Experimental Investigation of Sound Absorbing Materials

Vishakha V. Mankar, Sandeep Thorat, Sachin Pawar, and Khushal Mulik

Abstract Noise has become one of the four major pollution types in the world. Constant exposure to noises can cause all kinds of health problems such as hearing loss, cardiovascular disease and sleep disorder. Following paper investigates the ability of porous and solid materials to absorb the generated sound for different geometries. Many natural and synthetic material have been developed and tested for acoustic applications. Impedance tube is used to find absorption coefficient of specimen is tested experimentally and the research shows the peak of absorption coefficient changes with porosity and peak value affected with various geometrical shapes in specimens. Finally, we get the peak absorption coefficient in porous material than the solid geometry of same material. In this research, we study the different sound absorbing materials with different geometry and comparative study between the materials. A thorough analysis of the research on the future scope of work, issue statements and goals connected to converting two-wheelers with IC engines into electric two-wheelers. In accordance with our practical analysis, our bike come in second position in overall championship, it is found that motor of electric vehicle generates high frequency sound. The intensity of research and the development in manufacturing processes, we anticipate that the range of new sound absorbing materials will expand to manufacture the casing of motor over the next few years.

Keywords Sound absorption · Carbon fibre · Electric vehicle · Pollution · Natural and synthetic material · Porous material

1 Introduction

Sound is becoming the most serious problem for livelihood many researches has been done and now researcher is more focused on the material which absorbs sound efficiently and that material does not have any adverse effect on lifestyle, it should be natural and concentrated on cost effectiveness. Control over the sound is becoming

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the need, sound not only interrupt the sleep but it causes a loss of hearing during continuous exposure with noise. Sound is a wave of vibration that propagates in various medium. A porous specimen has becoming the barrier which converts sound energy to heat energy. The factors which mainly affects the sound absorption are material thickness, airflow resistivity, porosity, density, etc. Wood-based material, hemp and coir are the natural fibres which is the better option for improving sound absorption.

In terms of porous materials and different geometrical specimen, Jiang et al. [1] investigated the comprehensive analysis of hole diameter, porosity, thickness and consist 3D printed material with 1mm diameter holes. The result shows the peak value of absorption at range from 0.24 to 0.99 from frequency range 4800–6400 Hz. Guzman examined the sound absorption in bricks by redesigning with different geometrical shapes which improves its structural strength. The mixture of brick is made up of plastics and raw dust of sawmill. From data, it is observed that the triangular shape design gives better sound absorption than hexagonal and octagonal shape. Atiénzar-Navarro et al. focused on the study of regular textile material without giving any structure which gives good absorption. By just folding the cotton textile and it gives the aesthetic look too and it is found that folding textile boosts sound absorption at medium and high frequencies but folding effect reaches saturation with a specific number of folds in the operating frequency range. Monkova et al. examined sound absorption qualities of open porous structures. The four different 3D structures (Cartesian, octagonal, rhomboid and starlit), it has been found that starlit sample absorbs the better sound than other three sample. David Griese et al. explored the study of honeycomb structure in sandwiched panel and results in large drop of sound transmission loss (STL). Dr. Muna S. Kassim focused on natural materials and to produce reinforced composites, used waste material like chicken feather, palm leaf, egg shell and wood dust. It is found that the jute woven and the saw dust has great ability to absorb sound than the chicken feather, palm leaf composites for frequency range 50–2000 Hz.The surface layer of egg shell particles and chicken feather has great insulation properties than jute and saw dust. Xie investigated the sound absorption ability of lotus type porous copper. It is found that the absorption coefficient increases with increase in frequency. The absorption coefficient of the 10 mm thick specimen which has uniform porosity 58% increases with decrease in pore diameter. It is found little challenging to customize the frequency for the noise control of specific application.

2 Statement of Problem

- Sound pollution causes a severe health issues.
- Sound in automobiles explores noise to surrounding.

3 Objectives

- To find the composition of material which is effective for sound absorption.
- Selection of specimen geometry for absorption of both low and high range of frequency.
- Manufacturing and experimentation of specimen
- Comparative analysis between different materials.

