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A Study on Rack Thickness Effect for Spent Fuel Pool Storage

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1. Introduction

Spent fuel storage problem has become one of the most important issues in these days. Alternative solutions has been suggested such as dry cask, consolidated fuel and etc. but still spent fuel pool storage rack is a mandatory at least for the storage right after reactor use. For the effective storage of used fuel, the development of high performance neutron absorbing materials is needed. One of the major concern for the used fuel storage is the assurance to keep subcriticality of the storage rack and the high performance neutron absorbing material is the vital part to assure this requirement. According to NRC guide line, the k-effective of the spent fuel storage racks must not exceed 0.95 [1]. To ensure its safety, subcriticality analysis is required.

Subcriticality analysis of the used storage in spent fuel pool have been performed by different authors. Criticality calculations for light water reactor spent fuel storage rack were carried out by Jae et al. They used AMPX-KENO IV code and considered the effect of rack pitch and rack thickness for consolidated fuel [2]. Park et al. calculated criticality for research reactor spent fuel pool under various pitches, different fuel meat sizes and water densities [3] and Massoud et al. examined the criticality safety under various fuel assembly column spacing [4].

In this study, the effect of rack thickness on the criticality of spent fuel pool for the storage of light water reactor fuel is studied with different contents of Gd neutron absorber.

2. Method

2.1. Model

Calculation model is shown in Fig. 1 and 2. As shown in Fig. 1, integral rack is used for calculation which acts as both structural member and neutron absorber. The fuel assemblies are infinitely arranged in horizontal direction and fully water flooded in axial direction. For conservative analysis, fresh fuel is used not considering burnup credit. The pitch of the fuel storage cell is 280 mm and the enrichment of U-235 in the fuel is assumed to be 4.5 wt %. The material of rack is Gd with stainless steel (SS).

- Thickness: 0.1 ~ 2 mm
- Gd content: 0.2, 1 wt%
- Boron: 0 ppm
- Water density: 1.0 g/cc

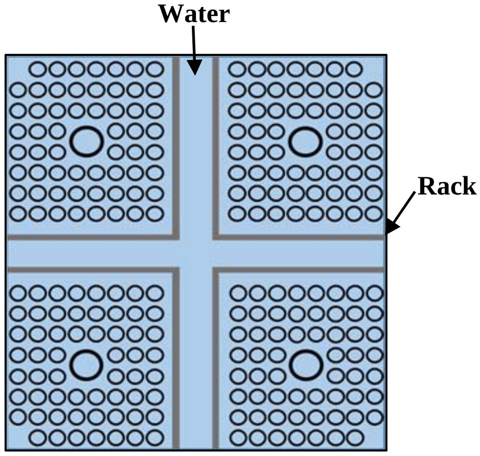

Fig. 1. Horizontal view of the spent nuclear fuel rack for criticality calculation.

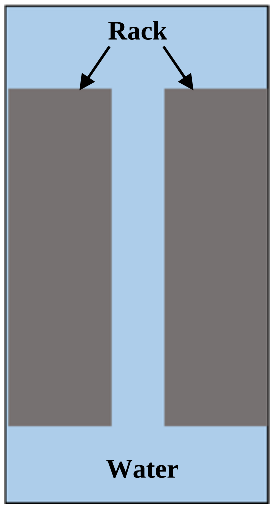

Fig. 2. Vertical view of the spent nuclear fuel rack for criticality calculation.

2.2. Computer program

The k-effective calculation was performed using McCARD code with ENDF-VII library. McCARD is a Monte Carlo neutron transport simulation code [5]. The number of neutron particles is 100,000 with 200 active cycles and 50 inactive cycles. And the standard deviations are about 0.00016 to 0.00020.

3. Result

3.1. Gd 0.2 wt% with SS

Fig. 3 shows thickness effect at Gd 0.2 wt%. The k-effective varies from 1.02316 to 1.01098. As thickness increases, the k-effective is continuously decreases.

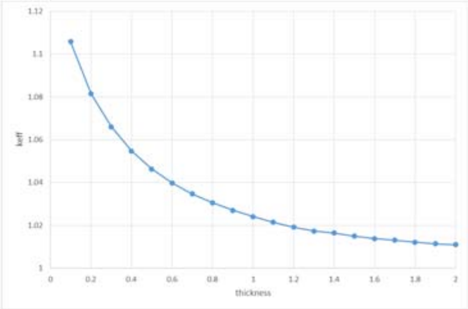

Fig. 3. Thickness versus k-effective at Gd 0.2 wt%

3.2. Gd 1 wt% with SS

Fig. 4 gives the effect of thickness on the criticality. It was found that k-effective values are from 1.04787 to 0.98916 in the range from 0.1 to 2 mm. The k-effective shows decreasing trend with increasing of thickness.

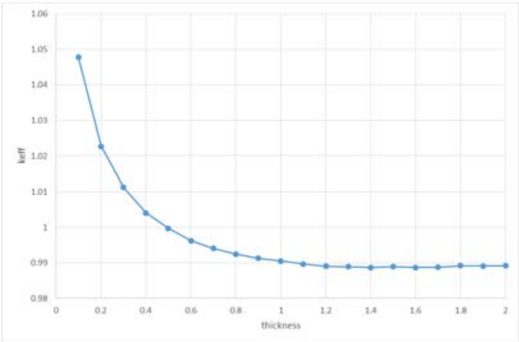

Fig. 4. Thickness versus k-effective at Gd 1 wt%

4. Discussion

Comparing 2 cases (Gd 0.2, 1 wt%) in condition of fixing the all of the variables except Gd contents, k-effective has the smaller value at the bigger Gd amount in overall range. As thickness increases, the k-effective decreases because the quantity of neutron absorbing material, Gd, increases.

However, the trend of the graphs is not proportional to thickness. As thickness increases, variance in k-effective parabolically decreases. Therefore, it is important to find effective thickness depending on Gd contents.

5. Conclusion

The criticality analysis has performed at Gd 0.2 and 1 wt% according to thickness change.

As thickness increases, the volume of the spent fuel pool rack increases. Therefore, absorbing material also increases according to thickness. It is essential to calculate optimum thickness according to Gd contents because k-effective is not proportionally increasing.

ACKNOWLEDGEMENT

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