Analyze the Sound Absorption Coefficient in PVC Impedance Tube

Mr. G. Vijayasekaran[a]
a, Assistant Professor,
Deparment of Mechanical Engineering
Gnanmani College of Technology,Namakkal,
Tamilnadu,India

Tinu Pappachan[b], Alagasan.S [c], Jagir Hussain. S [d]
b,c,d, UG Scholar,
Department of Mechanical Engineering,
Gnanamani College of Technology, Namakkal T
amilnadu, India

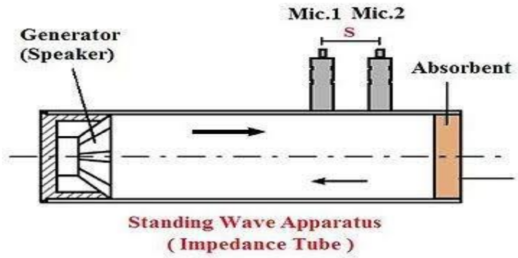
***Abstract*:- Traditional method of measuring sound absorption coefficient and sound transmission loss of acoustic material and treatments are time consuming and expensive. To overcome this limitation, normal incidence sound absorption and transmission loss measurement technique using an impedance tube was developed. Unfortunately this equipment is equally expensive. Using a calibrated acoustic sample, data obtained from the low-cost impedance tube were compared with those from a standard commercial tube with encouraging results. These include tube material, tube dimensions, frequency range, source transducer, pressure-microphones, sample and microphone holder, data acquisition and reduction technique.**

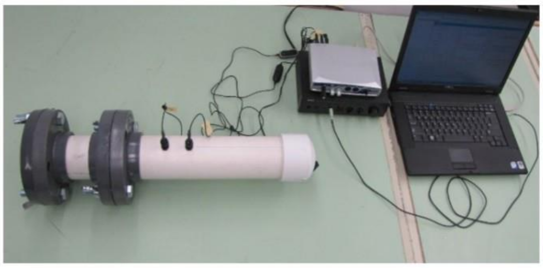
Keyword :- Microphone, speaker, test sample holder, fiberglass,

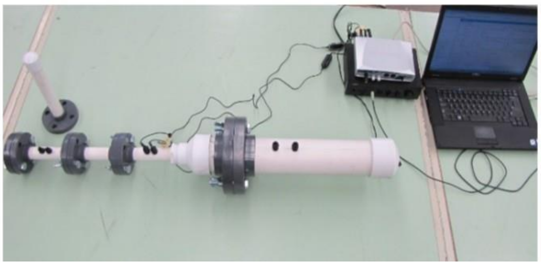
1. INTRODUCTION

Sound absorption is defined as the amount of acoustic energy dissipated in a material as a sound wave passes through it. The sound absorption coefficient (α) of a material is a dimensionless number valued between zero and one, over a range of frequencies, that represents a percentage of sound energy absorbed based on a unit area exposed to the sound. Figure 1 illustrates how an acoustic material reacts to impinging sound waves.

The incident wave impacts the face of the material, reflecting some of its energy and sending therest into the material. The energy sent into the material is either transmitted through the material,or absorbed within the porous structure of the material. The sound absorption coefficient is thesum of the percentages of sound that were not reflected. From Figures 1, the sound transmissioncoefficient, τ, is simply the ratio of the sound power transmitted through the material sample intoanother space to the sound power incident on one side of a material sample. Since some soundenergy will be lost when waves travel through the material's structure, it is evident that the soundtransmission coefficient will always be valued between zero and one.







ISSN: 2278-0181
ETEDM - 2019 Conference Proceedings

2.0 Development of the Low-cost Impedance Tube

2.1 Tube Diameter and Microphone Spacing

The tube is the most important functional as well as structural part of the apparatus. It supports the source at one end and supports a sample along with the sample holder at opposite end. Besides this, it governs the operating frequency range of the apparatus. For wider range of frequencies to be included for measurements, multiple size (diameter and length) tubes are required. The frequency range is defined as $f_l < f < f_u$, where f_l is lower working frequency limit and f_u is upper working frequency limit. The lower frequency limit is dependent on the spacing between the pair of microphones and accuracy of the measurement/analysis system. The rule of thumb suggests microphone spacing should be more than one percent of the wavelength of the lowest frequency of interest. The upper and lower limits of frequencies are defined as in equations below.

�<��
����<��
��

(2)

�> 0.01 �
����> 0.01 �
��

. (3)

Here K is tube factor. K = 0.586 for circular tube or K =0.5 for rectangular /square tube. The term c is speed of sound (m/s) in air.The term d is the inside diameter of the tube in meters while s is the distance between pair of microphones in meters. In many applications, frequency range from 100 Hz to 8000 Hz is usually considered for any material to be assessed based upon acoustical performance. The microphone spacing plays critical role in determining the lower cut off frequency of the tube as well. In this case, the microphone spacing is fixed by the lower usable frequency of a sound source. The speaker supports 80 Hz as the lowest frequency. Hence 50 mm of microphone spacing is generally used in large tubes (up to 100 mm diameter), while 20 millimeter spacing is used in smaller tubes having a diameter less than about 30 mm.

