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On the use of Coupled Cavity Helmholtz Resonator Inclusion for Improving Absorption Performance of Wooden Sound Diffuser Element

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Abstract

This study focused on the use of coupled multi-degree of freedom Helmholtz resonator inclusion for improving sound absorption of wooden sound diffuser element. Tubular shaped sound diffuser element was made from round waste wood from furniture industries. The multi-degree of freedom Helmholtz resonator was created through machining process for three different sound diffuser element diameter 4 cm, 6cm, and 8 cm. Laboratory test measurement conducted using B&K impedance tube 4206 refers to ASTM E-1050 standard. The results show that coupled multi-degree of freedom Helmholtz resonator inclusion works properly as expected. All model has promising performance in the mid to high frequency range between 500 Hz to 1 kHz. Even more, the bigger diameter gives a better possibility for shifting the sound diffuser element response to low frequency band below 500 Hz.

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1. Introduction

One of the most important thing to be considered in designing a room is that the intended acoustic quality to make sure the indoor environment meets the specific standard. Accordingly, solution for acoustic design for the concert hall, worship building, hospitals, and many other public gathering venues has attracted significant interest.

The poor quality of room acoustic is old and common problems anywhere that challenging to be improved and developed. One of the fundamental issues is the clarity of the sound and how to control the reverberations. The most popular way to fix this problem is by installing sound absorber and diffuser inside the room. The width and sequence pattern of the diffusers element gives effect on the frequency response. It would be associated with scattering and the diffusion coefficient. On the other side, the material for the elements does not affect significantly on the scattering pattern but on the sound pressure level of the scattered sound waves. For example, the sound pressure level of scattered sound waves by the glass would be greater than those by wooden element.

Research in this field has been done by many researchers for various objectives. The sound diffuser has been developed by in many different approaches. Some of them focused on the shapes of the diffuser element while the others on its sequence pattern [1-3]. According to the material for the sound diffuser, some research has been conducted in order to develop the green, less expensive and lighter that can be derived widely from natural resources such as fibers, wood, and rubber [4-6]. Sound insulation and absorption properties of wood and wood-based materials also have been reported in the literature [7-9].

In this study, the researchers focused on the improvement of absorption performance of wooden sound diffuser element by the resonant approach. The coupled cavity Helmholtz resonator inclusion is fitted within the wooden diffuser element. As reported in the literature, the using of dual cavity resonator brings the advantage for shifting the sound absorption to the lower frequency band. The acoustic coupling between coupled resonator can have a significant influence on the resonance property [10,11]. In addition, Helmholtz resonator has the highest damping capacity among other types of the acoustic resonator such as half and quarter wavelength resonator [12]. Differs from coupled models reported in previous literature, the proposed coupled structure

in this work constructed by multiple small Helmholtz resonators that connected to a single common back cavity. The bigger diameter diffuser element the small number elements attached to the common back cavity. This approach to being expected has the better performance on the shifting of sound absorption to the lower frequency band.

2. The object of the study

The diffuser element was made from teakwood while the neck is plastic straw. Details of its geometrical size and construction presented in Table 1 and Figure 1.

Table 1. Geometrical dimension of the diffuser elements

Parameters	Dimension (cm)		
Diameter (d)	$d_1 = 4$	$d_2 = 6$	$d_3 = 8$
Thickness	all: 2		
Neck	Cross section: 0.5; length: 5		
Front cavity	Cross section: 1.5; depth: 1.5		
Back cavity depth (c)	$c_1 = 1$	$c_2 = 2$	
Back cavity diameter	10		

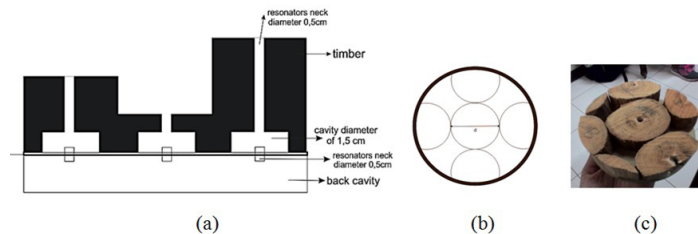


Fig 1. The configuration of the test sample. (a) side view; (b). top view; (c). the test specimens

3. Methods

The experimental investigation has been conducted by using transfer function based two microphone impedance tube. It refers to ASTM E-1050 standard. The impedance tube B&K 4206 was utilized. It controlled by PC that connected to the B&K Pulse 3160 LAN-Xi. A pair of quarter-inch microphone B&K 4187 with the B&K 2670 preamp are used for capturing the signals. A dedicated FFT based decomposition technique software is use for analysis the captured signals to extract incident and reflected waves components. The schematic diagram of the impedance tube is presented in Figure 2.

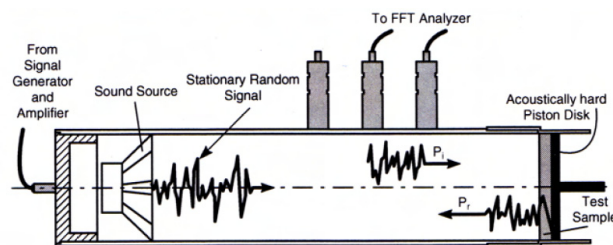


Fig 2. The schematic diagram of two microphone impedance tube according to ASTM E1050 [13]

From the incident and reflected component captured at two microphone positions, three frequency response are calculated: frequency response H_1 , frequency response associated with incident waves component H_i , and the frequency response function associated with the reflected wave component H_r .

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