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Experimental Validation of Enhanced Active Vibration Isolation Methodology on a Structure with Three Transmission Paths Excited by Amplitude Modulated Signal in Mid-frequency Band

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ABSTRACT

In recent years, production and propagation of electric vehicles and hybrid vehicles are increasing, which causes vibration and noise with medium frequency band and complex spectrum not occurring in conventional ICE vehicles. In addition, due to the miniaturization of the engine, the vibration reduction method through the existing structure modification is limited. Due to these problems, active engine mounts have been attracting attention and are being actively researched to simultaneously improve NVH performance, static and dynamic stiffness. Therefore, in this study, the effect of vibration reduction through an active mounting system with piezo actuator was tested through experiments, and a simple experimental setup was performed on the structure with three paths. In the experimental setup, path1 and path2 consist of rubber mount only, and path3 consists of rubber mount and piezo actuator. When the AM signal is applied to the source part, the vibration reduction effect of the path with the actuator is confirmed. Multi-NLMS algorithm is applied for control, and the signal generated from path3 of the source part is traced and used as an actuator input signal. This experiment shows that vibration reduction performance is effective in the path where the piezo actuator exists.

Keywords: Piezo actuator, Multi-NLMS algorithm, AM signal
I-INCE Classification of Subject Number: 40

1. INTRODUCTION

Recently, electric vehicle production is increasing in the automobile industry, and government policies are also moving toward reducing internal combustion engine (ICE). As the production of electric vehicles increases, noise and vibration in the mid-frequency band, which is not generated in ICE, is occurring. Conventional reduction methods are limited. So that reason, active mounting system is used to reduce noise and vibration in the mid-frequency band. Through this, it is possible to control the vibration of the band which cannot be achieved by the mount of the existing vehicle, and it is possible to

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achieve both the effects of the static and the dynamic stiffness. Research on active mounting systems has been actively conducted using various materials. Masih Hosseini et al. [1~3] manufactured nonlinear modeling and engine mounts using solenoid actuators. This has shown that nonlinearity can be linearized in certain areas. Roman Kraus et al. [4] manufactured and tested the mount by connecting the actuator and the viscous damper. Hee Dong Chae et al. [5~6] manufactured and test the MR damper to reduce the vibration caused by vertical, rolling and pitching during operation. Juncheol Jeon et al. [7~8] carried out the control using the roll mount with a magnetorheological fluid actuator and the RH mount with a piezo stack actuator. Takayoshi Kamada et al. [9] carried out the active vibration control through a series connection of a column and a piezoelectric actuator.

In this study, an experiment was conducted on a plate structure with one active path among three paths. The experimental setup is based on a source-path-receiver structure, the active path consists of a series combination of piezo actuators and rubber mounts, and the remaining path consists only of a rubber mount. The source and receiver were made of aluminium and the active path was setup in the third path. To implement of the experiment, the vibration reduction performance was evaluated by using the multi-NLMS algorithm as the input signal of the actuator.

2. EXPRIMENT SET-UP

The experimental setup is shown in Fig 1. It was based on a source-path-receiver structure, and the source and receiver were made of aluminium with a thickness of 10 mm and a length of 240 x 330 mm. There are three paths between the plates, and only the path 3 consists of an active path with a piezo stack actuator and a rubber mount, and the remaining path consists of only a rubber mount. The accelerometer was attached to each path, and the signal from the accelerometer was measured in real time using dSPACE. Then, the shaker was used to excite the source part, and the excitation force was measured from the impedance head attached to the end of the stinger. In addition, the input signal to the piezo-stack actuator was applied by using the multi-NLMS algorithm, and the signal generated from the path 3 source part was appropriately controlled.

