

# ANALYSIS AND EXPERIMENTAL INVESTIGATION OF SOUND ABSORBING MATERIALS FOR INDUSTRIAL NOISE CONTROL

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**Abstract:** These days, noise pollution is a major issue that affects the environment. The high amount of noise present in the industries has adverse impact on the workers, operators and people associated in those fields. The consequences could be as hazardous as heart attack or even lifelong hearing loss. Sound absorption through barriers, mufflers are some popular fields of study. Some natural extracted materials show impressive SAC at lower and mid frequencies. Moreover, natural materials usage in this field is being popular as they emit almost zero amount of greenhouse gases and their manufacturing process requires a little amount of energy to process for ready to usage. A galvanized steel pipe as the impedance tube was chosen because it is cheaper than the impedance tube available in the market. We have tried to measure sound absorption coefficient of some combinations of different materials as an acoustic barrier material.

**Keywords:** Natural porous materials, Sound absorption coefficient, Impedance Tube, Galvanized steel tube, Material combination

## 1. INTRODUCTION

The introduction of toxins into the environment that have a negative impact on it is known as pollution. Chemicals or material, such as sound, heat, or light, can be pollutants. Both naturally occurring contaminants and imported substances/energies can be considered pollutants, which are the elements of pollution. Point source and nonpoint source pollution are two common categories for pollution. According to V. D. Asimakopoulos et al. 9 million individuals worldwide lost their lives to pollution in 2015 [1].

In many developing countries, noise pollution from residential generators is a growing environmental problem. Salehin S. et al. in their article has measured 70-97 dBA ranged industrial acoustics in a typical industrial area in the South-Eastern region of Bangladesh [2].

According to the research, neighborhoods with a high concentration of people and low income contribute most in noise pollution. Industrial noise is a topic of interest of scientist from the time of ancient Rome. There are generally two widely accepted method of measuring normal incidental sound absorption coefficient certified by ISO 10534-1 and ISO 10534-2 denoting the acoustical absorption co-efficient and transfer function respectively [3, 4].

The second method states about transfer function theorem which utilizes reflection co-efficient of waves. According to Bhattacharya & Bihola, transfer function is more suitable than any other method as it integrates the differential parts of a propagated wave [5]. They had used pyrax glass impedance tube apparatus reflecting an

idea that uses various materials as the impedance tubing and measured the acoustics of lower ranged systems and found about 89.67% of more effectiveness rather than expensive setup. The factors along selecting sound absorbing natural material Nordin et al. quoted properties like toxicity, fiber size, density and porosity. Considering the properties and costing, natural materials cotton, jute fiber and saw dust was selected.

## 2. METHODOLOGY

In this research transfer function method has been introduced for impedance measurement of tubing arrangement. This is a method which utilizes two microphones which are fixed at two designated distant point (at distance  $x$  and  $x+S_0$ ). Those two microphones act as acoustic sensors measuring constant sound intensity which afterwards is converted to a control transfer function which can be reduced to incidence absorption co-efficient. Figure-1 depicts the graphical representation of the possible system setting for measurement of acoustic co-efficient. Here the frequency range is determined by the radius of the impedance tube and the distance between the two microphones. The incidental reflection factor can be determined using eqn. 1:

$$R = I_r/I_i \quad (1)$$

Where,  $R$  is the reflection co-efficient without an unit,  $I_r$  and  $I_i$  are the Intensity of reflected and incidental wave respectively.

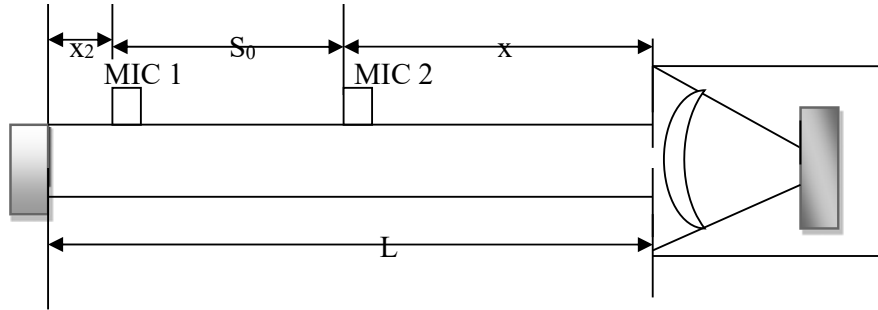


Figure 1. The impedance tube schematics

The sound absorption coefficient can be calculated as:

