IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Impact Factor: 6.252

Volume 2, Issue 7, June 2022

Acoustic Absorption Research on Woven Structure Fabrics

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Abstract:*Noise has become one of the world's four major pollutant categories. Textiles have been employed as noise reduction materials in construction, automotive, and other industries because of their porous, light, and easy processing features, however there have been few investigations on woven fabrics' sound absorption properties. The effect of structural elements of woven fabrics on acoustic absorption was investigated in this research. Fabrics with plain, twill, and honeycomb weaves were woven with identical warp density and used as acoustic measuring samples, which were measured using an acoustical detecting platform based on an impedance tube. The experiment is carried out on a perforated panel to see how changes in thickness, porosity ratio, and cavity depth affect the sound absorption coefficient.The analysis is carried out using the MATLAB software. Although pore parameters have an impact on the acoustic properties of woven fabrics, the influence of pore features on textile acoustic absorption cannot be attributed solely to porosity. Sound absorption performance of woven fabrics may also be influenced by the number and shape of pores.*

Keywords: Acoustic Absorption, Acoustical Property, etc.

I. INTRODUCTION

Noise has become one of the world's four major pollutant categories. constant noise exposure can lead to a variety of health issues, including hearing loss, cardiovascular illness, and sleep disturbances. Textiles are seen as a possible replacement to traditional porous materials due to their light weight, excellent machinability, and low costs among diverse sound absorption materials. because of its outstanding acoustic absorption properties in the high frequency band, the application range of textile sound absorbers is continuously expanding in noise reduction and vibration control. Porous absorbing materials have been characterised as cellular, fibrous, or granular based on their microscopic topologies. fibrous materials, in particular, are made up of a succession of tunnel-like apertures created by material fibre interstices. natural and artificial fibre materials are the two types of fibre materials. natural fibres can be vegetable (e.g., kenaf, hemp, and wood), animal (e.g., wool and fur felt), or mineral (asbestos), whereas synthetic fibres can be mineral (e.g., fibreglass, mineral wool, and glass wool), or polymer (e.g., nylon, polyester, and nylon) (polyester). nonwovens and felts have been the most studied sound-absorbing textile materials in recent years.

Due to their smaller thickness, woven textiles have poor sound absorption characteristics when compared to nonwovens and fiber-based felts. however, because of their superior structural design ability and dimensional stability, woven fabrics are commonly employed in domestic textiles and automotive decorations. versatility has become a noticeable trend in decorative fabrics in recent years. window curtains, for example, are intended to have not just traditional capabilities, such as shade and heat preservation, but also innovative capabilities, such as flame retardant, antimicrobial, and sound absorption.

II. OBJECTIVE

The effect of structural elements of woven fabrics on acoustic absorption was investigated in this research. Fabrics with plain, twill, and honeycomb weaves were woven with identical warp density and used as acoustic measuring samples, which were measured using an acoustical detecting platform based on an impedance tube. The experiment is carried out on a perforated panel to see how changes in thickness, porosity ratio, and cavity depth affect the sound absorption coefficient. The main objective of the study is:

DOI: 10.48175/IJARSCT-5112

- To determine acoustic absorption properties of woven materials.
- To check effects of thickness, incident frequency and porosity on absorption properties.

III. LITERATURE REVIEW

Umberto Berardi, Gino Iannace: Measurements on natural fibre samplesrevealed that thesematerials have good sound absorption coefficients, especially at medium and high frequencies, according to this paper. The inhomogeneity of natural fibres and the difficulty un developing models to anticipate their behaviour were validated by the high standard deviation values of the airflow resistance measurements. The considerable variability of the data indicated that direct methods for measuring material properties be limited, and that models capable of predicting material behaviour with the fewest available variables be considered. Using an inverse optimization technique, the coefficients that best represent the acoustic impedance and propagation constant for several natural fibres were computed.

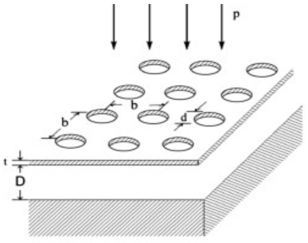
Dakai Chen, Jing Li, Jie Ren: The sound absorption property measurements in this study demonstrate that composites with short ramie fibre have superior sound absorption than ramie fabric reinforced PLLA composites. Furthermore, the addition of the flame retardant APP and the plasticizer PBAT improves the sound absorption properties of the ramie fabric/PLLA composites. The micro-phase separation in the PBAT/PLLA composites, the porosity of the single ramie fibre bundle, and the distribution of short ramie fibre and ramie fabric in the PLLA composites are also shown by SEM morphological studies. The fundamental cause for greater acoustical absorptivity is due to these unique features and their distribution.