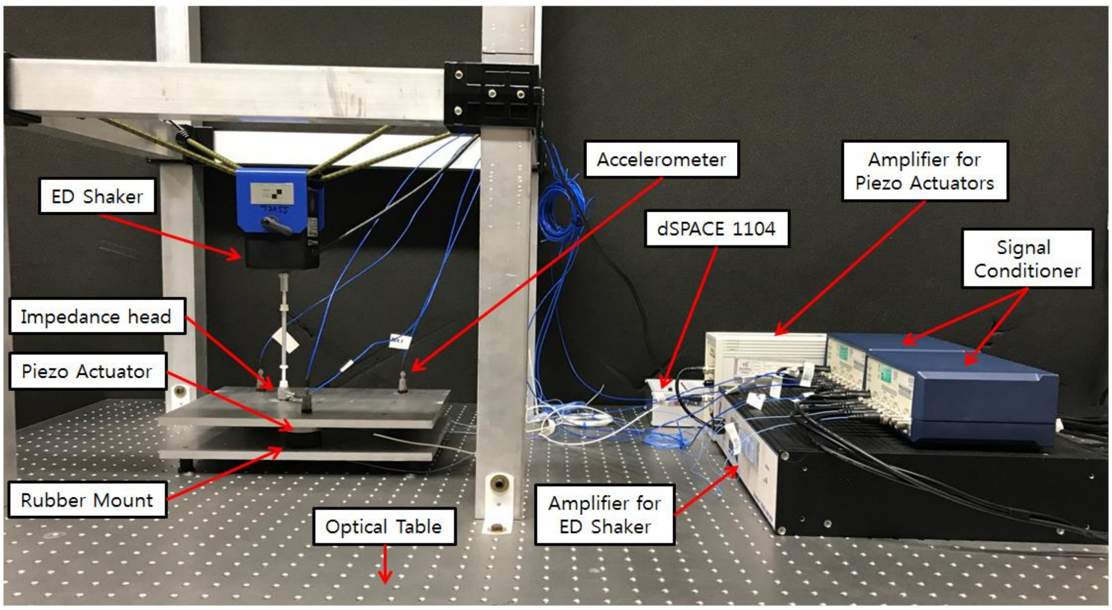

Figure 1. Experimental setup

3. EXPERIMENT RESULTS

3.1 AM signal

Experiments were conducted to investigate the reduction performance of AM signals with three frequencies. The input of the AM signal is given by the following equation (1).

$$u(t) = 2.5\sin(640\pi t) + 5\sin(920\pi t) + 2.5\sin(1200\pi t) \tag{1}$$

The results of the experiment are shown in Figure. 2 below, and the results are summarized in Table 1.

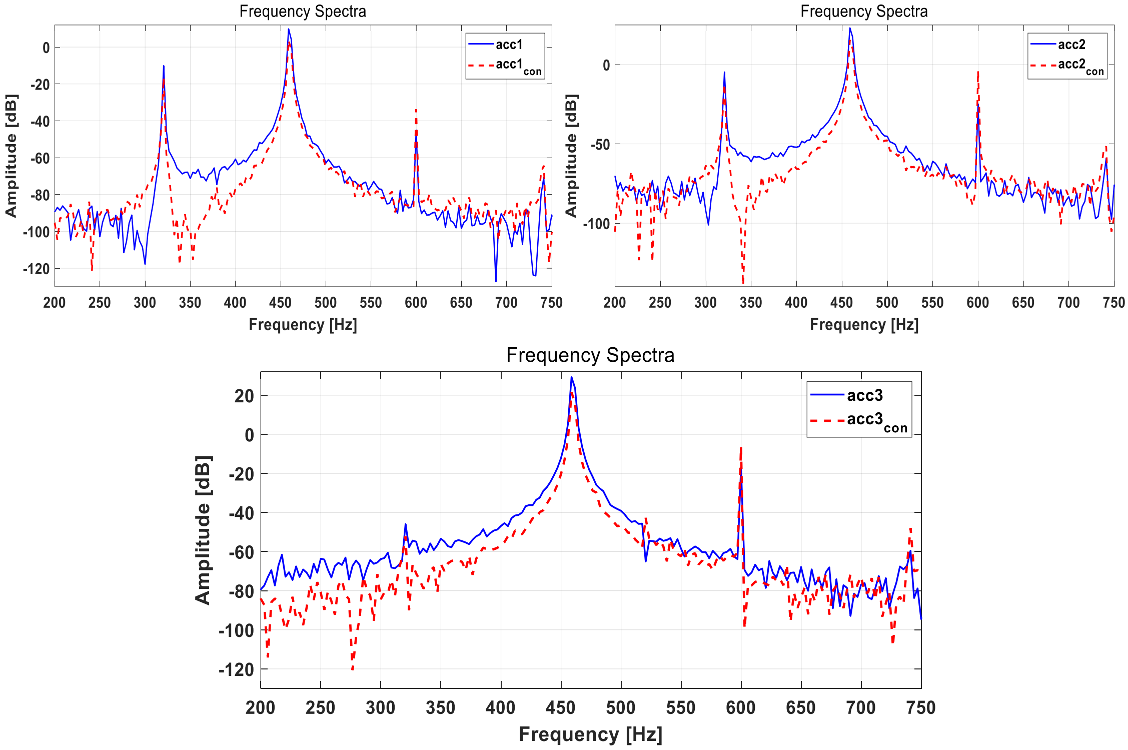

Figure 2. Results of the AM signal

Table 1 Results of path3 about each frequency band

dB scale	320Hz	460Hz	600Hz
Before actuator control	-45.95	29.25	-16.76
After actuator control	-52.21	21.48	-6.37
dB reduction rate	6.26↓	7.77↓	10.39↑

Table 1 shows the main frequency band reduction rates for path 3. It can be seen that 6.26dB is reduced in the 320 Hz band and 7.77dB is reduced in the 460 Hz band. However, it shows 10.39dB increase in the 600Hz band. However, when the total frequency band reduction performance is observed, the vibration reduction effect is shown that the excellent performance due to the active path.

4. CONCLUSIONS

In this study, vibration reduction performance of each path was investigated using a piezo actuator through experiments. The experimental setup was configured so that one of the path 3 had a piezo actuator. The experiment was conducted on the AM signal, which is a multi-frequency signal. As a result, it can be seen that the vibration is effectively reduced in the path where the actuator is located, and it is expected that vibration can be reduced more efficiently if there is an actuator in all the paths.

5. ACKNOWLEDGEMENTS

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