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WAVEGUIDE ABSORBER BASED ON A SPIRAL ACOUSTIC BLACK HOLE FOR VIBRATION DAMPING OF PLATE STRUCTURES

Seongmin Park[1] **Wonju Jeon**[1*]

[1] Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology, Daejeon, Republic of Korea

ABSTRACT

To reduce vibration in a plate, we propose a waveguide absorber (WGA) based on a spiral acoustic black hole (ABH). By applying an impedance method and taking into account a cut-on frequency, geometrical parameters of the WGA are obtained. Then, by analyzing the structural intensity of the plates, we optimize the attachment locations and directions to enhance the damping performance. The use of lightweight WGAs results in significant decreases in resonance peaks in numerical simulation and experiments.

Keywords: *acoustic black hole, vibration damping, elastic wave, flexural wave*

1. INTRODUCTION

Flexural waves cannot exit the straight wedge structure known as the acoustic black hole (ABH). The phase and group velocities of incident waves are slowed down to zero and elastic waves are confined near the ABH tip (1) when its thickness is smoothly lowered to zero by a power-law. The utilization of the ABH in vibration dampening, noise reduction, and energy harvesting has been the subject of several theoretical, computational, and experimental studies. (2-6). Recently, a spiral ABH was proposed to reduce the space by the ABH (7), and the damping capability was experimentally verified (8). An impedance method was used to analyze the wave properties in the spiral ABH (9).

[*]***Corresponding author***: *wonju.jeon@kaist.ac.kr*

When used on plate, the spiral ABH might be a heavy and bulky solution rather than a compact damper for beams. There have been various studies using ABH-based structures to provide vibration dampening using lightweight devices (10, 11), but those devices compromise the original structure's integrity, making their usage in real-world applications challenging. In this study, we suggest waveguide absorbers (WGAs) that are small and lightweight and are based on spiral ABHs to reduce plate vibrations.

2. RESULTS AND DISCUSSIONS

Fig. 1(a) describes four WGAs based on spiral ABHs. The spiral ABH component, the damping layer, and the connecting rod make up the WGA. Fig. 1(b) shows the mobility of the plate both with and without the WGAs. Using the WGAs, peak reductions of about 12–21 dB might be achieved. Peak reductions are contrasted with cases where spiral ABHs are affixed to plate edges and cases where dampening material is used. We were able to achieve higher dampening vibrations compared to the damping treatment example. Similar damping performance can be attained while the volume and weight of ABHs are mainly preserved as compared to the case of edge-attached ABHs.

3. CONCLUSIONS

We proposed WGA based on a spiral ABH to reduce plate vibrations. A rod, a damping layer, and a spiral ABH made up the WGA. By mounting the WGAs, reductions of peaks greater than 10 dB were achieved for the host plate. In comparison to dampening material or edge-attached ABHs, the WGAs were substantially lighter. Reference (12) contains thorough details on how to calculate geometrical parameter values and attachment data.

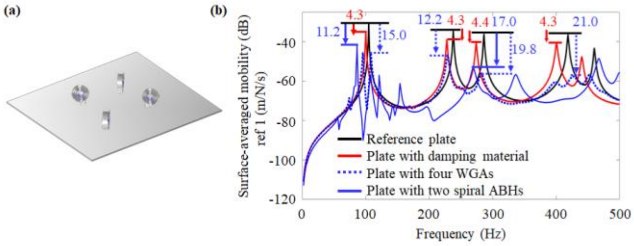

Figure 1. (a) plate with WGAs and (b) its surface-averaged mobility.

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