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Core Quadrant Power Tilt Induced by Control Rods Axial Position Mismatch

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1. Introduction

In general, high core quadrant power tilt (QPT) in the nuclear power plants can have an effect on the core power distributions and the peaking factors (FdH, Fq and Fxy) that are limited by the technical specifications. If the limits are not met, plant operation should be restricted at various conditions.

Actually, core quadrant power tilt in many nuclear power plants has been occurred frequently. This study deals with the various general causes of the core quadrant power tilt, including the control rods axial position mismatch induced quadrant power tilt problem.

2. Methods and Results

Definitions of quadrant power tilt and various causes of the quadrant power tilt are investigated.

2.1 Definitions of Core Quadrant Power Tilt

Some definitions for core quadrant power tilt are listed as follows [2].

1) Core Tilt : The ratio of maximum to average quadrant power.
2) Incore Quadrant Power Tilt (IQPT) : This condition exists when a core tilt is measured through the use of the Moveable Incore Detector System and is in excess of expected Core Asymmetries and that is required to verify the peaking factor compliance to the limit specified in the technical specifications.
3) Quadrant Power Tilt Ratio (QPTR) or excore tilt : A core tilt that is measured with the use of excore power range flux detectors. This is the only type of core tilt that is covered by the Technical Specifications.

2.2 General Restrictions of QPT

IQPT is not the Technical Specification required item. But it is needed to monitor regularly to get surveillance data for design and safety evaluations as follows [2].

1) IQPT between 0% and 2% : No action
2) IQPT between 2% and 4% : Information only
3) IQPT between 4% and the RSE separation line : Investigations into modeling and fuel rod design considerations
4) IQPT above RSE separation line : Re-evaluation of the RSE

Typical Technical Specifications require that the QPTR be less than 1.02 for power levels above 50% of rated thermal power. The value 1.02 was selected because the purpose of the specification is to limit, or require detection of gross changes in core power distribution between monthly incore flux maps. In addition, it is the lowest value of quadrant power tilt that can be used for an alarm without spurious actuation [2].

In most Technical Specifications, when the Quadrant Power Tilt Ratio is between 1.02 and 1.09, reactor power must be reduced 3% for each 1% indicated excore tilt from rated thermal power (RTP). For Quadrant Power Tilt Ratios in excess of 1.09, reactor power must be reduced 3% for each 1% indicated excore tilt from rated thermal power and the specification must be met within the next 2 hours, or power reduction below 50% RTP is necessary [2].

2.3 General Causes of QPT

The following parameters could be effective on causing QPT [1].

1) Even lattice fuel assembly design
2) Center assembly burnup gradient
3) Fuel shuffle strategy
4) The flow and/or temperature distribution
5) INCORE measurement related deviation
6) As-built manufacturing data

2.4 Control Rods Position Mismatch Induced QPT

In addition to the general QPT causes, each control rods axial position (step) in a same bank can be mismatched during the core power level changes because of the rod insertion or withdrawal speed differences in some moments. And it can induce the core QPT.

To simulate the situation, core quadrant powers were calculated in the condition of power decreasing mode

(100% to 0% power) with some control rods axial position mismatch (4~11 steps difference) for WEC type 2-loop nuclear power plant.

From the results as shown in the Fig. 1, the control rods axial position difference in simply 4 ~11 steps can induce the relatively high core QPT (maximum around 1.5%).

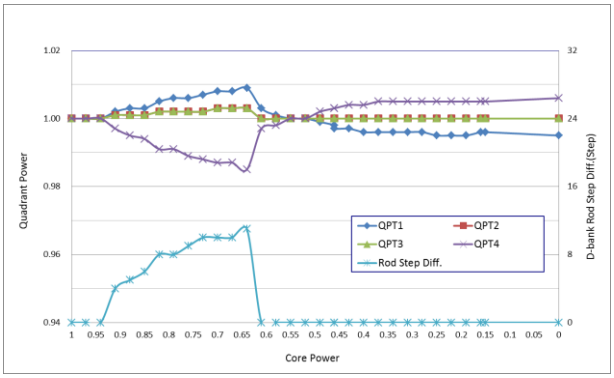

Figure 1. Simulation Result of Control Rods axial Position Mismatch

3. Conclusions

Based on the simulation results in each control rods axial position mismatch in a same control bank, it was found that some control rods axial position mismatch (simply around 10 steps difference) can induce quadrant power tilt relatively high (around 1.5%). With the other causes induced QPT, it may exceed the technical specification limit (2%). So it is needed to drive the control rods in detail during the operation including power change mode.

4. Future Plan

This study simply performed only for 2-loop WEC type nuclear power plant in Korea. The various simulation calculations from many type of nuclear power plant data will be needed to get more accurate and effective results.

REFERENCES

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