# AN INVESTIGATION OF SOUND ABSORBING MATERIALS IN MODIFIED IMPEDANCE TUBE

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***Abstract*** **- Noise control materials are used in passive noise control and are sensitive to different noise sources. The noise reduction characteristics of a material are studied using impedance tube. In this paper we studied the accuracy of the modified impedance tube. The sound absorption coefficient were calculated using two materials namely cotton felt and Polyurethane Foam in two different impedance tubes, existing impedance tube and an modified impedance tube for a frequency range of 80Hz to 1600Hz. Sound absorption coefficient of both the materials were measured. The difference in valus of the existing tube and modified tube were studied and error in the reading of the modified impedance tube has been calculated.**

***Index terms*** **– Impedance Tube, Sound Absorption Co-efficient, sound absorbing materials.**

## I. INTRODUCTION

Characterization of noise absorbing materials, like wool or polymer foam, in the context of building or transport applications, need the evaluation of acoustic and nonacoustic (or macroscopic) properties of those materials. According to Olivier Doutres the acoustic properties evaluate the sound absorbing efficiency of the material, whereas the nonacoustic properties help to predict the material acoustic response in various industrial applications by the using an appropriate model [1]. Various materials are used for this purpose, namely Polyurethane Foam, Felt fabric either cotton or wool, coir etc. The sound energy absorbed by a material when the sound waves incident on it is called its sound absorption co-efficient. It is represented by 'α'. The value of Alpha (α) varies between 0-1, '0' means non of the incident sound energy is absorbed by the material while '1' represents that all the incident sound energy is absorbed. The equipment used to measure the absorption co-efficient of the material is called impedance tube. We measured the sound absorption co-efficient of a few sample materials in the existing tube and modified tube. The readings were compared and the error in the reading was calculated.

## II. IMPEDANCE TUBE

The impedance tube is equipment used to measure the sound absorption of the material. This helps to confine the propagation of sound in just one direction i.e. from source to the sample material. Thus the three-dimensional wave equation is reduced to one dimensional wave equation. The design specifications of the impedance tube are given by ASTM E-1050 and ISO 10534 standards [2] . It has loud speaker at one end and sample holder with rigid determination at other end. The microphones are placed between the loud speaker and the sample. The loud speaker is driven by signal source and one dimensional wave carries the sound energy towards the sample. The standing waves are produced inside the tube due to the cylindrical construction of the impedance tube. The material placed at the other end absorbs sound energy based on its absorption co efficient .a standing wave pattern is formed by the reflected back remaining waves.

## III. EXPERIMENTAL SETUP

The impedance tube can be used to find the sound absorption coefficient of the given sample material. The experimental setup consists of a signal generator connected to the speaker at one end of the impedance tube as shown in **Fig. 1** .Required sound frequency and be set in the signal generator to find the sound absorption co-efficient of the material for that frequency. Sound waves are generated in the impedance tube through the speaker mounted inside it. The sample about six inches in diameter [3] is placed at the other end of the tube. The tube has a rigid termination behind the sample holder so that the incident sound waves are reflected back. A microphone is placed in the impedance tube to measure the intensity of the incident and reflected wave. The microphone is connected to the data acquisition system which is fitted with a pre-amplifier. The amplified signals are then connected either to a CRO or spectrum analyzer .

