Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 29-30, 2009

The Study on Isotopic Inventory Estimations of LWR Fuel Using SCALE5

Jae Cheol Kim[a], Hyun Ju Na[a], Tae Young Han[a], Yong Suk Lee[a] , Byung Chul Lee[a]
[a] Future and Challenges Inc., Bongcheon-dong, Kwanak-gu, E-mail : jc1466@fnctech.com

1. Introduction

The systematic data management of nuclear spent fuel history is needed to assure transparency and safety of nuclear spent fuel generated in domestic nuclear power plants. The previous study[1] described the result of conceptual design for the national nuclear spent fuel database system for systematic data management. In this study, the preliminary results of LWR fuel isotopic inventory estimation using SCALE5 (especially, using NEWT-TRITON module) are discussed. The result of isotopic inventory estimation will be one of the important data in the spent fuel database system.

2. Isotopic Inventory Estimation of LWR Fuel

The LWR spent fuel assembly generally consists of normal/low enriched fuel rods, poison rod, guide tube, instrument tube, and neutron source. Also the array number of fuel assembly varies such as 14x14, 16x16, and 17x17 which depends on core designs. These physical and geometric information, and the isotopic inventory information of every fuel assembly types must be also contained in the database system.

The inventory, decay heat and radioactivity of various isotopes in LWR fuel types can be calculated using two dimensional geometrical information in SCALE5, especially in NEWT-TRITON module.

There are many types of fuel assemblies used in Korean LWR. The gadolinium (GD) burnable poison rod is used in fuel assembly in KSNP which has the geometry similar to UO_2 fuel rod. On the other hand, the various type of burnable poison rods are used in the WH type plants. The burnable poison rod used in WH type plants contains Gd_2O_3, PYREX, B_4C, and has the annular shape.

The typical parameters used in the inventory estimation of KSNP and WH type fuels are provided in table 1. In calculations, fuel assemblies of KSNP and WH type were simulated as 1/4 piece which is rectangular shape and symmetric. The sample of U235, U236, P239, P240 isotopic inventory estimation results as a function of various burnup (MWD/MTU) are provided in Figure 1, 2, 3, 4 and compared with the inventory information of nuclear design report.

Additionally, the fuel pin powers in the fuel assembly were calculated by using both SCALE5 and CASMO as shown in Figure 5 for additional validation of the SCALE5 results.

Table 1. Calculation parameter of fuel assembly.

Parameter	KSNP	WH
Array	16x16	17x17
Rod pitch, cm	1.285	1.2598
Assembly pitch, cm	20.78	21.5
Pellet diameter, cm	0.826	0.805
Outside rod diameter, cm	0.970	0.950
Diameteral gap, cm	0.018	0.0165
Poison material	Gd_2O_3	Al_2O_3+ B_4C
No. of poison rod	8	12
UO_2 enrichment, wt%	2.35/1.28	4.2
Poison enrichment wt%	4	13.5
Specific power, MWt /ton	37.1	38.6

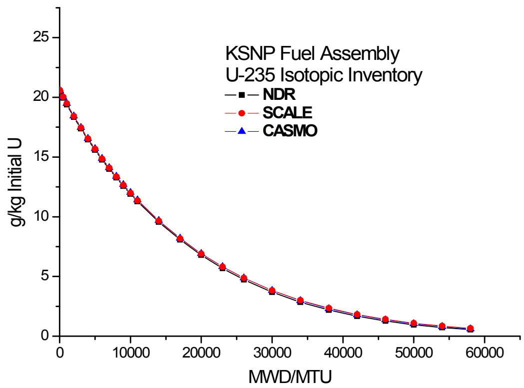

Figure 1. Example result of U-235 inventory using SCALE5 (KSNP fuel assembly)

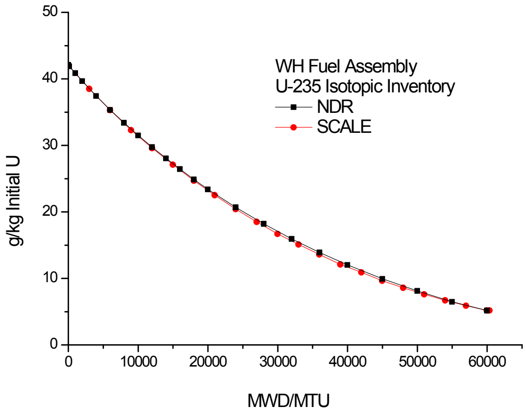

Figure 2. Example result of U-235 inventory using SCALE5 (WH fuel assembly)