4 Research Methodology

4.1 Geometry Selection
4.2 Software Analysis
4.3 Experimentation.

4.1 Geometry Selection

Specimen

In this study, all specimens are made of 3D printing material of carbon fibre. The structure of test specimen as shown in Fig. 1, the geometries of these specimens are of 29 and 99 mm in diameter and 10 mm thickness with pore holes of 1 mm diameter. Specimen as shown in Fig. 2, the geometries of these specimens are of 29 and 99 mm in diameter and 10 mm thickness with pores of hexagonal shapes shows in fig. The unit cell is shown in Fig. 3 for two honeycomb panel cell angle (θ), , vertical member height (*h*), angled member length (*l*) and cell wall thickness (*t*). The unit cells in Fig. 2 shown are of hexagonal model, the relationship between the unit cell size and geometric parameter is given.

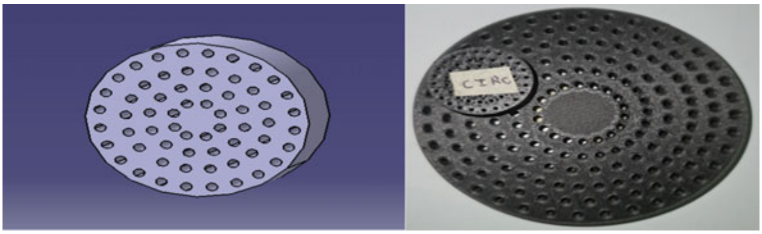

Fig. 1 Cad model of specimen with circular holes and its 3D printed specimen

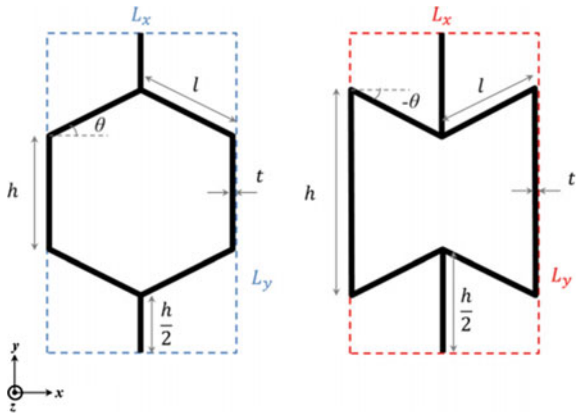

Fig. 2 Unit cell of honey-comb

$\mathrm{Lx} = 2l \cos \theta$
$\mathrm{Ly} = 2(h + l \sin \theta)$.
$l = 1$ mm
$h = 1$
$\theta = 30°$

4.2 Software Analysis

The harmonic acoustic analysis gives an idea about how much sound is absorbed at given frequency. A test setup is modelled in Ansys software and the specimen is imported to modelled setup where the acoustic boundary condition is specifying by giving velocity of sound and density of material. At the one end of impedance tube force is defines and on the other end surface velocity resistance and reactance is defined. Two different microphones are placed at two different position which is used to find the reflection and transmission of sound. For mesh sizing, select mesh