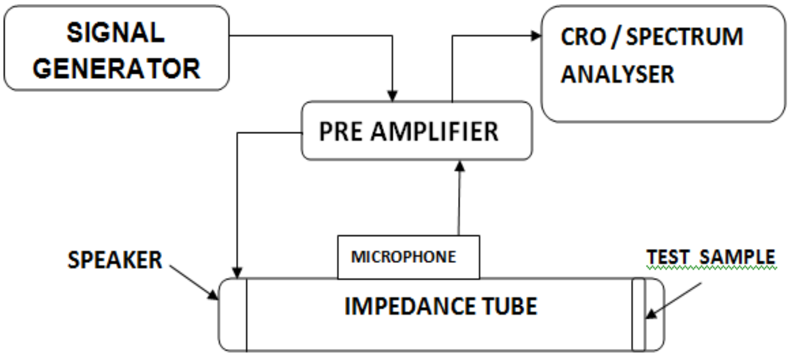


**Fig. 1. Experimental setup**

## IV. SAMPLE

Two samples used for the experiment namely

1. Cotton Felt (HMCCP) 10mm + PVC 3mm
2. NWF + FR PUF 80/25

***Sample Properties***

*Cotton Felt (HMCCP) 10mm + PVC 3mm*

**Fig. 2 Sample of Cotton Felt**

Felt is a textile that is produced by matting, condensing and pressing fibres together. The composite setup helps absorb sound of higher frequencies [4].The most dimple of these is to apply heat and moisture to the blended fiber which cause them to bind together well. Felt can be made of natural fibres like wool and cotton or artificial fibbers like acrylic. While the manufacturing/felting process of different materials is different [5]. There are different types of felt, some are soft **Fig. 2** , while some are tough. Felt has varying fibre content, density and colour depending on the nature of use. Natural fibers/ materials are desirable since they are cheaper, non-abrasive and renewable [6]. It comprises inter-curled and entangled cotton textile-length fibbers having artificially induced twists and bends. The fibres of the material are entangeled with each other so that it increases the mutual frictional engagement of the fibres and hence the tensile vigor of the material.

*NWF + FR PUF 80/25*

Non-Woven Fabric + Fire Resistant Polyurethane Foam with a density of 80kg/m$^3$ and thickness of 25mm. The polyurethane (PU) foam **Fig. 3**, are widely used as insulating and core materials for furniture, cooling and freezing systems, in house building, shipbuilding etc. The density and other mechanical properties of PU foams are given by various ISO standards [7] The PU foams have been applied also as core materials of sandwich constructions with steel plates, in building the industrial houses, warehouses, sport houses, fruit stores, carrying freezers and cold stores, where they have to do insulating [7].

**Fig. 3** Polyurathane Foam Sample

Long, flexible segments, contributed by the polyol, give soft, elastic cross linking polymer. High amounts of give tough or rigid polymers. Long chains and low cross linking give a polymer that is very stretchy, short chains with lots of cross links produce a hard polymer while long chains and intermediate cross linking give a polymer useful for making foam. In some respects a piece of polyurethane can be regarded as one giant molecule. One consequence of this is that typical polyurethanes do not soften or melt when they are heated, they are thermosetting polymers. The choices available for the isocyanates and polyols, in addition to other additives and processing conditions allow polyurethanes to have the very wide range of properties that make them such widely used polymers. PU are thermoplastic and thermoset in nature. The type, position, and structure of both the isocyanate and polyol determine the progress of PU forming reactions as well as their properties and end-use applications.

## V. TEST RESULT

The two sample materials have been tested for their sound absorption co-efficient in the modified tube and the existing tube and the test result have been discussed below.

***Result Discussion***

Table. 1. NWF + FR PUF 80/25 (Production)

| FREQUENCY (Hz) | EXISTING TUBE (α) | MODIFIED TUBE (α) | ERROR (%) |
|---|---|---|---|
| 80 | 0.039 | 0.045 | **2.3** |
| 100 | 0.057 | 0.049 | **1.9** |
| 125 | 0.074 | 0.066 | **1.16** |
| 160 | 0.116 | 0.109 | **0.36** |
| 200 | 0.168 | 0.160 | **0.22** |
| 250 | 0.235 | 0.228 | **0.08** |
| 315 | 0.304 | 0.295 | **0.08** |
| 400 | 0.409 | 0.400 | **0.04** |
| 500 | 0.541 | 0.512 | **0.28** |
| 630 | 0.703 | 0.694 | **0.02** |
| 800 | 0.805 | 0.800 | **0.003** |
| 1000 | 0.699 | 0.725 | **0.13** |
| 1250 | 0.574 | 0.562 | **0.04** |
| 1600 | 0.458 | 0.450 | **0.03** |

**Table 1** shows the sound absorption coefficient of Polyurethane Foam material. It can be seen that PU has better sound absorption properties at higher frequencies. The readings are taken in both existing and modified tube and percentage error has been calculated.