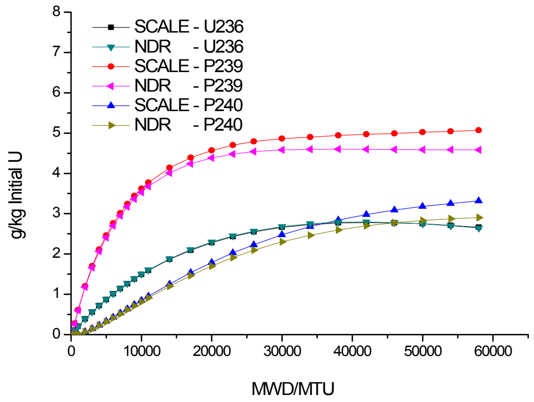

Figure 3. Example result of U-236, P-239, P-240 inventory using SCALE5 (KSNP fuel assembly)

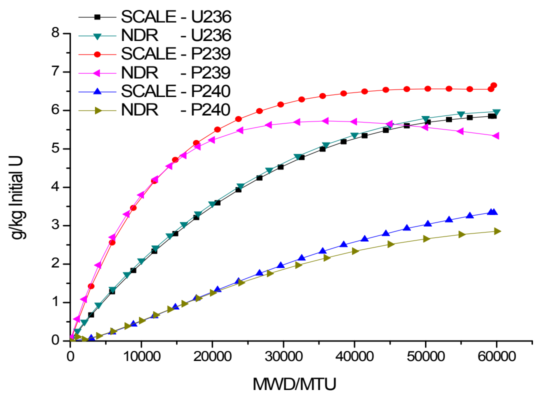

Figure 4. Example result of U-236, P-239, P-240 inventory using SCALE5 (WH fuel assembly)

0.987 1.018 −3.06	0.995 1.021 −2.52	1.010 1.025 −1.49	1.026 1.028 −0.21	1.035 1.030 0.49	1.042 1.029 1.21	0.899 0.934 −3.76	0.888 0.946 −6.10
0.972 1.003 −3.14	0.984 1.007 −2.29	1.009 1.013 −0.37	1.040 1.018 2.15	1.048 1.020 2.72	1.036 1.018 1.80	0.818 0.818 0.05	
0.977 1.005 −2.76	1.001 1.011 −1.03	1.055 1.030 2.44	0.962 0.968 −0.63	0.966 0.968 −0.20	1.072 1.033 3.74		
0.994 1.009 −1.45	1.031 1.016 1.49	0.962 0.967 −0.57	0.000 0.000 0.00	0.000 0.000 0.00			
1.015 1.014 0.12	1.047 1.021 2.52	0.970 0.971 −0.09	0.000 0.000 0.00				
1.053 1.021 3.14	1.054 1.024 2.88	0.855 0.843 1.40					
0.975 0.971 0.37	1.085 1.037 4.61						
0.000 0.000 0.00					Guide Tube	Gd-BP	SCALE CASMO Err(%)

Figure 5. Example result of pin power using SCALE5

Figure 1 and Figure 2 show that isotopic inventories of U-235 as a function of various burnup decreased and then converged to near zero. On the other hand, Figure 3 and Figure 4 show that isotopic inventories of U-236, P-239, P-240 generally increased and then converged to each specific values. The results of isotopic inventories using SCALE5 were generally agreed with the data in nuclear design report. However, the calculation results of the isotopic inventory P-239 had large relative errors despite absolute errors are not significant. Also, the calculation results of fuel pin powers by using both SCALE5 and CASMO were generally agreed well.

Therefore it can be considered that the calculation results of isotopic inventories using SCALE5 can be used as data of nuclear spent fuel database system.

3. Conclusion

To setup the DB system for spent fuel managements, fuel burnup characteristics of the fuel as a function of burnup were estimated using SCALE5 code. It was found that the results of isotopic inventories using SCALE5 were generally similar to those of nuclear design report, and the results of fuel pin powers were also similar to calculation results using CASMO. Therefore it can be considered that the calculation results of isotopic inventories using SCALE5 can be used as data of nuclear spent fuel database system. The estimation of decay heat and radioactivity of spent fuels using SCALE5 will be also implemented to provide the additional data in the DB system.

Acknowledgement

This paper is the product of “Establishment of Integrated Spent Fuel Management Database System” project supported by MKE (Ministry of Knowledge Economy).

REFERENCES

[1] Y. S. Lee, B. C. Lee, “The Study on the Conceptual Design of Natural Nuclear Spent Fuel Database System”. *Proceeding of Korean Nuclear Society Spring Meeting*, Gyeonju, Korea, 2008.