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RESEARCH ARTICLE

STUDY AND EVALUATION OF SOUND ABSORBING TREATMENT IN SILENCERS

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ABSTRACT

Sound absorbing materials can be used to attenuate sound travelling in ducts. Typically, sound absorbing materials are used to line the internal surfaces of ductwork or are used in splitters in packaged attenuators. A duct system was constructed to test various materials such as rockwool, polyurethane and polyisoprene where the expansion chamber that filled with these materials has different diameters 16, 20 and 24 cm. The acoustical parameter that evaluates the effectiveness of these materials are the sound attenuation, which can easily be measured and give a general idea of the frequency response of the silencer. In this study, the selective acoustic attenuation achieved through the use of different thicknesses of the material means that an innovative technique can be adopted for the design and construction of sound mufflers.

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INTRODUCTION

Acoustical material plays a number of roles that are important in acoustic engineering such as the control of room acoustics, industrial noise control, studio acoustics and automotive acoustics. Sound absorptive materials are generally used to counteract the undesirable effects of sound reflection by hard, rigid and interior surfaces and thus help to reduce the reverberant noise levels (Castagnede *et al*., 2000). They are used as interior lining for apartments, automotives, aircrafts, and ducts, enclosures for noise equipments and insulations for appliances (Alton, 2001). All noise control problem starts with the spectra of the emitting source. Therefore, sound absorbing materials are chosen in terms of material types and dimension, and also based on the frequency of sound to be controlled (Lee and Joo, 2004). There are many important factors that one should consider during studying sound attenuation in dissipative silencers such as the type of material used for the duct treatment, material thickness, density, perforation, hole diameter and environmental conditions (temperature) (Jdidia *et al*., 2014).

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Materials Specification and Configuration

In this research, different materials were used rockwool, polyurethane and polyisoprene rubber to determine the effect of thickness and temperature on sound attenuation. The three tested materials used in the measurements are identified in Table 1. A representative scanning micrographs for cells of materials appeared in Figure 1.

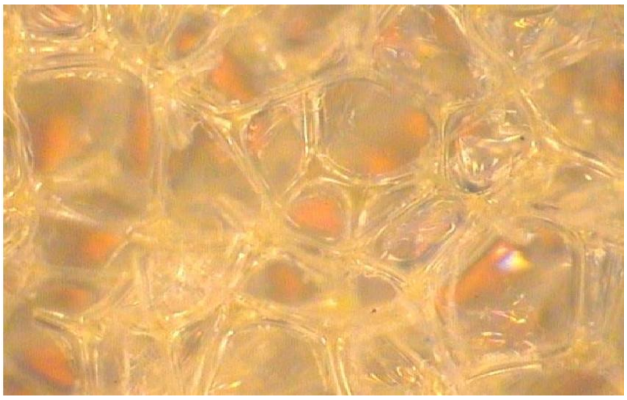
EXPERIMENTAL WORK

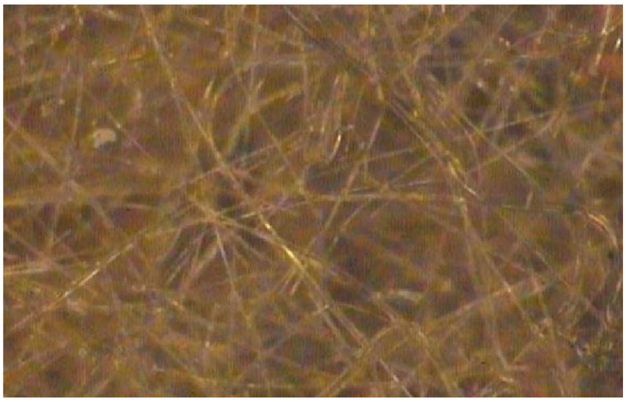
Sound Attenuation at Different Thickness

The experimental arrangement used to carry out the acoustic measurements on the designed silencer is shown in Figure (2). The first part of the measuring technique constructed from a source duct with 160 cm length and connected to the silencer with an outer cross section area of diameter 6 cm. A loudspeaker in a separate box connected to the source duct at one end of the tube, and excited by one third octave band signal through a power amplifier. Microphone probe from stainless steel at the other end is used to detect sound. The second part represents the tested silencer which consists of a perforated main duct and an outer expansion chamber with different diameters 16, 20 and 24 cm and length 50 cm. The expansion chamber was filled with different absorbing materials.

