by 0.1~0.3lbm for long period design and also the maximum crud thickness is increased. The boron mass and thickness are both increased due to the extension of fuel cycle which means it may cause the increase of CIPS risk. The inputs are optimized at current operating cycle, so the new inputs of BOA code and more detailed study for long period cycle will be performed for crud-induced power shift (CIPS) risk assessment.

3. Conclusions

The long period core design for WH type of KHNP is simulated and evaluated the risk assessment for the result. 89 feed assemblies and 4.95w/o uranium enrichment (3.2w/o for Axial-blanket) are used for fresh fuel rods. The cycle length of long period design is increased by 6 month than the average of operated cycles satisfying the criteria of risk assessment for the core design; maximum F△h and maximum pin burnup and so on, except burndown curve.

For the CIPS risk assessment by BOA code, the boron thickness and mass are increased, which means CIPS risk may be increased. Therefore, more detailed study will be performed for CIPS risk by various cycle design and more units for long period cycle.

REFERENCES

[1] The Nuclear Design Report for Kori unit2 and unit3,4 Nuclear Power Plant, KEPCO NF.

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[3] BOA 3.0 Manual, EPRI