Modal Analysis of Alternative Spent Nuclear Fuel Transportation Cask for Normal Conditions of Transport Test

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1. Introduction

During the past 40 years since 1978, when commercial nuclear power generation started in Republic of Korea, various types of spent nuclear fuel have been generated and temporarily stored in wet spent fuel storage pools in a nuclear power plants. However, the capacity of such temporary storage is expected to be full in the near future. Currently, construction of interim dry storage facility inside or outside of the nuclear power plant is being discussed to solve this problem. Therefore, it is expected that transport of the spent nuclear fuel in the wet storage pools will be conducted within a short time and thus, the safe transport of spent nuclear fuel should be secured.

Therefore, it is necessary to perform the normal transport test on the road and sea transport conditions to measure the applied loads to the transportation platform, cask, and fuel assemblies and to check whether the spent nuclear fuels can maintain its integrity under the measured loads.

To verify this, normal transport test is being planned to measure shock and vibration loads and strain of fuel rods under normal transport conditions. It is best to perform the normal transport test with a cask which will be used for spent nuclear fuel transport. However, it has not determined yet which cask will be used for spent nuclear fuel transport. Therefore, it is planed that the test will be conducted by using the currently available cask as an alternative.

In this study, modal analysis of the available cask is performed and important modes related to the normal conditions of transport were investigated.

2. Modal Analysis

The KORAD-21 cask was designed for the transport of low burn-up PWR spent nuclear fuel. The 1/3 scale model of KORAD-21 was manufactured and related safety examinations including drop test, water immersion test, high temperature test and thermal test were carried out, but it is difficult to use it to this normal transport test because real scale model was not manufactured [1]. As an alternative way, OCL cask owned by Doosan Heavy Industries & Construction will be used for the present transport test. However, it is required to be investigated whether its dynamic characteristics is similar with KORAD-21 which is expected to be used for spent nuclear fuel transport in Republic of Korea.

If the dynamic characteristics between the two different casks are similar, the test results will be applicable for KORAD-21 cask. Therefore, the modal analysis of OCL cask and KORAD-21 cask was performed and the results were compared.

The modal analysis is performed by applying a frictionless boundary condition to the trunion as shown in the Figure 1. The results of modal analysis are shown in Table 1. As a result of the modal analysis, it was observed that the major lower order modes are not related to the cask bending or torsional modes but it is related to the bending or torsional modes of trunion itself.

Table 1 also shows the results of comparing the frequency of each mode frequency of the OCL cask

with those of the KORAD21.

It is believed that vertical translation and pitching modes are the most important for the normal conditions of transport because the vertical shock and vibration loads will be dominant during transport by truck or ship.

As shown in the table, the pitching frequency of OCL cask is well matched with that of KORAD-21 cask. However, the vertical translation frequency of OCL cask is quite different compared with that of KORAD-21.

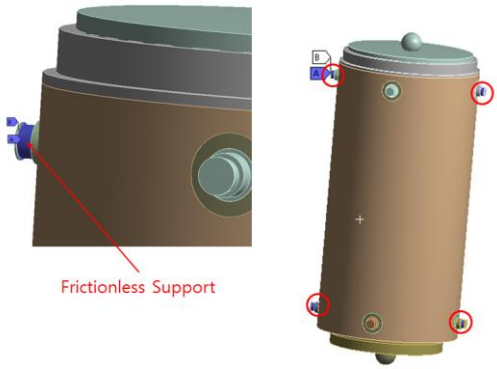
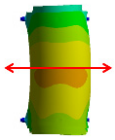
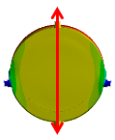
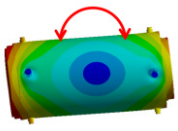
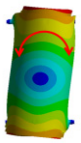
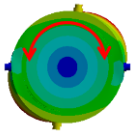


Fig. 1. Boundary condition of the present modal analysis.

Table 1. Mode shapes for OCL cask

Mode no.	OCL	Frequency (compared with that of KORAD21)
1	Translation-horizontal (1) 	-29.5%
2	Translation-horizontal (2) 	-27.8%
3	Translation-vertical 	-25.8%
4	Rotation-pitching 	-3%
5	Rotation-yawing 	-7.3%
6	Rotation-rolling 	-30.3%

It is expected that the frequency difference on vertical translation mode can be minimized by adjusting the boundary condition of the trunion and adjusting the weight and center of gravity of the impact limiter.

3. Conclusion

Modal analysis of the transportation cask for the normal transport test was carried out. Modal analysis of OCL cask and KORAD21 was conducted and discussed. As a result of the modal analysis, it was observed that the major lower order modes were not related to the cask bending or torsional modes but it was related to the bending of torsional deformation of trunion itself. It was expected that the frequency difference on vertical translation mode can be minimized by adjusting the boundary condition of the trunion and adjusting the weight and center of gravity of the impact limiter.

REFERENCES

[1] Cho, S. S., et all, Safety Test Report of KORAD-21 Transportation Cask, KAERI-CR-685.2018.