Table 1. The density of different materials

Material	Density (kg/m^3)
Polyurethane	14.0
Rock wool	150.0
Polyisoprene	100.0





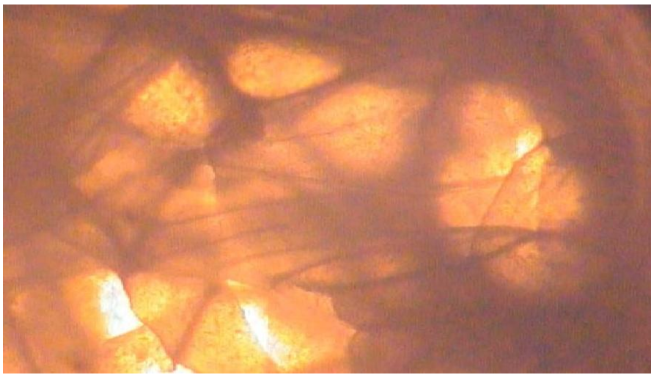


Fig. 1. Photographs of the micrographic surface construction of: (a) Polyurethane material (b) Rock wool material (c) Polyisoprene material

The perforation ratio of the main duct is about 30% from the total surface area of the perforated tube. Two different perforation hole radii are designed for the silencer to study the effect of hole radius on sound attenuation. The third part represents the receiving duct (Anechoic termination) to reduce sound reflection at the end of the tested silencer (it is 50 cm long). The probe measures the sound pressure levels just before and after inserting the tested silencer. The tested materials are rock wool, polyurethane and polyisoprene rubber with different thickness 5, 7 and 9 cm.

Sound Attenuation at Different Temperatures

The test arrangement used to carry out the sound attenuation measurements at high temperatures for different materials is shown in Figure (3). The first part represents the source duct (its length 160 cm). A loudspeaker is connected to the source duct and in order to avoid burning out the speaker, a water cooling system was installed at the end of the tube. The loudspeaker emitted with a white noise signals and amplified by a power amplifier (B & K 2717). The sound in the test section is measured by a 1/2 inch microphone, type 4182 that can withstands temperatures up to 700^{o}C. The sound pressure level in the measuring and receiving ducts was at least 10 dB above the background noise. The second part represents the test section which includes the heating unit; the temperature in that area can be regarded as uniform temperature. The third part represents anechoic termination to reduce sound reflection at the end of the tested sample. Two different materials (polyurethane and rock wool) were tested in the sound attenuation measurements. The samples were mounted between two heavy steel frames in the test section of the duct system.

RESULTS

Sound Attenuation at Different Thickness

Sound absorbing materials can be used to attenuate sound traveling in ducts. Typically, sound absorbing materials are used to line the internal surfaces of ductwork or are used in splitters in packaged attenuators. A duct system was constructed to test various materials such as rock wool, polyurethane and polyisoprene rubber.

Where the expansion chamber of the duct is filled with these materials with different diameters 16, 20 and 24 cm and the chamber length is 50cm. The acoustical parameter that evaluates the effectiveness of these materials are the sound attenuation, which can easily be measured and give a general idea of the frequency response of the silencer. In this study, the plane sound wave is the only wave that can propagate and so sound pressure is constant across the duct section. Accordingly, the microphone is used to measure the sound pressure level before and after filling the chamber with test sample. The sound attenuation ∇L of the silencer has been calculated from sound pressure measurements in the duct according to (Munjal, 1987);

$$\Delta L = L_{P1} - L_{P2} \qquad (1)$$

where L_{P1} is the spatial average sound pressure level in the frequency band in the test duct when the expansion chamber not filled with the material and L_{P2} is the spatial average sound pressure level in the frequency band in the test duct, when the test silencer is installed.

The average sound pressure level L_P has been calculated by measuring the sound pressure levels at three times by using the following relation (Munjal, 1987).