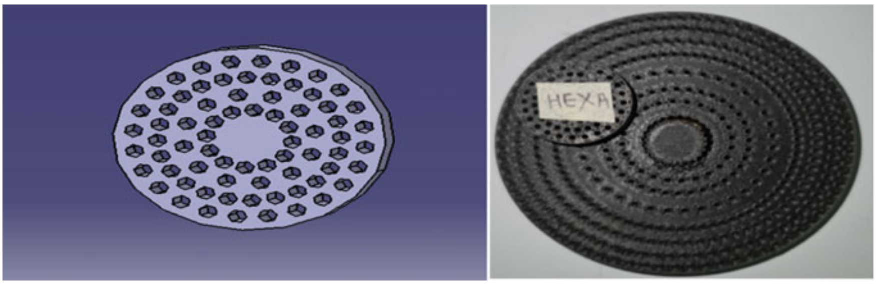

Fig. 3 Cad model of specimen with hexagonal holes and its 3D printed specimen

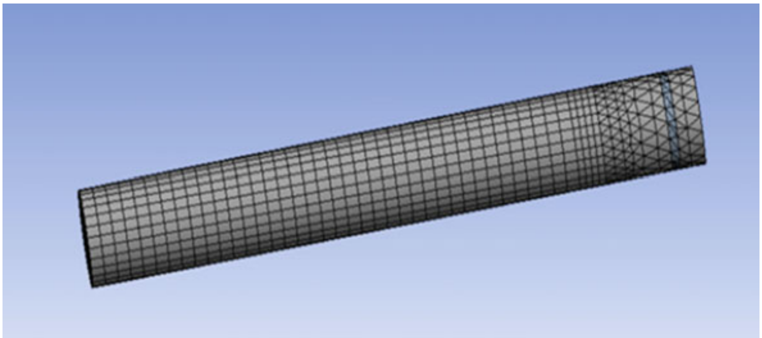

Fig. 4 Meshing

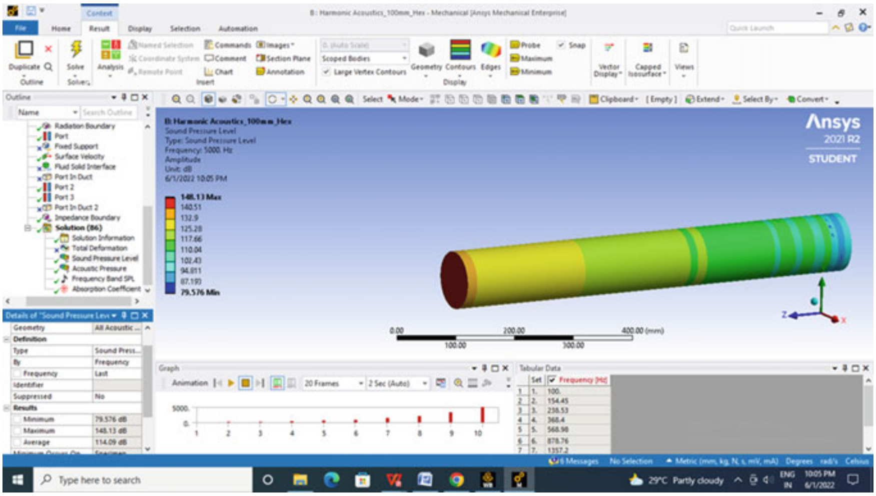

Fig. 5 Sound pressure level distribution

as default and 3 edges are defined so that fine mesh is obtained as shown in Fig. 4 and a sound pressure level in Figs. 5 and 6.

4.3 Experimental Analysis

The sound absorption coefficient of the 3D printed specimen of both porous (circular and hexagonal) was calculated by BSWA SW series impedance tube which is having minimum sound absorbing material with diameter of 30 and 100 mm. The specimen was placed at extreme end of tube and on other end loudspeaker was placed which acts as a source of sound. To find the acoustic properties of specimens, two microphones were placed at distance as shown in Figs. 7 and 8.

