Variation of Modal Characteristics of Electrical Cabinet According to the Excitation Level in Impact Hammer Test

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1. Introduction

There are many electrical cabinets in nuclear power plants. Safety-related equipment is typically seismic qualified before installation. Seismic qualification of equipment is possible when identifying the accurate dynamic characteristics of the equipment.

According to the nature of the cabinet, the dynamic characteristics of the electrical cabinet vary nonlinearly with excitation level [1], [2]. This study analyzed the nonlinear variation of the dynamic properties of an actual cabinet. For the purpose of this study, a seismic monitoring system cabinet was selected as a specimen. The impact hammer tests were conducted to identify a variation of the dynamic characteristics of the specimen by increasing the impulse level. Modal identification technique was used to extract the modal properties of the cabinet from the measurements.

2. Experiments

2.1 Impact Hammer Test

The specimen cabinet is a seismic monitoring system cabinet which is a safety related equipment installed in nuclear power plants. It is made of steel plates by welding. The total weight of the cabinet is 311.8 kg. The weight without the doors is 244.6 kg. Six accelerometers were installed on the cabinet to measure the acceleration responses as shown in Fig. 1.

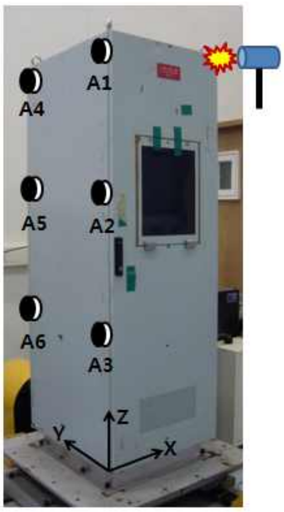

Fig. 1 The location of impact point and accelerometers

This study performed only in X-direction as shown in Fig. 1. The impact hammerings were applied at the top of the cabinet in the opposite side of the accelerometers by increasing the impulse level. The experiment was implemented in two separated cases; with and without the cabinet doors. The 10 blows were applied for each case by increasing the impulse level.

2.2 Measurements

Accelerometers were calibrated before testing using the vibration calibrator. The accelerations were recorded for about 10 seconds till the vibration stops after impacting. The time interval of the record is 1/256 second. OROS system [3] was used as a FFT analyzer.

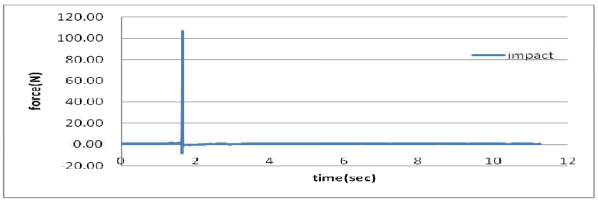

Fig. 2 impact force

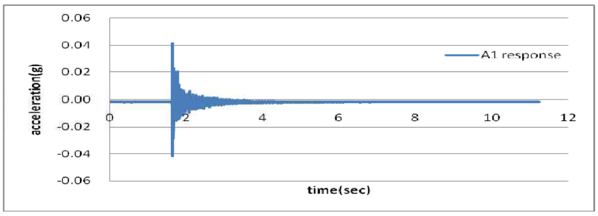

Fig. 3 acceleration response at A1

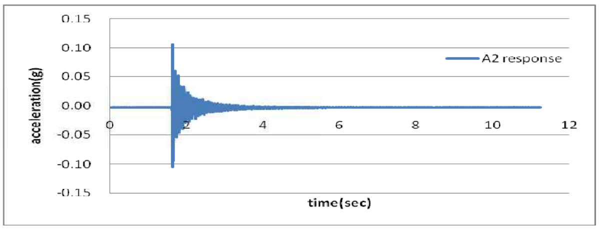

Fig. 4 acceleration response at A2

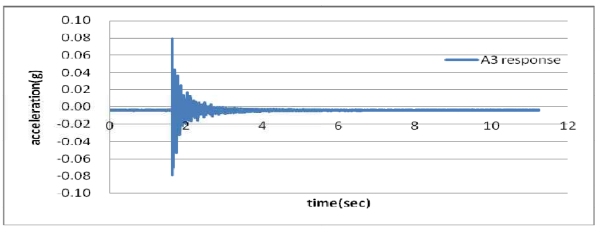

Fig. 5 acceleration response at A3

Fig 2 ~ 5 show typically the time history signals recorded from a case of tests. Fig 2 is an impact force. Fig. 3 to 5 show the acceleration response recorded at A1 to A3 of accelerometers.

