Cutoff Frequency for Rigid Body Acceleration of KORAD21 Cask in Drop Accidents

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1. Introduction

The purpose of this paper is to investigate the cutoff frequency for rigid body acceleration in KORAD21 drop test. The acceleration of the spent nuclear fuel cask was measured by using three IEPE accelerometers and the cutoff frequency for the rigid body acceleration was determined by obtaining the first natural frequency from the 1-m side puncture test.

2. Cutoff Frequency and Rigid Body Acceleration

9-m free drop test and 1-m puncture test were performed using KORAD21 1/3 scaled model in order to demonstrate the structural performance of KORAD21 spent nuclear fuel cask. In 9-m free drop test, 5-kinds of postures including vertical, lid vertical, horizontal, inclination, center of gravity were considered, and 1-m puncture tests included a side-puncture test and a lid-vertical-puncture test.

One important characteristic of the drop test is that the stress wave propagates through the cask, resulting in very large vibratory motion or stress components in the acceleration data due to rigid body mode, shell mode, and contact between internal components. In order to remove such vibratory components, the raw acceleration data should be filtered with low pass filter at a lowest natural frequency maintaining the acceleration component due to rigid body motion [1-3].

During the drop test of various postures, the 1-m side puncture test is that the cask freely drops over the rupture bar while keeping the cask horizontal. Therefore, this paper used 1-m side puncture test to determine the first bending mode and first order natural frequency of the cask.

3. Test Results for Cutoff Frequency

Accelerometers and strain gauges are attached to the test model to evaluate the behavior characteristics before and after impact due to the drop. Acceleration data were stored at a rate of 100,000 samples/s and the acceleration was measured at a frequency of 10 kHz.

Fig. 1 shows the photographs after the 1-m side puncture test and the raw acceleration data measured from three accelerometers. Fig. 2 shows the result of PSD (power spectral density) using three raw acceleration data. The natural frequency of the first bending mode was calculated as 490Hz.

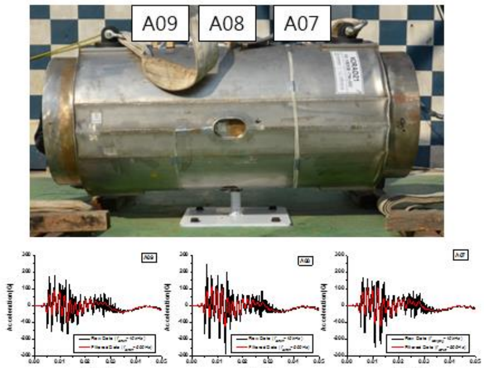

Fig. 1. Side puncture test result and the raw acceleration data.

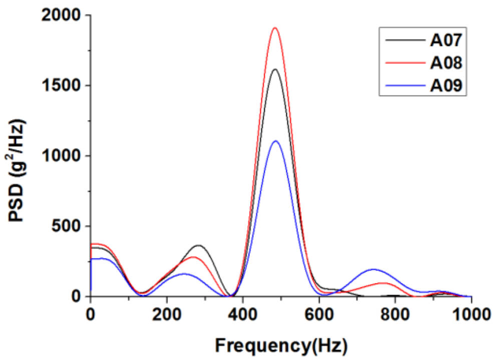

Fig. 2. PSD results obtained from the acceleration data.

Fig. 3 shows an example of the filtered acceleration data in the 9-m vertical drop test using the cutoff frequency obtained in this study. An 8th order Butterworth filter was applied and the cut-off frequency was 500 Hz. For both the drop test and the burst test. The filtered acceleration data means the rigid body deceleration acting on the cask when it was dropped.

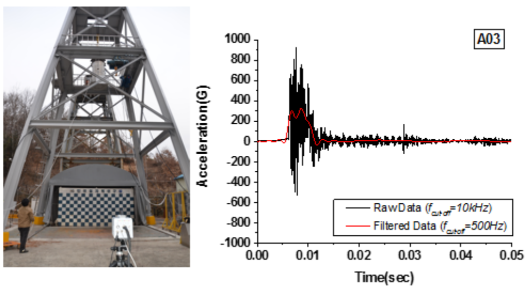

Fig. 3. Vertical drop test and the filtered acceleration data.

4. Conclusions

We presented the cutoff frequency to calculate the rigid body acceleration acting on the cask during drop test of KORAD21. The cutoff frequency for obtaining the rigid body acceleration was obtained as the natural frequency for the first bending mode from the 1-m side puncture test, and it was 490Hz. The cut-off frequency was determined as 500 Hz for both the drop and the puncture tests. The raw acceleration data was applied to the 8th order Butterworth low pass filter with the determined cutoff frequency to check rigid body deceleration acting on the cask. The cutoff frequency presented in this paper should be applied equally to the post-processing of the drop analysis [4].

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