$$\alpha = 1 - |R|^2 \quad (2)$$

Apart for the microphone in the tube, the impedance tube must be straight with a consistent cross-section and smooth, nonporous wall without holes. The tube wall thickness was chosen such that it would not be driven to vibrate by sound and would not exhibit vibration resonances within its operating frequency range. Tubes of various diameters and lengths are needed in order to measure a larger range of frequencies. In order to explore the sound absorption coefficient at a wide range of frequencies, a tube with 100mm and 30mm was designed. The frequency range is specified as follows:

$$f_u < \frac{0.58 \times \text{the speed of sound (m/s) in the air}}{d} \quad \text{or} \quad d < \frac{0.58 \times \text{the speed of sound (m/s) in the air}}{f_u} \quad (3)$$

$$f_l < \frac{0.01 \times \text{the speed of sound (m/s) in the air}}{S_0} \quad \text{or} \quad S_0 < \frac{0.01 \times \text{the speed of sound (m/s) in the air}}{f_l} \quad (4)$$

$$S_0 < \frac{0.45 \times \text{the speed of sound (m/s) in the air}}{f_u} \quad (5)$$

Here, 'd' is the inner dia of tubing,  $S_0$  is the space between the sensors

The distance between the sound source and first point of sensing,

$$x > 3d \quad (6)$$

The distance between the test sample and second point of sensing,

$$x_2 \geq 2d \quad (7)$$

$$\text{Total Length, } L = x_2 + x + S_0 \quad (8)$$

The diameter of the microphone,

$$d_{mic} < 0.2 S_0 \quad (9)$$

Based on the experimental setup, the values of d,  $S_0$ ,  $x_2$ , x and L are 110 mm, 415 mm, 215 mm, 320 mm and 950 mm respectively. Those values are selected by studying reference no.

### 3. EXPERIMENTATION AND TESTING

4Ω12W of model C2976B speaker was selected as sound source. Amplifier circuit was attached with it and frequency was generated through 3.5mm wired plug. With each condenser microphones, preamplifier circuits were attached and signal was analyzed in UNIT UTD2102CEXa high bandwidth of 100MHz and a large sample rate of 1GSa/s. As per Figure 2 assembly was done. It required modification in the sections like

speaker holding box and sample holder. The speaker holding box was wooden and rigid to operating frequency and sound waves. Sample holder was created with 5 mm thick PVC pipe and backed with steel plate. PVC pipe inner diameter was machined up to the outer diameter of the impedance tube and the backplate fitted firmly inside the sample holder with no air gap left.

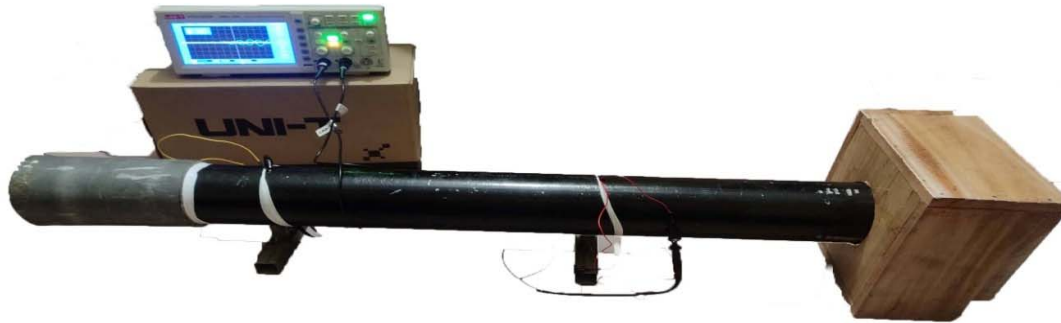


Figure 2. Impedance Tube assembly with all components

To keep the assembly air tight, Teflon tape was used. The joints and mountings which are removable was tightly sealed with Teflon tape.