2.2 Test Sample Holder

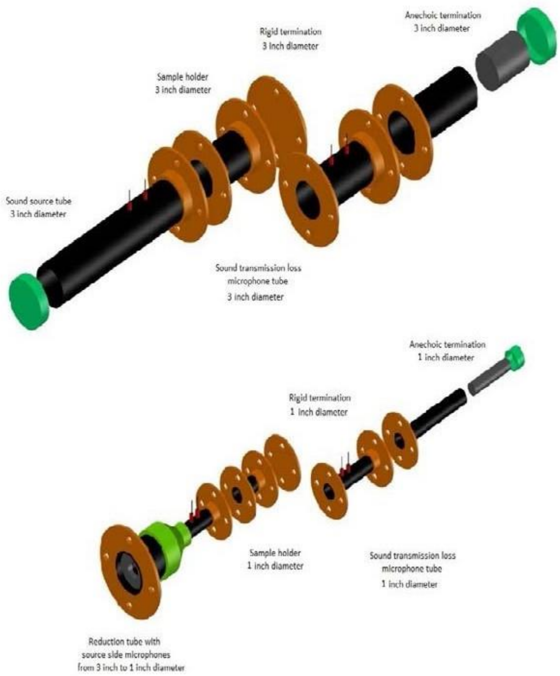
Sample holder plays critical role of aligning test piece in normal position to the direction of traveling planer wave. It is also made up of same cross sectional dimensions as the PVC pipe used in building the impedance tube on the source side. There are different ways to attach the sample holder to the main tube. Many ways including threading, quick release coupling require special machining adding to the cost of the apparatus. Connecting the tubes with standard flanges reduced the cost significantly. The standard flanges are readily available in the market with minimum conditioning required to be used for the desired purpose. Flanges provide easy way to secure the sample into place and make the assembly / disassembly simpler without adding more cost to the apparatus. The similar design and approach is implemented for both the tube sizes (large and small impedance tube with sample holders).

2.3 Sound Source and Microphones

Sound source is nothing but a speaker able to produce a planer wave of broadband noise in the interested frequency range. A full range cone driver (Dayton Audio ND65-8) with a flat frequency response over the desired frequency range was selected for the sound source. An anechoic backing is required on the back side of the source in order to avoid any reflected wave to interfere with the forward progressing plane wave. For measuring the incident and reflected waves, microphones are required to be positioned in such a way as to not disturb the plane wave generated, and be able to measure the sound pressure levels inside the tube. For this purpose, the microphones are mounted flush with the inner wall of the tube. The microphones should be removable, and the microphone holder should not allow any sound wave to leak into sounding environment in order not to degrade the quality of planer wave. The microphone selected was the low-cost Radio Shack Clip-on Omnidirectional studio microphone. Special care must be taken while selecting material and building the holder. To comply with all these conditions, a simple solution was to use nylon or metal reinforced nylon cable glands (traps used to secure cables in electrical devices).

2.4 Assembly

Various sections of tubes were cut to desired length and fixed with flanges using PVC sealant for air tight joints. It was made sure to flush mount all the mating parts in order to avoid any breakage in the tube continuity. Schematics and actual photographs of the complete apparatus and various sections can be seen in Figure 3.



2.5 DESIGN

Sound source is nothing but a speaker able to produce a planer wave of broadband noise in the interested frequency range. A full range cone driver (Dayton Audio ND65-8) with a flat frequen cerresponse over the desired frequency range was selected for the sound source. An anechoicbacking is required on the back side of the source in order to avoid any reflected wave tointerfere with the forward progressing plane wave. For measuring the incident of and reflecer waves, Microphones requiredtobepositioned in such a way as to not disturb the plane wave generated, and be able to measure the sound pressure levels inside the tube. For this purpose, the microphones are mounted flush with the inner wall of the tube. The microphones should move able, and the microphone holder should not allow any soundWavetoleakintosounding environment in order not to degrade the quality of planer wave. TheFor measuring the incident and reflected waves, microphones are required to be positioned in such a way as to not disturb the plane wave generated, and be able to measure the sound pressure levels inside the tube. For this purpose, the microphones are mounted flush with the inner wall of the tube. The microphones should be removable, and the microphone holder should not allow any sound wave to leak into sounding environment in order not to degrade the quality of planer wave. The microphone selected was the low-cost Radio Shack Clip-on Omnidirectional studio microphone.

