A Free Drop Analyses of Spent Nuclear Fuel Metal Cask for Various Positions

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1. Introduction

OASIS-32D, the spent nuclear fuel metal cask developed by KEPCO E&C, needs to go through a free drop test through a distance of 9m in accordance with 10 CFR 71[1]. This study is to find a drop position for which maximum damage is expected, and to confirm the structural integrity of OASIS-32D. For the purpose of the study, various drop positions - 0°, 30°, 45°, 60°, 90° and 180° off-angle drops as described in Table 1 and Fig. 2 are taken into considerations. The analyses are performed using ANSYS LS-DYNA. As a result of analyses, the structural integrity of OASIS-32D is maintained.

2. 9m free drop analyses

2.1 Analysis model and method

OASIS-32D finite element model consisting of the cask, canister and fuel assemblies was developed using the solid, shell and mass elements in ANSYS as shown in Fig. 1.

The velocity of 13.3 m/s corresponding to 9m free drop under 1g (gravitational acceleration) is applied on the cask, canister and fuel assemblies as the initial condition for the analyses. The contact condition between bumper and the rigid target surface is the node to surface contact used in impact analysis.

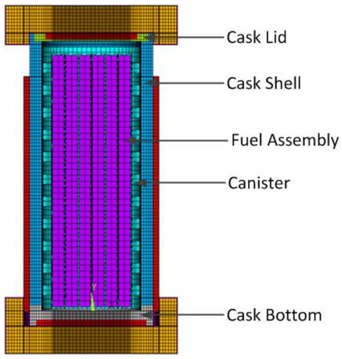

Fig. 1. FE model of OASIS-32D.

2.2 Positions of cask

The 6 cases of 0, 30, 45, 60, 90 and 180 degrees cask positions shown in Table 1 were used in the free drop analyses. The cask positions of cases 1, 3 and 5 are shown in Fig. 2, from the left side.

Table 1. Drop analysis cases

Case	Degree of Cask	Description
1	0	Bottom-Vertical Drop
2	30	Corner Drop
3	45	
4	60	
5	90	Horizontal Drop
6	180	Top-Vertical Drop

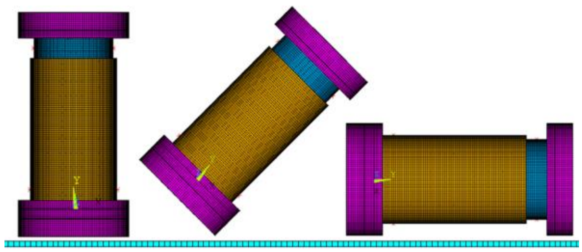

Fig. 2. Positions of cask drop (Cases 1, 3 and 5).

Table 2. Ratio of analysis results to allowable stresses

Comp.	Stress	Case 1	Case 2	Case 3
Cask Lid	Pm	0.74	0.69	0.31
	Pm + Pb	0.52	0.50	0.22
Cask Shell	Pm	0.13	0.19	0.02
	Pm + Pb	0.10	0.21	0.02
Cask Bottom	Pm	0.44	0.25	0.17
	Pm + Pb	0.44	0.22	0.12

Comp.	Stress	Case 4	Case 5	Case 6
Cask Lid	Pm	0.08	0.15	0.49
	Pm + Pb	0.11	0.15	0.36
Cask Shell	Pm	0.15	0.37	0.31
	Pm + Pb	0.12	0.26	0.37
Cask Bottom	Pm	0.27	0.42	0.26
	Pm + Pb	0.19	0.41	0.17

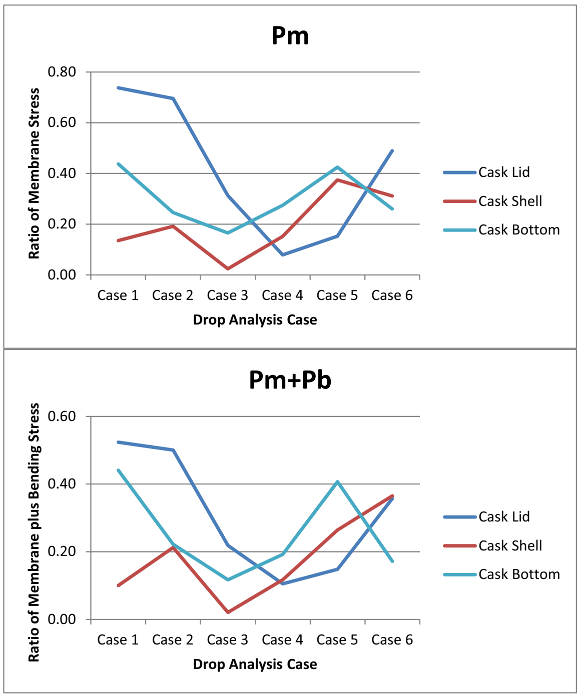

Fig. 3. Variation of ratio for each case.

2.3 Results

Since the purpose of these analyses is to check the structural integrity of the cask, the stresses of cask components are described in Table 2 and Fig. 3. The ratio of the result stresses to the allowable stresses, i.e., membrane stress and membrane plus bending stress to the allowable stresses are tabulated in Table 2. As shown in Table 2, each component of OASIS-32D has a lot of margins. Fig. 3 shows that the maximum stresses of each component vary along with the positions of the cask. According to the Table 2 and Fig. 3, the position that causes the maximum damage is the bottom-vertical drop position (Case 1).

3. Conclusion

To find a position for which maximum damage is expected, the 9m free drop analyses for various cask positions are carried out. The maximum stress for cask lid is occurred in Case 1, bottom-vertical cask drop. All of the stresses are within the allowable stresses, and have margins bigger than 25%. Therefore, the integrity of OASIS-32D is maintained under the 9m free drop condition.

REFERENCES

[1] 10 CFR 71, “Packaging and Transportation of Radioactive Material”, Jan. 2017.