Table 1. Sample properties

| Sample name         | Sample Diameter (cm) | Sample length (cm) | Sample weight (gm) | Pure Material in % | Figure                                                                                |
|---------------------|----------------------|--------------------|--------------------|--------------------|---------------------------------------------------------------------------------------|
| Sample 1 (Cotton)   | 11.9                 | 2.5                | 192                | 70                 |   |
| Sample 2 (Saw Dust) | 11.9                 | 2                  | 280                | 71.5               |  |
| Sample 3 (Jute)     | 11.9                 | 2                  | 280                | 71.5               |  |

### 3.1 Determination of Absorption coefficient in Simulating Environment

To determine the absorption coefficient of the specimen The Harmonic Acoustics Analysis System has been done. In this system both the Structural and Harmonic analysis of a material can be done. In Engineering Data, the Delany Bazley Model has been included for every material to be analyzed.

For Saw dust, Jute fiber and specimen the input value was Fluid resistivity with respect to Frequency. The value was

given at descending order as the frequency increases the acoustic pressure level increases which decrease the value of Fluid flow Resistivity. Moreover, the other material properties have also been included into the Engineering Data.

### Geometry

The geometry has been kept basic in structure to avoid contact body errors and an enclosure was set as the replacement of Impedance Tube.

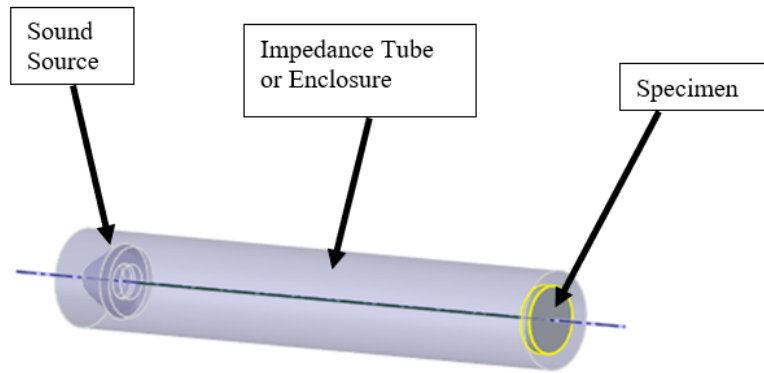


Figure 3. Space claim Geometry

#### Acoustic Pressure

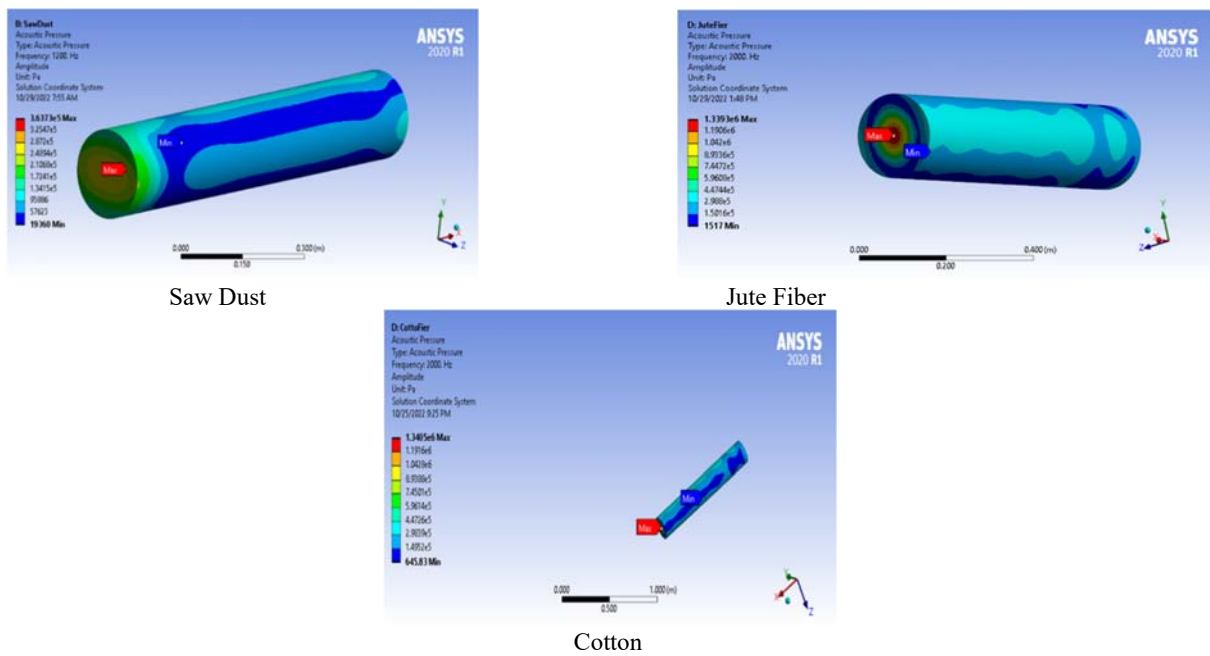
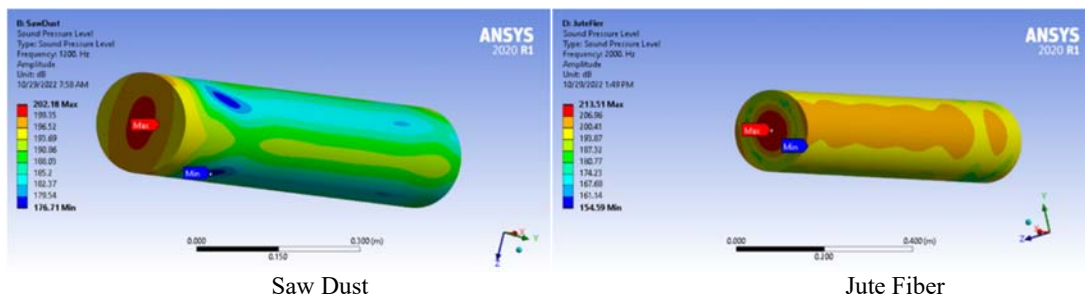


Figure 4. These figures show different acoustic pressures on impedance tube

Different colors show amount of intensity. Lighter color indicates lesser intensity whereas, darker color shows higher intensity.

#### Sound Pressure Level



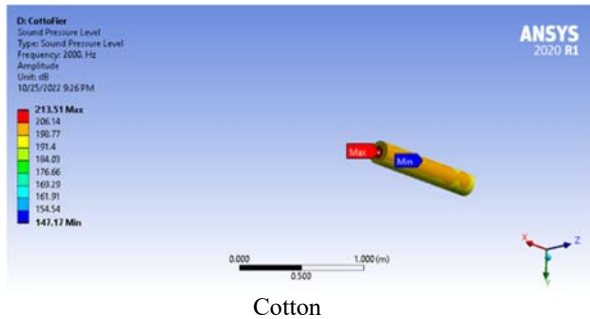


Figure 5. These figures indicate different sound pressure levels on the impedance tube

The sound pressures are higher close to the source and have different impacts on different regions of the impedance tube.