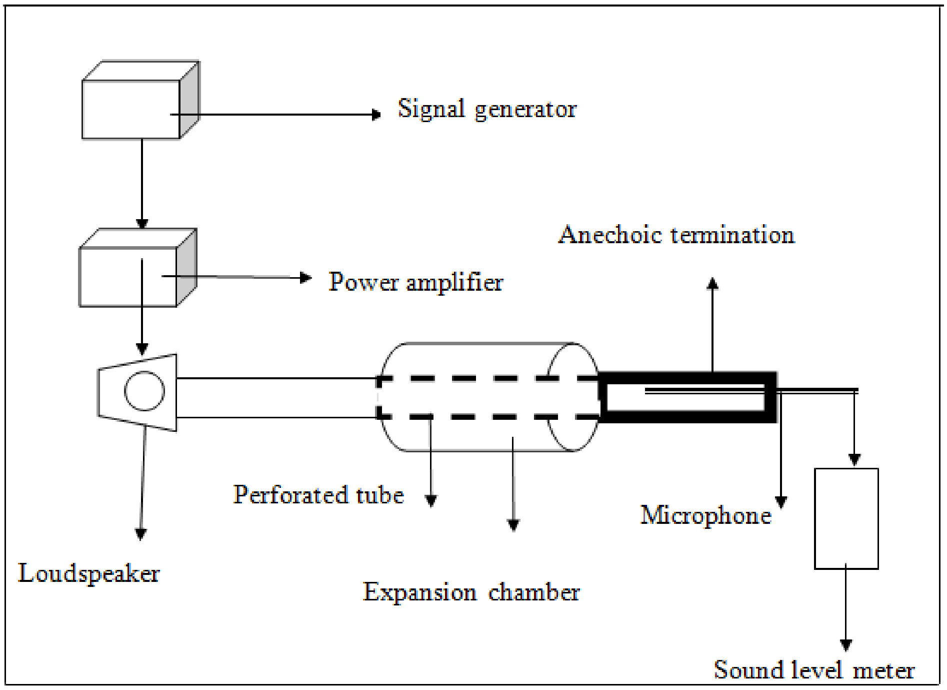


Fig. 2. Schematic diagram for the experimental measurement setup for sound attenuation at different thickness

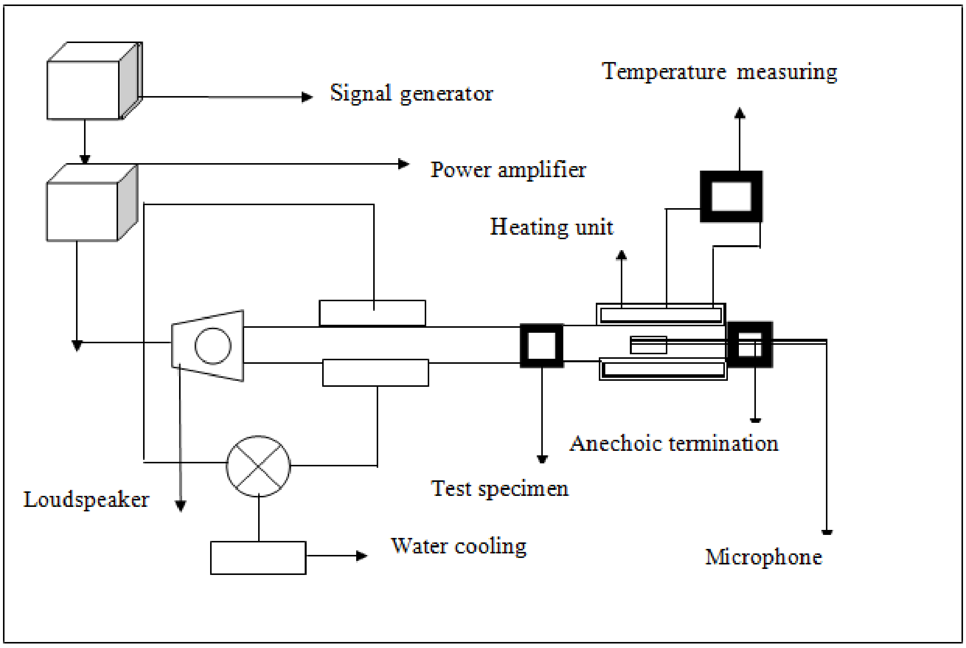


Fig. 3. Schematic diagram for the experimental measurement setup for sound attenuation at different temperatures

$$L_P = 10 \log \left[\frac{1}{n_m} \sum_{i=1}^{n_m} 10^{\frac{L_{Pi}}{10}} \right] \quad (2)$$

where n_m is the number of measurements.

Figures (4a), (4b) and (4c) show the sound attenuation for different materials rockwool, polyurethane and polyisoprene rubber against frequency at different thickness.