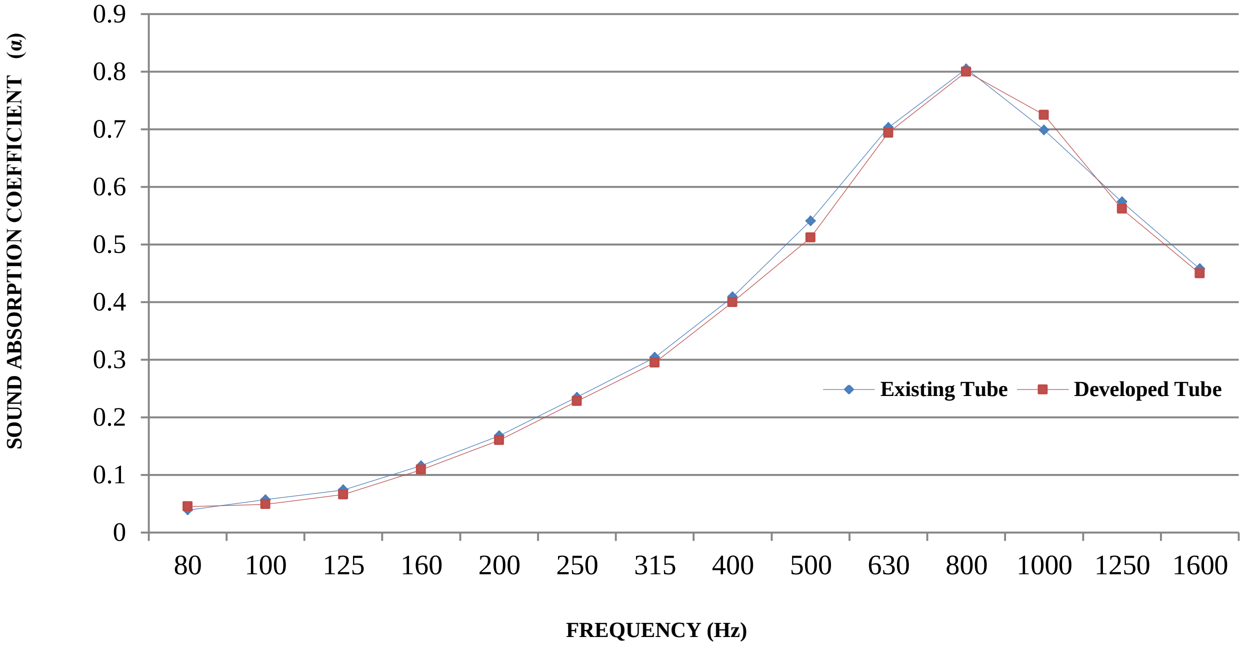


**Fig. 4** Existing tube (vs) Modified Tube (PU Foam)

**Figure 4** graphically represents the deviation in the sound absorbtion co-efficient reading taken in the modified and existing tube of the material against the preset frequencies. Average error is around 0.33%

