Safety Impact Evaluation on Minor Actinide Addition to LMR Metal Fuels

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1. Introduction

In case of transmutation fast reactor, small amount of TRU or minor actinide is mixed with fuel materials in order to reduce high-level radioactive waste finally. As a fuel composition, U-Th-MA or U-Pu-MA fuels are suggested as candidate fuels in lead-bismuth cooled transmutation reactor. The metal fuel fabrication validity only has been studied for larger fuel loading amount than oxide fuel case. However, as TRU amount in fuel increase, nuclear characteristics might be changed a lot depending on specific isotopic amount. Especially, the safety impact by TRU addition has to be verified in order to maintain core safety. Therefore, this study is focused on the core performance change such as reactivity swing, neutron spectrum and temperature coefficient depend on the variation of minor actinide composition.

2. Variations of Minor Actinide Isotopic Content

Effect of the minor actinide addition were analyzed for lead-bismuth cooled fast reactor, PEACER-300 which is 300 MWe LFR as shown in figure 1.[1] Effect was analyzed for the variation of reactivity, Doppler coefficient, and coolant density coefficient. For these calculations, TRANSX/DANTSYS/DIF3d code system with KAFAX-F22 library is used and the verification of this code system was performed by Monte Carlo code system – MONTEBURNS.

Amount of 9 minor actinide isotopes – Np-237, Am-241, Am-242m, Am-243, Cm-242, Cm-243, Cm-244, Cm-245, and Cm-246 – were varied by 5% and 10% increase for the sensitivity check on core performance.

The increase of Am-242m, Cm-244 and Cm-245 amount leaded the higher reactivity as shown in figure 2. Only the increase of Am-241 amount showed less negative value of Doppler coefficient. In case of coolant density coefficient, less positive value were showed by Am-241 amount increase and Am-242m and Cm-245 could made more positive value as shown in figure 3.

3. Variations of Minor Actinide Total Amount

In the reference core, the minor actinide total amount is 3.9 w/o. Under maintaining the minor actinide fractions, minor actinide total amount were changed to 0%(0 w/o), 50%(1.95 w/o), 150%(5.85 w/o) and 200% (7.8 w/o) of the reference. As total amount was increased, reactivity and coolant density coefficient were increased and Doppler coefficient showed less negative values.

Using the results of parametric study on each isotope which is mentioned above, the safety impact factors of each isotope could be acquired about unit mass. The comparison was attempted between the effect by changing minor actinide total amount and the calculated effect by weighted sum of isotopic impact factors. The error between code calculation results and expected results showed 6.03% in reactivity as shown in table I. In case of Doppler coefficient and coolant density coefficient, these errors were not exceeded by 6% and 8% respectively.

4. Conclusions

Depend on the mass change of minor actinide, safety performance values were evaluated. Only Am-241 isotope can make Doppler coefficient be less negative. Coolant density coefficient can be more positive by increase of Am-242m and Cm-245. Therefore, these 3 minor actinides should be considered to decide fuel composition limit in safety design aspect.

Using the safety impact factors for each isotope, approximate core performance change might be acquired about various minor actinide compositions without

complicate calculation.

Acknowledgement

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Reference

[1]. Jae-Yong Lim, and Myung-Hyun Kim, "Transmutation Characteristics in a Pb-Bi Cooled Fast Reactor, PEACER-300," *Proceedings of ICAPP-2006*, International Congress on Advances in Nuclear Power Plants, June 4-8, Reno, NV (2006).

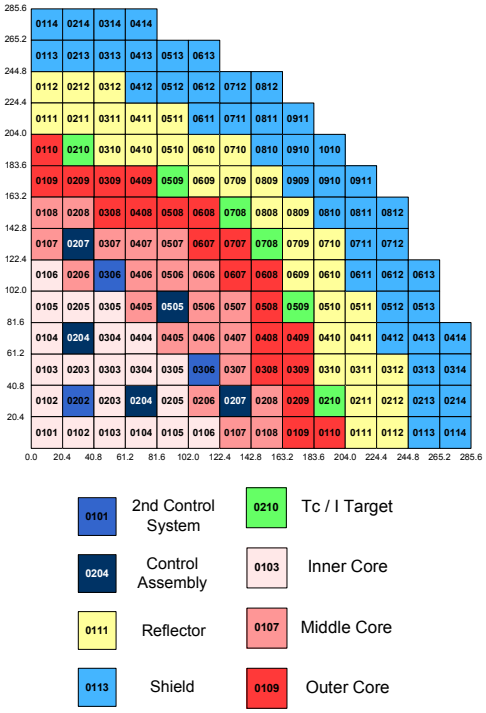

Fig. 1. 1/4 Core Layout of PEACER-300

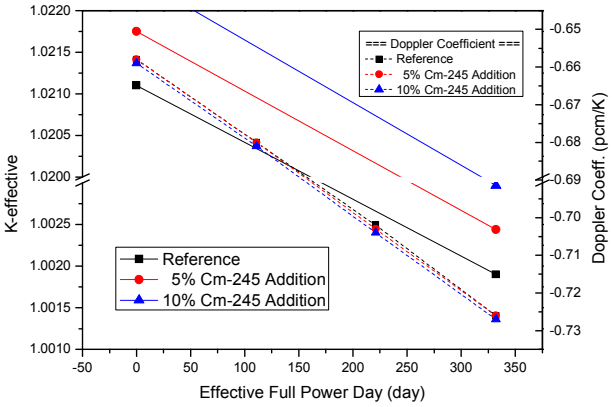

Fig. 2. K-eff and DC Changes by Cm-245 Mass Change

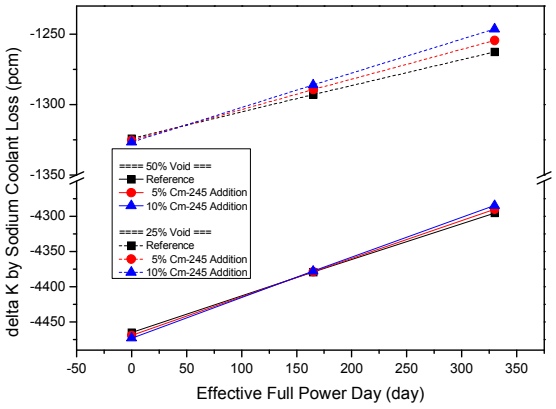

Fig. 3. Coolant Density Coefficient Changes by Cm-245 Mass Change

Table 1. Comparison between DIF3d Results and Parametric Prediction to the M.A. Amount Change

Nuclide Contents				Keff	△Keff to Reference (pcm)	Predicted △Keff from weighted isotopic effects (pcm)	Relative Errors
j	Pu	U	M.A.				
1	34.0%	66.00%	0.00%	1.02678	-935.3	-991.7	6.03
2	34.0%	64.05%	1.95%	1.03132	-482.0	-495.8	2.86
3	34.0%	62.10%	3.90%	1.03614	0.0		
4	34.0%	60.15%	5.85%	1.04121	507.6	495.8	-2.31
5	34.0%	58.20%	7.80%	1.04652	1,037.9	991.7	-4.45