They illustrate that the sound attenuation increases as the thickness increase, which are expected, that attributed to the thickness effect. This means that, more of sound wave traveling in the absorber, however depending upon their air flow resistively of the absorbing material especially at low frequencies, the attenuation can be reach a point where further increase the absorber thickness yields no further benefit (Ray, 2013). These figures also indicate that, the maximum values for the sound attenuation are appeared at frequency 1000 Hz for rock wool and at 1250 Hz for Polyurethane and polyisoprene rubber. The levels are 57.2, 55 and 37.3 dB for thickness 9 cm, 47.2, 45 and 33 dB for thickness 7 cm and 40.5, 41.5 and 28 dB for thickness 5cm respectively and falling slightly in high frequencies. This can be due to the mismatch at the lining surface for high frequencies. This mismatch is due to the porous material and the perforated duct is approximated by complex acoustic impedance (Smith *et al*., 1995). The rockwool material shows the best acoustic attenuation behavior during this investigation.

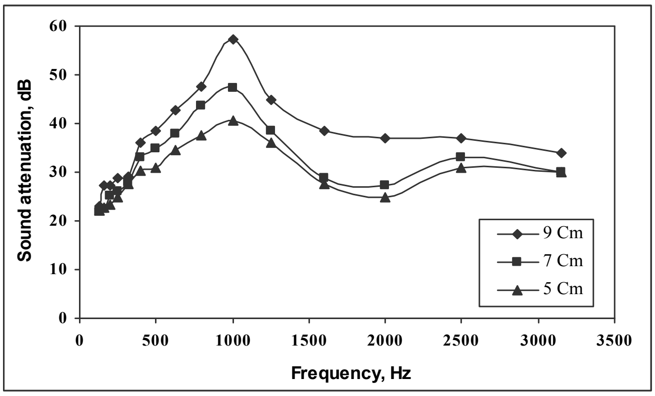


Fig. (4a). Sound attenuation for rockwool material at different thickness

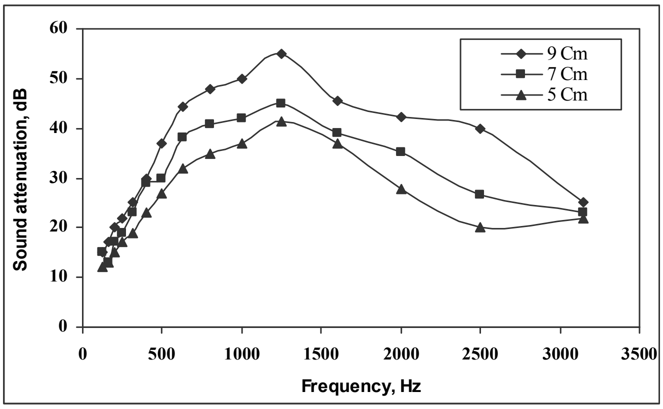


Fig.(4b). Sound attenuation for Polyurthane material at different thickness

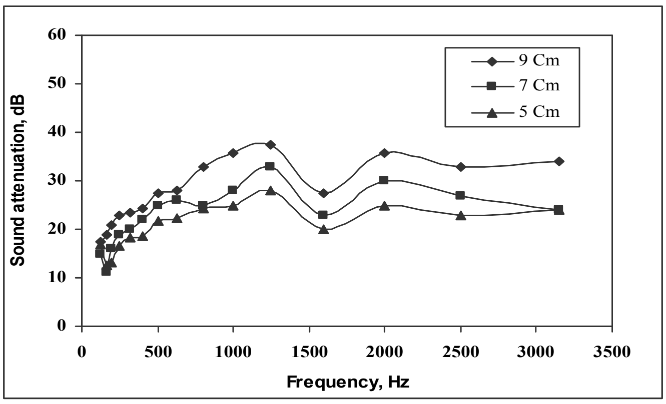


Fig.(4c). Sound attenuation for Polyisoprene rubber material at different thickness

