Shielding Effects of Reinforcement Structure and Heat Transfer Fin in the OASIS-32D Cask

Yong IL Kim*, Young Tae Han, Joon Gi Ahn, In Ho Song, and Gyu Cheon Lee
Korea Electric Power Corporation E&C, 111, Daedeokdae-ro 989beon-gil, Yuseong-gu, Daejeon, Republic of Korea
*yongil@kepco-enc.com

1. Introduction

The shielding effects of Reinforcement Structure (RS) and Heat Transfer Fin (HTF) in the OASIS-32D cask have been examined. The OASIS-32D is a dual purpose metal cask for spent nuclear fuel transport and storage developed by KEPCO E&C. It is designed to store 32 PWR spent fuel assemblies (FA) that have been cooled for 10 years. The RS is a component lying between basket and canister for fixing the basket. The HTF is a component embedded in the neutron shield outside of cask shell for heat removal from inside to cask surface. Both components have discontinuity in shielding point of view, axial in RS and azimuthal in HTF. The shielding effects of RS and HTF have been examined in this paper by using MAVRIC module of SCALE 6.1 code [1]. MAVRIC is a 3-dimensional Monte Carlo particle transport code with automated variance reduction using importance calculations by deterministic method to enhance calculation efficiency.

2. Methods and Results

2.1 Source term calculation

The radiation sources for the shielding analysis are neutrons and gammas from ACE7 spent nuclear fuel with 10 years of cooling time obtained from the depletion calculation using ORIGEN-ARP module of SCALE 6.1 code. In the depletion calculation, the ACE7 fuels with an initial enrichment of 3.5wt% are assumed to be burned for three cycles at a power level of 40 MWt/MTU in the reactor core and have total discharge burnup of 45 GWD/MTU.

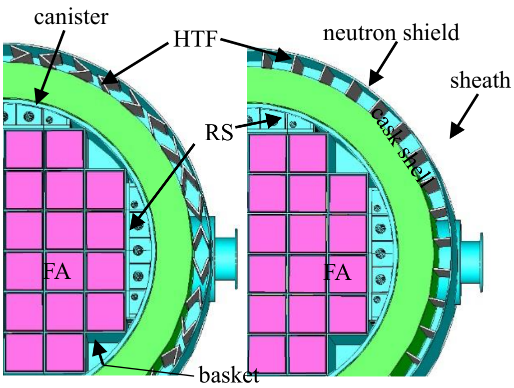
2.2 Shielding analysis

To examine the shielding effects of the RS and HTF, transport calculations have been performed and compared for various combination of cases with and without the corresponding structures. The calculation cases were setup as shown in Table 1 to compare the shielding effects of the RS and HTF.

Table 1. Calculation models

Case	Component Combination	Note
1	RS, HTF (bent shape)	All components included, Reference case
2	No RS, HTF (bent shape)	RS removed
3	RS, No HTF	HTF removed and replaced by neutron shield material
4	RS, HTF (straight shape)	All components included, straight shape HTF used

The partial view of OASIS-32D cask is shown in Figure 1. The basic model of HTF has a shape with a bent at 60 degrees as shown in Figure 1-a and made of aluminum. In addition to the basic HTF model, the shielding effect of the HTF shape was also evaluated by replacing with a straight shape HTF as shown in Figure 1-b. The neutron shield material, resin, is not shown in Figure 1 to represent the HTF structure clearly.



a. Bent HTF b. Straight HTF

Fig. 1. Partial view of OASIS-32D cask.

2.3 Results

The calculated dose rate distributions for analyzed cases are shown in Figure 2.

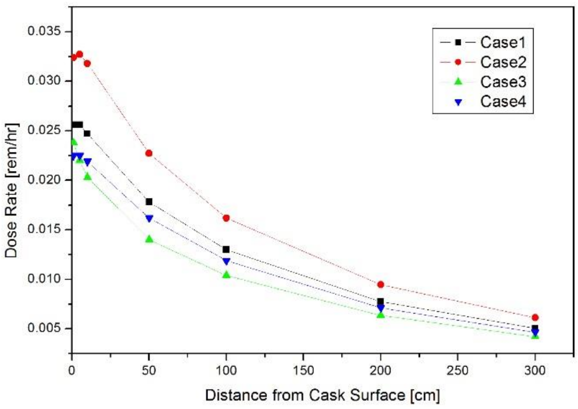


Fig. 2. Dose rate distributions.

Previous OASIS-32D cask shielding analysis experience [2] has shown that the most demanding dose requirements required by the relevant regulations [3] is the dose condition at a distance of 2m from the side of the cask surface. Therefore, the shielding effects of RS and HTF based on the 2m dose rate are summarized as follows:

1. No RS (Case 2): 22% increase
2. No HTF (Case 3): 18% decrease
3. Straight shape HTF (Case 4): 8% decrease

The results show that the RS has shielding effect of 22% compared to No RS model and the shielding effect is higher when the HTF is not used unlike the RS. The negative shielding effect of HTF is due to the fact that the amount of shielding material, resin, is reduced by the inclusion of HTFs in the neutron shield that is effective in neutron shielding. The shielding effect of the HTF shape can be interpreted in the same context because the amount of shielding resin is smaller in the basic model, the bent shape, than that in the straight shape model. It should be noted that the specific figures of the shielding effects are only valid for OASIS-32D cask model and they depend on the specific geometry and materials.

3. Conclusions

The analyses performed on shielding effects of RS and HTF showed that the straight HTF is more effective on the shielding point of view than the bent HTF. Also, the straight shape HTF is known as more efficient on heat transfer point of view than the bent shape. Therefore, it is recommended that the HTF of the OASIS-32D cask be designed in a straight shape.

REFERENCES

[1] "SCALE: A Comprehensive Modeling and Simulation Suite for Nuclear Safety Analysis and Design," ORNL/TM-2005/39, Version 6.1, Oak Ridge National Laboratory, June 2011.

[2] "Shielding Design for the Development of Spent Fuel CASK for Transportation and Storage," Proc. KRS Autumn 2015, Busan, Sec. I, p. 33, Korean Radioactive Waste Society, October 14-16, 2015.

[3] 10CFR71, "Packaging and Transportation of Radioactive Material," 1996.