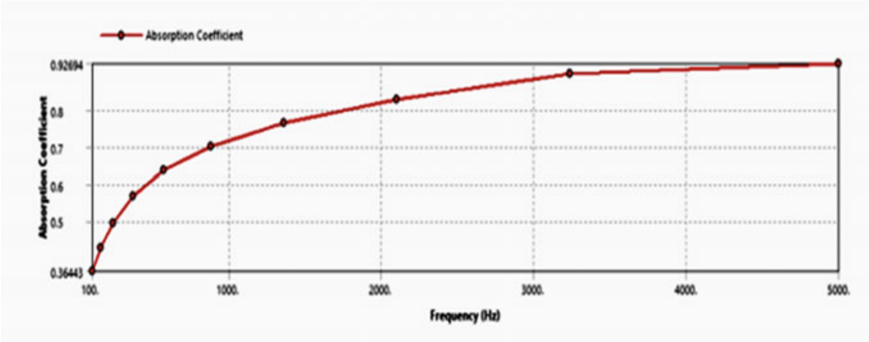

Fig. 6 Sound absorption coefficient

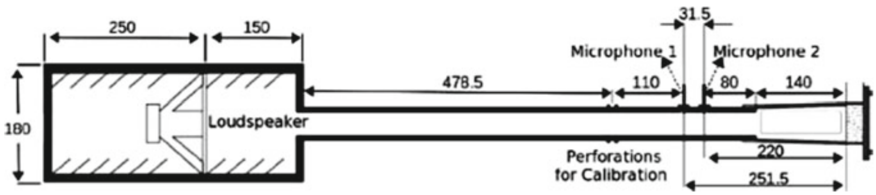

Fig. 7 Experimental setup

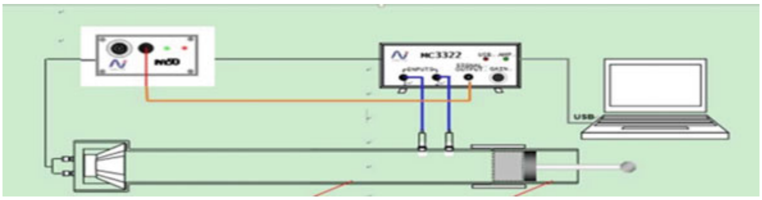

Fig. 8 Connections of testing

5 Results and Discussion

The result of experimentation of carbon fibre specimen for the harmonic acoustic and absorption coefficient. This study analyses the 3D fabric honeycomb and circular holes structure under certain boundary conditions, and in previous research, it has been found that honeycomb and circular structure improves the sound absorption performance in a better way than in solid structures. Sound waves are efficiently get reflected in cavity like structure. The sandwich structures are effective isolation provider for low frequencies. It is found that the porous material specimen showing great results for higher frequencies and the solid specimen of same material shows a good absorption coefficient for higher frequency. Specimen of carbon fibre having circular holes has absorption coefficient 0.7–0.88 for higher frequencies 5000–6000

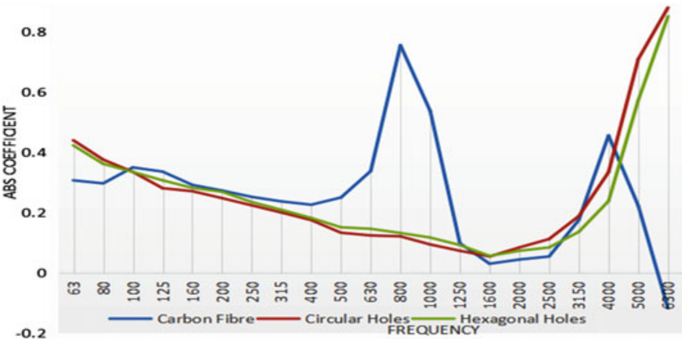

Fig. 9 Graph of sound absorption coefficient of carbon fibre with circular and hexagonal voids

Table 1 Absorption coefficient of different specimen

S. No.	Material	Frequency range (Hz)	Absorption coefficient
1	Carbon fibre	800 1000	0.756 0.538
2	Carbon fibre (circular)	5000 6000	0.881 0.71
3	Carbon fibre (hexagonal)	5000 6000	0.573 0.852

Hz which shown in Fig. 9. Specimen of carbon fibre having hexagonal holes has absorption coefficient 0.57–0.85 for higher frequencies 5000–6000 Hz. Comparison of absorption coefficient for different frequency ranges between carbon fibre, carbon fibre with circular and hexagonal voids as shown in Table 1. Experimental results as shown in Fig. 9.

6 Conclusion

In this paper, we investigated the fabricated 3D printed specimen testing in an impedance tube and its sound absorption coefficient has been calculated. The result shows the maximum sound absorption coefficient for higher frequencies. The sound absorption coefficient of different materials has been studied and carbon fibre with different geometry are tested in stand wave tube. The results of the analysis show the values of harmonic response and sound pressure level at different frequencies. Material properties and initial boundary conditions are applied under harmonic acoustic. It has been seen that the honeycomb and circular void structure are effective for higher frequency. By increasing thickness of material sound absorption increases for medium and high frequency. The highest sound absorption coefficient ranging from 0.85 to 0.88 was achieved by specimen and having good performance for higher frequencies ranging 5000–6000 Hz. It has been concluded from experiment that the frequency characteristics of specimen with voids are better to achieve sound absorption for maximum frequency range. Practically, we can use natural materials like coir, jute and carbon fibre solid specimen for low frequency range like muffler works in range of 63–500 Hz. Composition of carbon fibre and onyx material with different geometry can work for industrial noise range from 1 to 600 MH and carbon fibre with voids helps to manufacture casing of motor as its produce high frequency of sound.

7 Future Scope

- It also can used in a noise controlling duct in heating, ventilation and air conditioning (HAVC) system. Muffler is the best example of pipes, duct that can reduce the sound. Fundamentals used to develop the muffler are reflection of sound and dissipation of sound. Porous material is used to increase dissipation and thermal effect as they are converting sound into heat.
- We have practical experience for electric vehicle bike where we see that there is high frequency sound in motor. So we can make carbon fibre casing for motor which can absorb high frequency sound.

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