Effect of Temperature on Sound Attenuation

Ventilation ducts and air conditioning heating are representing the sources of noise in commercial and industrial applications. So many industrial applications required an estimation of the acoustic performance of the duct silencers at high temperatures. Sound absorbing materials are the most important common used to attenuate noise. The used materials in this section are rockwool and polyurethane and we exclude polyisoprene rubber due to its low sound attenuation. Figures (5a) and (5b) show the sound attenuation measurements against frequency for rockwool and polyurethane materials at different temperatures, t = 20 ^{o}C, t = 80^{o}C, 140^{o}C and 200^{o}C. From theses figures we noted that the peak of sound attenuation has shifted to higher frequencies as temperature increases. This effect causes a reduction of the sound attenuation in lower frequencies as temperature increases. The observed changes are due to the porous materials are affected by temperature dependent phenomena (Jdidia *et al*., 2014; Gogate and Munjal, 1993). Where the acoustic impedance depends on the density and the sound velocity and these two parameters also depend on temperature. The density decreases with temperature when sound velocity increases with temperatures. And hence the sound attenuation decreases as temperature increases. Additionally the bandwidth of the attenuation peak changes with changing temperature and a definite trend is not obvious.

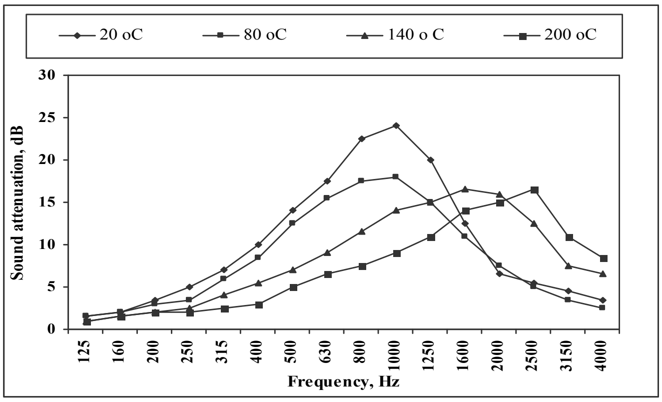


Fig. (5a). Sound attenuation for rockwool material at different Temperatures

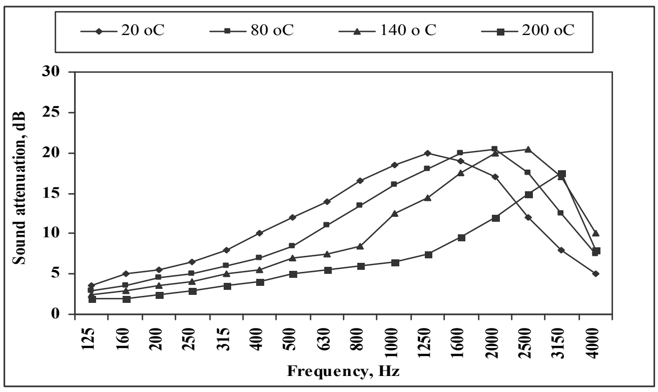


Fig.(5b). Sound attenuation for polyurethane material at different temperatures

Conclusion

This research presents experimental investigations for different materials such as rockwool, polyurethane and polyisoprene which are used for sound attenuation in dissipative mufflers. The selective acoustic attenuation achieved through the use of different thicknesses of the material. Rockwool material give the best sound attenuation in this research. This research also presents the effect of temperatures on these materials and show that the sound attenuation of these materials shifted to higher frequencies as the temperatures increase.

Overall, the research offers a good opportunity to select the appropriate configuration and geometrical parameters that give the required performance of such silencer type for a given application.

REFERENCES

Alton, F. 2001. "The master handbook of acoustics", 4th edition, New Yourk: McGraw-Hill.

Castagnede, B., Aknine, A., Brouard, B. and Tarnow, V. 2000. "Effects of comparison on the sound absorption of fibrous materials", Applied Acoustics, 61.

Gogate, G. and Munjal, L. 1993. "Analytical solution of sound propagation in lined or unlined circular ducts with laminar mean flow", *Journal of Sound and Vibration*, 160.

Jdidia, M. B., Akrout, A., Taktak, M., Hammami, L. and Haddar, M. 2014. "Thermal effect on the acoustic behavior of an axisymmetric lined duct", Applied Acoustics.

Lee, Y. E. and Joo, C. W. 2004."Sound absorption properties of thermally bonded nonwoven based on composing fibers and production parameters", *Journal of Applied Polymer Science*, 92.

Munjal, M. L. 1987. "Acoustics of Ducts and Mufflers", John Wiley and Sons, Inc., New York.

Ray, E. F. 2013. "Absorptive silencer design", Part VIII, Industrial Noise Series, June.

Smith, B. J., Peters, R. J. and Owen, S. "Acoustic and noise control", 2nd Edition, (1995)

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