Evaluating the Feasibility of Improving Operational Scenario Accuracy through Long-term ASI Search

Kwon Sung Ju[a] *, Nam Youn Duk[a], Seo Geon Ho[a], Yoon Joo Il[a], Lee, Jongsun[b], Cho Dae-Hee[b]
a) 242,Daedeok-daero 989 beon-gil, Yuseong-gu, Daejeon, 34057, Republic of Korea
b) [38120]1655, Bulguk-ro, Yangbuk-myeon, Gyeongju-si, Gyeonsangbuk-do, Korea
**Corresponding author: sjukwon@knfc.co.kr*

1. Introduction

In nuclear power plant operations, control rods are mainly used to control the Axial power Shape Index (ASI) within the operation limits when power ascension or reduction. In Korea, the ACEONED[1] or 3D core analysis code is utilized to generate operational scenarios for the transient core control. These scenarios are based on reactivity and control rod worth for the core, which are calculated using nuclear design methods. The accuracy of the nuclear data is verified through startup physics test within approved uncertainty ranges. If the behavior of xenon can be accurately predicted, it would improve the precision of operational scenarios. This paper evaluates the potential of the ASI search method to enhance the accuracy of predicting xenon behavior in the transient core.

2. Methods and Results

ASI search is a function typically used for safety analysis to simulate a virtual core that has reached the operation limits of ASI (e.g., -0.27, +0.27). In addition, this functionality is also used to accurately simulate the core by correcting the difference between the measured and designed ASI. ASI search is usually performed once at a specific time (i.e., specific burnup or time) assuming the core is in xenon equilibrium. If the core is in transient, the ASI search performed at a specific time cannot accurately predict the density of the iodine and xenon in the upper and lower core. Therefore, performing ASI search continuously for more than one cycle of xenon oscillation (approximately 32 hours) allows for a more realistic prediction of iodine and xenon distribution in the transient core. In this section, ASI search method is explained and the code for simulating the core using ASI search is introduced, and the long-term ASI search results are discussed.

2.1 ASI search method

The ASI is an index representing the power deviation between the upper and lower region in the core. If the upper or lower region power can be adjusted, the core condition can be simulated with the desired ASI(target ASI). For this purpose, a technique called ASI search is generally used. Through the ASI search method, pseudo absorption cross-section are additionally considered in the neutronics calculation to achieve target ASIs which is given values.

2.2 SIMON

The SIMON(SImulation and MONitoring) program, which simulates and predicts the core using 3D codes, has been developed at KNF (Fig. 1). SIMON perform functions such as production of operational scenarios and prediction of core reactivity, which were previously performed by ACEONED, using the built-in 3D neutronics calculation module. The basic concept of the operational scenario is to withdraw or insert control rods to maintain the HFP(Hot Full Power) ESI(Equilibrium axial Shape Index) corresponding to core power changes. If the operational scenario is produced using the 3D core analysis code, relatively more calculation time is required than the 1D code. Therefore, SIMON uses a parallelization technique to solve this problem, improving calculation performance about 20 times faster than the existing 3D core analysis code. In addition, by simplifying the program input, the interface is configured so that user can obtain the desired result with minimal input.

SIMON can read the PI(Plant Information) data of the nuclear power plant and simulate the core by using the core power, coolant temperature, ASI, control rod position, etc. included in the PI data as inputs for the 3D core analysis code.

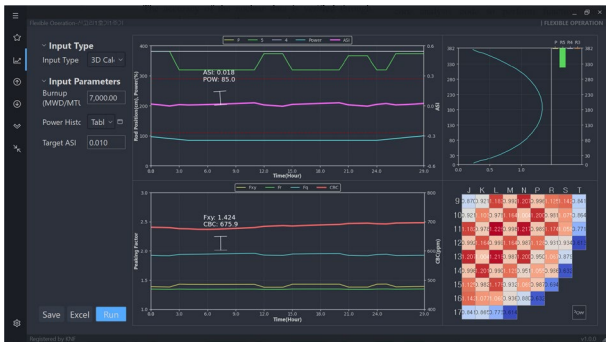

Fig. 1. SIMON program execution screen

2.3 Applying Long-Term ASI Search

In order to confirm the long-term ASI search effect, specific operation data from a commercial reactor where the change in xenon oscillation is expected to be large were obtained and used for core simulation. In the

acquired operation data, the history of ASI control during the power reduction to about 50% after a specific event occurred is recorded. Core power, control rod position, and ASI in the PI data for a period of time are used as inputs for SIMON prediction calculations. Basically, all inputs obtained from PI data except ASI are used from start to finish of prediction calculation, and SIMON predicts ASIs. Fig. 2 shows the difference between predicted ASI of SIMON and measured ASI of PI data according to the use of long-term ASI search. Briefly about the operation history on the PI data, the control rods are inserted until 18 minutes, the power reduction sharply to 63%, and the control rod groups are withdrawn to a specific position for ASI control (up to 50 minutes). After that, the control rod groups are used to properly control the ASI, and after 300 minutes, the control rod groups are not moved any more. Thus, long-term ASI search was performed considering the operation history.

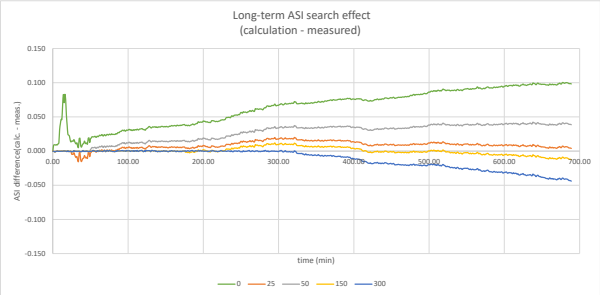

Fig. 2. Long-term ASI search effect

2.4 Results

It was confirmed that an ASI difference error of up to 0.1 occurred when the ASI search was performed at the initial point, whereas an error of up to 0.05 occurred when the long-term ASI search was performed.

Theoretically, the ASI difference is expected to decrease as the period of applying the long-term ASI search increases. However, as shown in Fig. 2, the application period and the error do not show a linear correlation. The reason is expected to be due to the inclusion of errors caused by the core analysis code simulation and the actual core behavior, and additional analysis is required. Nevertheless, when long-term ASI search is applied, the effect of improving the ASI difference can be confirmed. Therefore, if an appropriate application condition and period are well selected, it can be used to improve the prediction calculation results.

3. Conclusions

Based on PI data, the effect of long-term ASI search was evaluated. Although there was no linear relationship between the duration of the long-term ASI search and the ASI difference, it was confirmed that the accuracy of the ASI prediction calculation was improved by applying the long-term ASI search. In the future, we plan to conduct additional research on the appropriate application conditions and period so that long-term ASI search can effectively applied.

REFERENCES

[1] Lee, Ki Bok, “User’s manual ACE/ONED(Version 1.0)”, KAERI/TR-631/96, Sep 17, 1996.