Critical Effect According to Number of Spent Fuel Nuclide

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1. Introduction

Spent fuel nuclides are important variables on the effect of burnup credit in criticality analysis of spent fuel pool and transportation / storage cask.

This paper shows that criticality reactivity changes according to the number of spent fuel nuclides applied to the analysis in the same wet spent fuel pool system.

2. Modeling Approach and Assumptions

2.1 Spent Fuel

The spent fuel data applied to the analysis are as follows.

- Design : 17x17 WH V5H
- Enrichment : 4.5wt%
- Burnup : 45,000MWd/MTU
- Cooling : 5 year

2.2 Spent fuel pool

The spent fuel pool is modeled as an infinite array of 2x2 model as shown in Figure 1 below. To model the isotopic content of fuel assembly in three dimensions, the axial burnup profiles from NUREG/CR-6801 are used. [1]

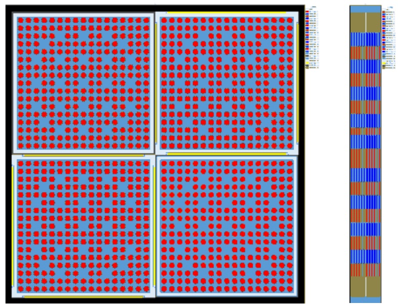

Fig. 1. Analysis model.

2.3 Computer Codes, Cross Section Library

For this analysis, SCALE 6.1 and the 238-group ENDF/B-VII cross section library was used. SCALE 6.1 is the most recent release of the SCALE code system which has been heavily used throughout the world for criticality analysis. The SCALE code system is a series of modules run by sequence drivers. For this work, TRITON sequence was used for depletion and CSAS5 sequence was used for calculation of k_{eff}. [2]

2.4 nuclides used in the analysis

The nuclides used in the analysis were sorted in ascending order of the number density of the nuclides, and the number was increased by 20 each.

First, we selected 28 nuclides from NUREG-6665. In the second, 22 nuclides were added to the above nuclides to select 50 nuclides. From the third, up to 310 nuclides were selected by adding 20 nuclides. [3]

3. Analysis Result

The criticality calculations were performed for 15 cases. As a result of calculation, the reactivity decreased as the number of nuclides increased as shown in Table 1 and Fig. 2. When 28 nuclides of NUREG-6665 were applied, the reactivity was 0.91544, and when 310 nuclides were applied, it was 0.89279. The reactivity difference between the maximum case and the minimum case was 0.02295.

Table 1. Result of criticality calculations for each case

Number of nuclides	$k_{eff} \pm \sigma$
28	0.91544 ±0.00020
50	0.91366 ±0.00020
70	0.90583 ±0.00019
90	0.90066 ±0.00018
110	0.89795 ±0.00020
130	0.89554 ±0.00019
150	0.89385 ±0.00020
170	0.89401 ±0.00019
190	0.89279 ±0.00019
210	0.89250 ±0.00018
230	0.89271 ±0.00019
250	0.89252 ±0.00018
270	0.89299 ±0.00022
290	0.89249 ±0.00020
310	0.89279 ±0.00019

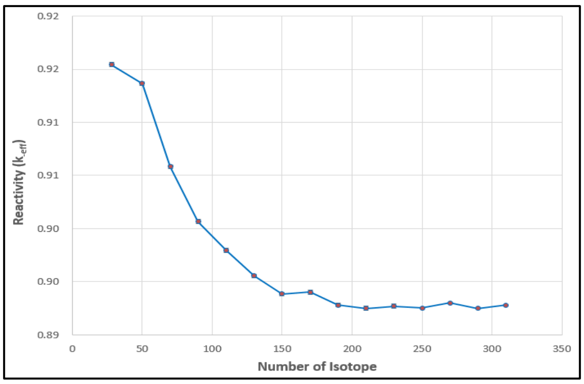

Fig. 2. Trend of reactivity change for each case.

4. Conclusions

This paper shows that criticality reactivity changes according to the number of spent fuel nuclides applied to the analysis. 15 cases from 28 to 310 depending on the number of spent nuclear fuel nuclides were calculated. As a result of calculation, the reactivity decreased as the number of nuclides increased. And reactivity converged after 150 nuclides. Therefore, it is considered that the number of nuclides to be applied in the critical analysis is selected to be approximately 150 based on the number density of radionuclides. The results of this study are expected to be used as basic data for the selection of the critical analysis applied nuclides based on burnup credit.

REFERENCES

[1] J.C. Wagner, M. D. DeHart, and, C. V. Parks, Recommendations for Addressing Axial Burnup in PWR Burnup Credit Analyses, US NRC, NUREG/CR-6801, Oak Ridge National Laboratory, 2003.

[2] Scale. A Comprehensive Modeling and Simulation Suite for Nuclear Safety Analysis and Design, Version 6.1, 2011.

[3] C. V. Parks, M. D. DeHart, and J.C. Wagner, Review and Prioritizationo f Technical Issues Related to Burnup Credit for LWR Fuel, US NRC, NUREG/CR-6665, Oak Ridge National Laboratory, 2000.