Hsiao Mun Lee, Zhaomeng Wang, Kian Meng Lim, Heow Pueh Leea: Series of tests were conducted in a reverberation room on commercial P.E.B. noise barriers to investigate their absorption ability. During the testing, the effects of sample size on the noise barrier were also investigated. The sound absorptive and reflecting surfaces of two types of noise barriers (metal and plastic) were evaluated. Only for frequencies above 315 Hz and 630 Hz did the sound absorptive surfaces of the metal and plastic noise barriers outperform reflecting surfaces in terms of sound absorption. The results showed that sample size had no effect on noise barrier sound absorption ability, except when the sample size was too small (2 m2) at frequencies below 100 Hz and over 4000 Hz.

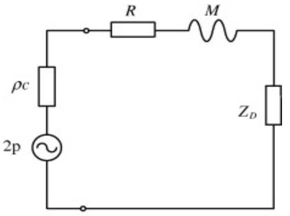
Mlando Basel Mvubu, Rajesh Anandjiwala, and Asis Patnaik: The univariate significance test revealed that all of the parameters, as well as two of the three two-way interactions, had significant effects on observed sound absorption coefficients in this investigation. Blend ratio and air gap were the only two-way interaction effect that failed to have a significant effect on sound absorption coefficient at the 95 percent confidence interval. The sound absorption coefficients increased as the air gap was extended from 0 to 25 mm, however they peaked at 15 mm air gap, after which they slightly reduced as the air gap was increased from 15 to 25 mm.From the literature survey we came to know that how we can control the ficientsound absorbtion coef by controlling the different parameters of materials

IV. IMPLEMENTATION

The sound absorption capabilities of a material change when the parameters discussed above change. as a result, using MATLAB software, the study is carried out on perforated panels to check the influence of all parameters creating changes in the material's sound absorption characteristic. Noise control treatment methods such as perforated panels are excellent for absorbing noise, particularly noise in the lower frequency ranges. perforated panels work in a similar way to Helmholtz resonators in that they absorb sound. perforated panels are a collection of Helmholtz resonators.



(a)



(b)

Figure 1: Perforated panel set-up **Figure 2:**Electric circuit [11]

Effective panel absorption is formed by the exterior sheeting, an air space (perhaps filled with an absorptive liner), and an inside board. The important concern is to ensure that this absorption occurs at the desired frequency.quation for perforated frequency isThe e:

$$\mathrm{Fpp} = \frac{\mathrm{C}}{2 \times \Pi} \times \sqrt{(\frac{б}{\mathrm{t} \times \mathrm{D}})}$$

Where, Fpp= Perforated frequency
C= Velocity of fluid
б= Porosity ratio of panel
t= Thickness of panel
D= Depth of cavity in panel

This equation is used to create the programme, which is then analysed using MATLAB software. All of the figures are based on research. The dependent parameter is the perforated frequency, whereas the independent parameters are the porosity ratio, thickness, and cavity depth. The results are taken after some of the aforesaid parameters are analysed using MATLAB programme.

bsorbtionA oundS orosity onP Effect of:

To check the effect of porosity on sound absorbtion, different data were collected from literature. This data is curving fitting operation then analysed on MATLAB by performing

Table 1: Sound absorption coefficient as function of frequency and density for fabrics

	Density(Kg/m^3)			
	199.50	**207.60**	**249.54**	**257.54**
Frequency(Hz)	**Sound absorption co-efficient**			
500	0.08	0.12	0.15	0.15
750	0.15	0.155	0.1	0.14
1050	0.155	0.155	0.16	0.22
1300	0.16	0.19	0.2	0.14
1600	0.175	0.14	0.22	0.16
2000	0.16	0.12	0.31	0.25
2500	0.17	0.23	0.28	0.32
3150	0.24	0.31	0.45	0.39
4000	0.34	0.42	0.58	0.56
5000	0.45	0.56	0.77	0.7
6250	0.47	0.83	0.92	0.75

Table 2: Sound absorption coefficient as function of frequency and density for wool boards

	Densities(g/cm3)						
	0.300	**0.299**	**0.314**	**0.291**	**0.286**	**0.295**	**0.291**
Frequency(Hz)	**Sound absorption co-efficient**						
1000	0.045	0.044	0.04	0.049	0.04	0.05	0.05
1250	0.055	0.056	0.045	0.065	0.06	0.065	0.075
1500	0.06	0.062	0.05	0.074	0.075	0.07	0.08
1800	0.073	0.072	0.07	0.08	0.08	0.08	0.095
2000	0.08	0.08	0.08	0.08	0.095	0.094	0.105
2300	0.12	0.11	0.12	0.14	0.12	0.11	0.138
2650	0.15	0.14	0.14	0.175	0.145	0.16	0.175
3200	0.16	0.15	0.148	0.18	0.155	0.175	0.195
4000	0.19	0.18	0.185	0.22	0.205	0.195	0.25
5000	0.265	0.26	0.28	0.34	0.275	0.28	0.365

The data shows the change of sound absorbtion coefficient with respect to change in density and frequency. this data to check the result in graphical form Small analysis is made on. The analysis is made on MATLAB software from this data and the graphs were obtained.