#### 4. RESULTS AND DISCUSSIONS

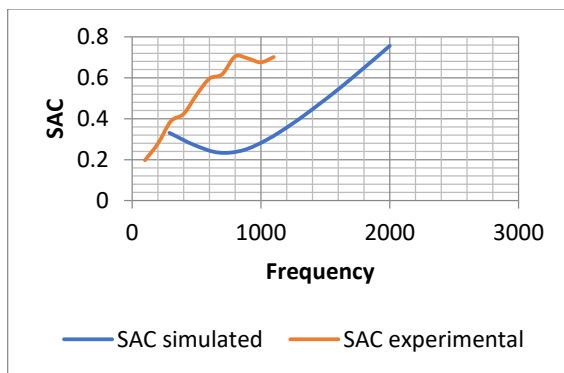


Figure 6. Frequency vs SAC for Saw Dust sample

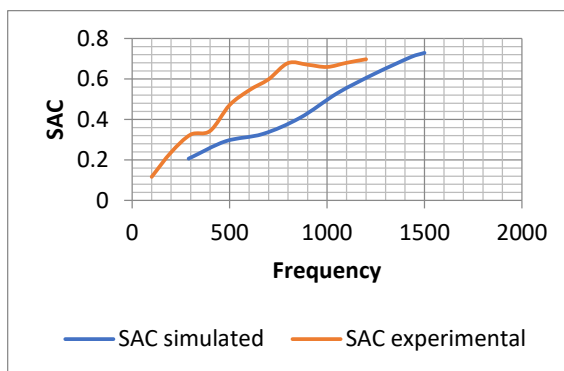


Figure 7. Frequency vs SAC for Cotton sample

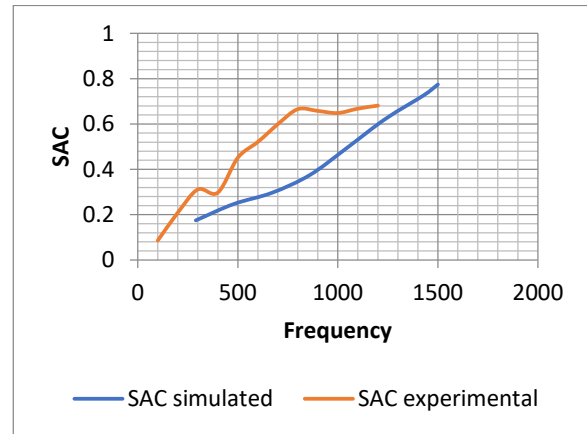


Figure 8. Frequency vs SAC for Jute Fiber Sample

Eva LABAŠOVÁ and Rastislav ĎURÍŠ et al. tried two layers of polyurethane in their research [11]. It inspired to analyze the different combinations.

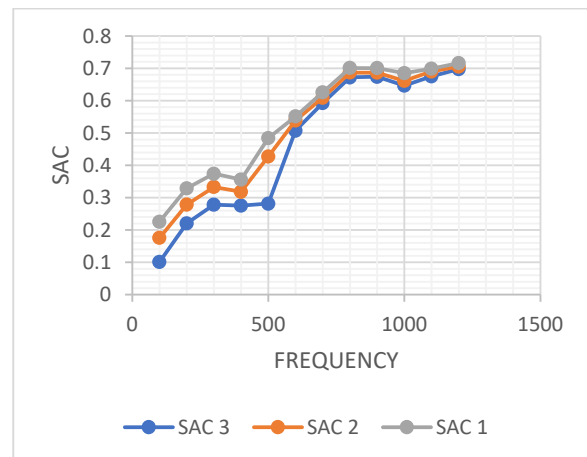


Figure 9. Frequency vs SAC for SAC1, SAC2, SAC3

SAC 1 curve denotes the orientation- Material orientation of Cotton, Jute fiber and Saw dust  
SAC 2 curve denotes the orientation- Material orientation of Cotton, Saw Dust and Jute Fiber  
SAC 3 curve denotes the orientation- Material orientation Jute fiber, Saw Dust and Cotton

The Graphs show that the best orientation of these three specimens will be the Cotton, Jute fiber and Saw dust. In this orientation the sound will impede first on the cotton surface, some of the sound will be propagated, some will be absorbed and then the transmitted wave will propagate to the next panel.

#### 5. CONCLUSIONS

The maximum SAC obtained from the experiment was **0.716444** and it was from the orientation of cotton, jute fiber and saw dust. There are some deviations in the graphs has been noticed. The reasons behind the deviations are, the lower sensitivity of the microphones,

some random noise coming out of environment, speaker amplifier circuit was not efficient enough to generate maximum output from the speaker.

Sealing of the impedance tube may leak in some situations. There may be some gap between the sample combinations. A function generator can help to produce steady signals.

Our test shows that the usage of natural fiber is far more effective and ecofriendly than the conventional synthetic materials.

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