Table. 2. Cotton Felt (HMCCP) 10mm + PVC 3mm

| Frequency (Hz) | EXISTINGN TUBE (α) | MODIFIED TUBE (α) | ERROR (%) |
|---|---|---|---|
| 80 | 0.037 | 0.029 | **4.6** |
| 100 | 0.039 | 0.032 | **3.2** |
| 125 | 0.032 | 0.025 | **4.78** |
| 160 | 0.035 | 0.028 | **4** |
| 200 | 0.039 | 0.030 | **4.9** |
| 250 | 0.054 | 0.048 | **1.2** |
| 315 | 0.083 | 0.076 | **0.7** |
| 400 | 0.138 | 0.130 | **0.33** |
| 500 | 0.224 | 0.216 | **0.12** |
| 630 | 0.214 | 0.220 | **0.07** |
| 800 | 0.198 | 0.192 | **0.09** |
| 1000 | 0.208 | 0.200 | **0.14** |
| 1250 | 0.259 | 0.252 | **0.07** |
| 1600 | 0.320 | 0.312 | **0.06/2.5** |

Table. 2 shows the sound absorption coefficient of Cotton Felt material. It has been observed that for cotton felt material the sound absorption increases with increase in frequency. Average error between the readings is 1.8% .

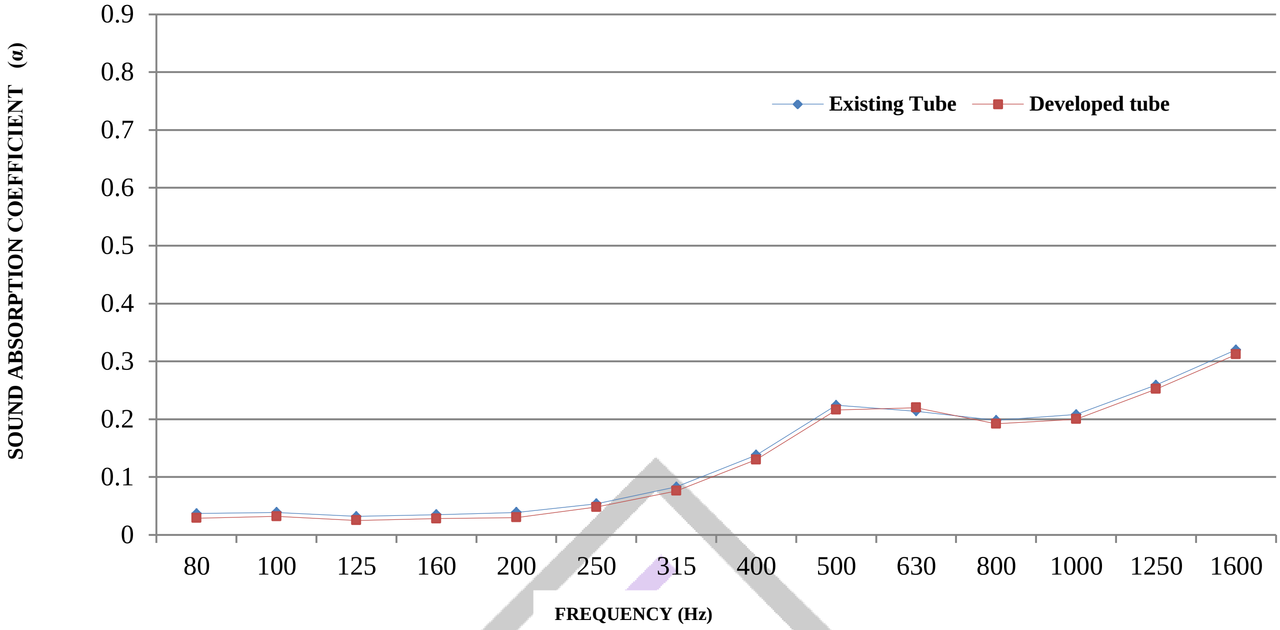


**Fig. 5. Existed tube (vs) modified tube (Cotton Felt)**

**Figure 5** shows a comparison of the sound absorption of the two materials.

## VI. CONCLUSION

The sound absorption co-efficient of both the materials, Polyurethane Foam and Cotton Felt, are taken in the modified and existing tubes. Average of 3% Error has been calculated for the modified tube compared to the existing impedance Tube. From the readings it can be observed that error in the modified tube tends to be higher at lower frequencies under 200Hz.

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