Impedan ce Tube Part	**Part Description**	**Source**	**Quantit y (No.)**
Source (Speaker)	Dayton Audio ND65-8, 2.5" AL Full Range Driver	290-206 (**P***)	1
Microphone	Radio Shack Clip-on Omnidirection al Microphone	33-3013 (**R***)	**2**
PVC Tubes	Standard PVC Unthreaded Pipe (Size φ1'' & Size φ3")	48925K9 5 (**M***)	**5' Each**
Cable	PVC Cable Glands	PG-7 (**G***)	**6 Each**
Sound Card	External High Definition 2 Channel I/O Audio Card	Audiophi le 192 (A*)	**1**

3.0 VALIDATION STUDY

The custom built impedance tube and the measurement system chain is validated by comparingmeasured results with those measured from a commercial impedance tube using standardsamplesTheFor measuring the incident and reflected waves, microphones are required to be positioned in such a way as to not disturb the plane wave generated,. he commercial reference tube used is the industry standard Brüel & Kjær impedancetube type 4206. the period of time, we believe the impedance tube can be modified further with This apparatus uses two different tubes of 100 mm and 29 mm respectively forlow and high frequency ranges. Four different types of acoustic materials as shown in Figure 4

4.0 USE OF EDUCATION

Many universities in the emerging countries in Asia, South America or East Europe may not able to afford expensive acoustic laboratories to encourage students to actively pursue education experimental acoustics, noise and vibration. One of the reasons for this is the cost involved insetting up labs and purchasing instrumentation. The impedance tube developed in this study can be duplicated with limited resources. The demonstration, experimentation sessions will allowstudents to explore further studies in this field. This tube will help the school, colleges and universities to start new programs in acoustic and NVH (noise, vibration and harshness). Overthe period of time, we believe the impedance tube can be modified further with laboratorystandard microphones and measurements system to improve accuracy.

6.1 LITERATURE SURVEY

1. ASTM, ASTM C423-02a. Standard Method of Test for SoundAbsorption of Acoustical Materials everRooms,
2. American Society forTesting and Materials, Philadelphia, PAT 1972.
3. Barnard, A.R., Evaluation of measurement technologies to determine the acoustical properties of porous and multi-layered acoustic treatments,inMechanicalEngineering. 2004, Michigan Technological University
4. tLord, H., W.S. Gatley, and H.A. Evansen, Noise Control for Engineers. 1980, New York: McGraw-Hill Book Company.
5. ttp://scitation.aip.org/content/asa/stan dards 5. Fahy, F., Foundations of Engineering Acoustics. 2001: Elsevier Academic Press.

MATERIALS AND METHODS

¬ SPEAKER

¬ PVC TUBES

¬ FIBREGLASS AND COTTON SHODDY

¬ MICROPHONE(Radio shack clip on omnidirectional microphone)

REFERENCES

1. ASTM, ASTM C423-02a. Standard Method of Test for Sound Absorption of AcousticalMaterials in Reverberation Rooms, American Society for Testing and Materials,Philadelphia, PA, 1972.
2. Barnard, A.R., *Evaluation of measurement technologies to determine the acoustical properties of porous and multi- layered acoustic treatments*, in *Mechanical Engineering*. 2004, Michigan Technological University.
3. Lord, H., W.S. Gatley, and H.A. Evansen, *Noise Control for Engineers*. 1980, New York:McGraw-Hill Book Company. 4.http://scitation.aip.org/content/asa/standar ds
5. Fahy, F., *Foundations of Engineering Acoustics*. 2001: Elsevier Academic Press.
6. Chung, J.Y. and D.A. Blaser, *Transfer function method of measuring in-duct acousticproperties. I. Theory.* Journal of Acoustical Society of America, 1980. 68(3): p. 907-913.
7. Chung, J.Y. and D.A. Blaser, *Transfer function method of measuring in-duct acousticproperties. II. Experiment.* Journal of Acoustical Society of America, 1980. 68(3): p. 914-921.

8. Seybert, A.F. and D.F. Ross, *Experimental determination of acoustic properties using two-microphonerandom-excitation technique.* Journal of Acoustical Society of America,1977. 61(5): p. 1362-1370.
9. ASTM, ASTM E1050-98. Standard Test Method for Impedance and Absorption of Acoustical Materials Using a Tube, Two Microphones, and a Digital Frequency AnalysisSystemAmerican Society for Testing and Materials, Philadelphia, PA, 1972.
10. International Standards Organization (ISO), *Standard test method for impedance andabsorption of acoustical materials using tube, two microphones and a digital frequencyanalysis system*, in *E1050-12*. 2012.
11. International Standards Organization (ISO),*Standardtestnmethodformeasurement ofnormalincidentsound transmission of acoustical materials based on transfer matri method*, in *E2611-09*. 2009.
12.http://www.bksv.com/applications/materi altesting/acousticmaterialtesting