Resuls:

Effect of Thickness of material on perforated frequency

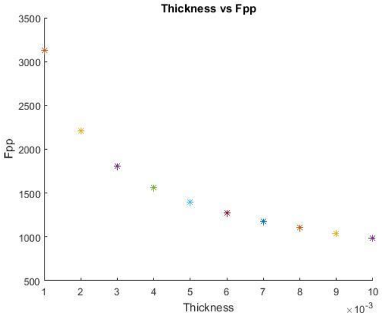


Figure 3: Graph of Thickness vs Perforated frequency

Table 3: Effect Thickness on perforated frequency

C(m/s)	**D(m)**	**sigma**	**t(m)**	**Fpp(Hz)**
340	0.15	0.5	0	inf
340	0.15	0.5	0.001	3124.2
340	0.15	0.5	0.002	2209.1
340	0.15	0.5	0.003	1803.8
340	0.15	0.5	0.004	1562.1
340	0.15	0.5	0.005	1397.2
340	0.15	0.5	0.006	1275.4
340	0.15	0.5	0.007	1180.8
340	0.15	0.5	0.008	1104.6
340	0.15	0.5	0.009	1041.4
340	0.15	0.5	0.010	987.95

When Fpp of the panel is calculted by varying thickness of the material in certain manner 0-10mm while keeping б(Porosity ratio=0.5), D(Depth of cavity=0.15m), C(Speed of air=340m/s) constant then it is observed that the Fpp(Perforated frequency) of the system decreases as the thickness of the material increasesin depth of cavity.

Effect Porosity Ratio on Perforated Frequency:

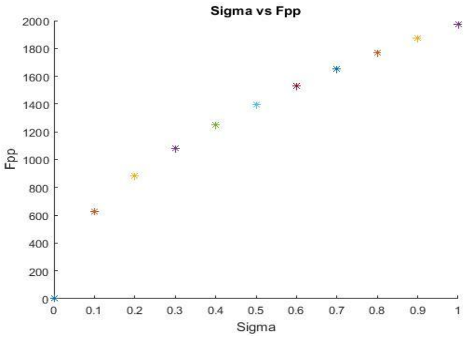


Figure4: Graph of Porosity ratio vs Perforated frequency

Table 4: Effect of porosity ratio on perforated frequency

C(m/s)	t(m)	D(m)	sigma	Fpp(Hz)
340	0.005	0.15	0	0
340	0.005	0.15	0.1	624.8394
340	0.005	0.15	0.2	883.6564
340	0.005	0.15	0.3	1082.3
340	0.005	0.15	0.4	1249.7
340	0.005	0.15	0.5	1397.2
340	0.005	0.15	0.6	1530.5
340	0.005	0.15	0.7	1653.2
340	0.005	0.15	0.8	1767.3
340	0.005	0.15	0.9	1874.5
340	0.005	0.15	1.0	1975.9

When Fpp of the panel is calculted by varying Porosity ratio of the material from 0-1 while keeping t(Thickness =5mm), D(Depth of cavity=0.15m), C(Speed of air=340m/s) constant then it is observed that the Fpp(Perforated frequency) of the system increases with increase in porosity ratio.

quencyEffect of depth of cavity on perforated fre:

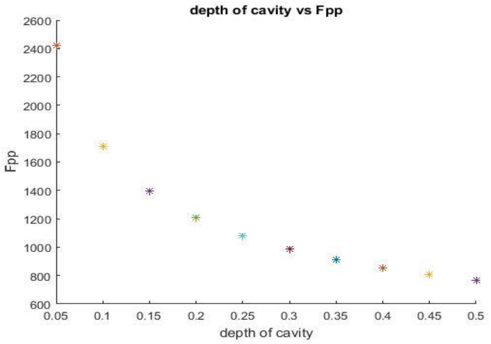


Figure 5: Graph of depth of cavity vs Perforated frequency

Table5: Effect of depth of cavity on perforated frequency

C(m/s)	t(m)	sigma	d(m)	Fpp
340	0.005	0.5	0.0	inf
340	0.005	0.5	0.05	2420.0
340	0.005	0.5	0.10	1711.2
340	0.005	0.5	0.15	1397.2
340	0.005	0.5	0.20	1210.0
340	0.005	0.5	0.25	1082.3
340	0.005	0.5	0.30	987.95
340	0.005	0.5	0.35	914.67
340	0.005	0.5	0.40	855.59
340	0.005	0.5	0.45	806.66
340	0.005	0.5	0.50	765.26