2.3 Test Results

The transfer functions were computed from the time history acceleration responses. The polynomial cure fitting algorithm [4] was utilized to extract the dynamic characteristics from the measured signals. Table 1 and Fig. 6~9 show the variation of the dynamic characteristics by increasing the impulse level.

According to the experiment results, the larger the impact energy gets, the lower the damping ratio becomes. The damping ratios get increased gradually in accordance with the impacting level in the case of removing the doors. However, the damping curve of the specimen with doors shows a different trend from that in the case of removing the doors.

Table. 1. Dynamic characteristics of the specimen

CASE No.	With door			Without door		
	Impact Load(N)	Frequency (Hz)	Damping (%)	Impact Load(N)	Frequency (Hz)	Damping (%)
1	75.51	18.36	2.64	56.22	12.76	2.29
2	172.29	15.12	18.75	107.13	12.58	2.72
3	220.81	14.56	17.68	222.50	12.39	3.00
4	326.77	13.40	16.95	319.49	12.26	3.20
5	418.48	12.85	14.37	380.89	12.22	3.25
6	502.72	12.72	15.63	483.55	12.16	3.18
7	605.69	12.50	14.19	643.57	12.09	3.19
8	720.03	12.28	13.10	753.66	12.03	3.49
9	824.93	12.12	12.35	999.68	11.93	3.36
10	908.89	11.77	12.78	1166.31	11.89	3.44

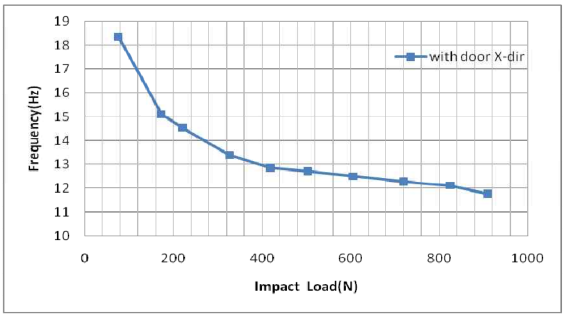

Fig. 6 Variation of the frequency (with door)

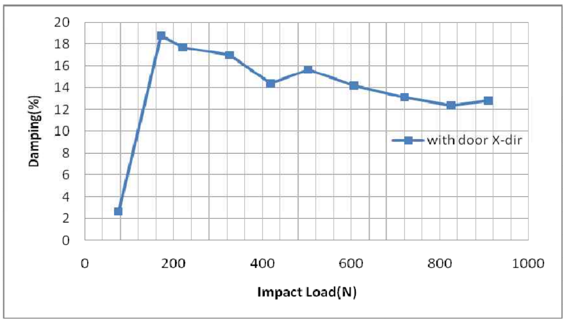

Fig. 7 Variation of the damping ratio (with door)

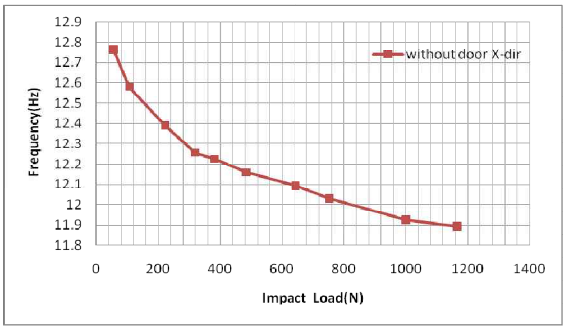

Fig. 8 Variation of the frequency (without door)

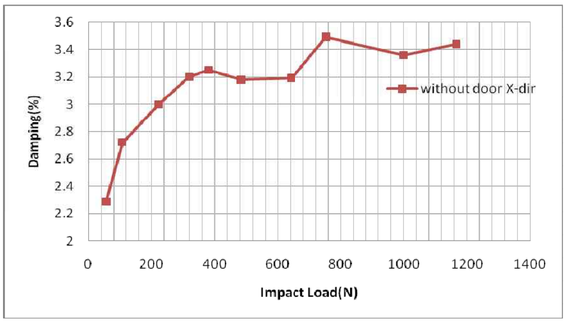

Fig. 9 Variation of the damping ratio (without door)

3. Conclusions

This study analyzed that the dynamic characteristic of the electrical cabinet varies nonlinearly in accordance with the excitation level. The increment of the impact energy produces the lower frequency of the cabinet. The attachment of the door to the cabinet results in high damping values. The nonlinear variation of the dynamic characteristics of the electrical cabinet might be accepted as an important fact that should be considered during the seismic qualification of safety related equipment.

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