When Fpp of the panel is calculted by varying Depth of cavity of panel from 0-0.5m while keeping t(Thickness =5mm), б(Porosity ratio=0.5), C(Speed of air=340m/s) constant then it is observed that the Fpp(Perforated frequency) of the system decreases with increase in depth of cavity.

on sound absorbtion coefficient uencyEffect of density and freq:

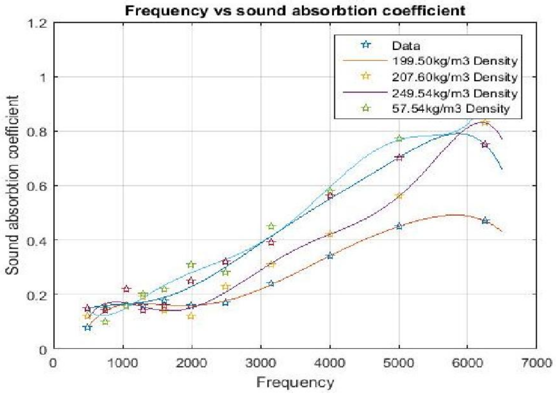


Figure 6: Sound absorption coefficients with different densities of wool boards

When the density of wool boards was raised, the sound absorption coefficients varied or marginally rose with increasing frequency in the low frequency region. The sound absorption coefficients also indicated a substantial increasing trend in the high frequency range (Figure 6). This is due to the fact that high density causes microscopic pores in the inside board. Low-frequency acoustic waves have a tough time entering the interior, and a considerable portion of these waves are reflected at the surface, resulting in the board's poor low-frequency sound absorption capabilities. Meanwhile, when the density of the board rises, the permeability of the board decreases, and flow resistance rises.

Given the absorbed high-frequency acoustic waves in the board surface, the larger the acoustic waves attenuate at the surface, the greater the degree of absorption, which leads to enhanced high-frequency acoustic wave sound absorption capabilities with increasing density. The effect of increasing density on the effect of high-frequency acoustic waves, on the other hand, is negligible.Thus, increasing density insignificantly enhanced the sound absorption coefficients at low frequencies.

DOI: 10.48175/IJARSCT-5112

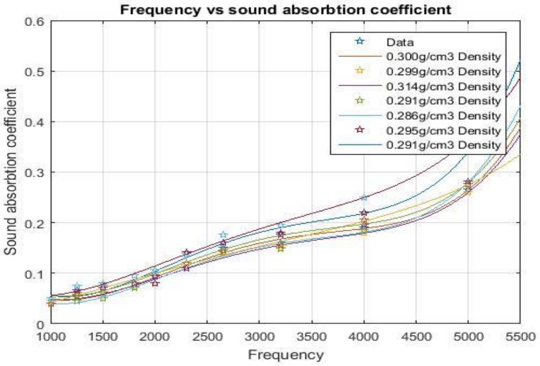


Figure 7: Sound absorption coefficient as a function of frequency for fabrics.

For all fabrics, the absorption coefficient rose as the sound frequency increased. When compared to the thick fabrics, the slopes of the curves were substantially steeper for the porous and medium fabrics, and they were much higher at mid-and high frequencies. Although density is a significant component in establishing a fabric's sound-absorption capacity, it also provides an estimate of the void/air spaces in the fabric.

V. CONCLUSION

Because of their porous, light, and easy processing properties, noise reduction materials such as cloth have been employed in building, automation, and other industries. The amount of sound that a material absorbs is determined by several factors. Incident frequency, material thickness, porosity ratio, and surface finish quality are the characteristics in question. The thickness of the material and the porosity ratio are the two characteristics that have the greatest influence on sound absorption. As a result, in order to control sound absorption, these parameters must be kept within reasonable bounds. With independent settings, sound absorption varies linearly. Analysis on a perforated panel using MATLAB software is used to check the influence of these settings on sound absorption.

The programme is written in MATLAB utilising a perforated frequency equation. We can clearly see from the graphs and corresponding values that increasing the thickness of the material or the depth of cavity in a perforated panel while keeping all other parameters constant reduces the perforated frequency, whereas increasing the porosity ratio while keeping all other parameters constant increases the perforated frequency. The other variables have a negligible impact on sound absorption. As a result, the thickness of the material, the porosity ratio, and the depth of the cavity in the panel must all be regulated in order to control sound absorption. In addition, data from the literature is used to investigate the influence of density on sound absorption. MATLAB software was used to conduct the analysis, and graphs were created. It shows that the density of material make huge impact on sound absorbtion properties.

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