FINAL PROGRESS REPORT

DEVELOPMENT OF SOUND PROOFING COMPOSITE MATERIALS USING JUTE PRODUCTS

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National Jute Board
Ministry of Textile
Govt. of India
3A, Park Plaza
71, Park Street
Kolkata-700016

Mechanical Engineering Department
and
Materials Science Centre
Indian Institute of Technology, Kharagpur
Kharagpur 721302
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1. Objectives of the Study

The importance of usage of natural composites in various field applications is increasing. In noise control, novel sound proofing materials based on the natural fibre have good potential for engineering applications. The usage of these sound proofing materials is still subjected to certain limitations in terms of effectiveness sound proofing properties and other important properties such as physical and flammability. One needs to investigate effective sound proofing materials for noise reduction.

Is jute a sound proofing material? To know the answer, the present study is focusing on the evolution of the acoustical properties of the jute and also their application on the noise reduction of the domestic home appliances and building acoustics. The objective of the present studies as follows:

a) Evaluation of physical and flammability properties of developed sound proofing material.

b) Evaluation of acoustical properties (NRC and STC) of chemically modified jute materials (Fibre, Felt and Composites).

c) Pilot trials done on household appliances like vacuum cleaner, washer/dryer to study the reduction in radiated sound power.

d.) Pilot trials in architectural applications.

2. Sample Preparation (Product Development)

Different forms of jute; jute felt, jute fibre (TD4 and TD5) and jute composite were used for physical, flammability and acoustical tests. TD4 and TD5 are the two different grades of the jute fibre among these TD5 is quality wise slightly better than TD4.

2.1 Fabrication of NR (natural rubber) latex jute composite

6” × 6” jute felt (400 gsm) specimens were dried in oven for 1hour to remove the water content in specimen. 10 pieces of this jute felt were treated with 1% NaOH (alkali) solution for 1 hour. This alkali treatment is used for to remove the impurities in specimens. These alkali treated jute felts were again washed by water till alkali free. It was tested by pH paper to check the neutrality. The washed jute felts were dried for again 1 hour in an oven at 80^0C. The dried felt was treated with 1% (by volume) natural rubber solution for 1 hour. Excess rubber latex was drained off and the rubber treated jute felts were dried in atmosphere for 1 hour. Jute rubber latex composite was prepared by pressing ten pieces of rubber treated jute felts in a hydraulic press at 140^0C with a pressure of 8 ton for 15 min. Similarly 2.5% natural rubber, 5% natural rubber and 10% natural rubber jute composites were prepared keeping all other parameters same. In the sample preparation, natural rubber was used as bonding agent between interfaces of the fibres. The 5% NR latex jute composite specimen provided the optimum bonding properties which is feasible for the tests. Fig. 1 shows the 5% NR Latex Jute Composite specimen.

Figure 1: 5% NR Latex Jute Composite

2.2 5% Natural rubber (NR) compounding

The solid content in natural rubber is 50 gm per 100 ml of natural rubber latex. So 200 ml of this latex having 100 gm of natural rubber requires the following in gradients with the mentioned amount for compounding.

Table 1: Ingredients of natural rubber latex

Sl. No	Chemical	Mass (gm)
1	2-Mercaptobenzothiozole (MBT)	1.0
2	1-Napthalene Sulfonic Acid	1.0
3	Sulfur powder	1.0
4	Gelatin	0.2
5	Zinc stearate	1.0

First of all these ingredients were mixed properly in a mortar and a pestle in 20 ml of distilled water. This paste was mixed with 200 ml of natural rubber latex. Then a magnetic stirrer stirred the above mixture for 4 hour. Finally compounded latex was obtained from which diluted compounded natural rubber latex having 5% rubber content was made by dilution with water.

Table 2: Weight of rubber content of sample

Sample	%NR in latex used	Weight of the sample (gm)	Rubber content in sample (%)
1	1	75.75	1.78
2	2.5	76.25	2.03
3	5	77.42	2.94
4	10	100.12	25.00
5	15	96.39	21.87

Table 2 shows the significance of the percentage of the natural rubber in jute composites samples. By increasing the percentage of the natural rubber content, the bonding between fibres of jute increases. On the other hand, the weight of the sample is also increasing. 5% NR latex jute composite gives the optimum bonding with respect to weight of the sample.

Out of these sample, normal specific sound absorption tests were carried out on cylindrical jute fibre TD4, alkali treated jute fibre (TD5), jute felt and natural rubber latex jute felt whereas physical, flammability and sound transmission class tests were attempted on natural rubber latex jute felt composite (NR latex jute composite).

3. Measured Properties of Jute

To know the potential application of any material, it is necessary to measure the properties of the jute. For measuring the properties of jute, preliminary knowledge on characteristics of jute are essential. By knowing the physical properties, one can judge the effects of the environmental conditions on the material. In addition, in the domestic and industrial application, it is necessary to have knowledge on flammability properties of material under working condition, Furthermore, based on the acoustical properties, one can distinguish whether jute is a good sound proofing material or not. In this chapter, initially different types of samples were prepared to measure the properties of jute. The physical, flammability and acoustical properties were measured for the different types of jute samples as per standards.

3.1 Characteristics of jute fiber and felt

(a)  **(b)** 

Figure 2: (a) Jute fibre and (b) jute felt samples (50 mm x 35 mm ϕ)

Two different forms of jute, jute felt and jute fibre as shown in Fig. 2 were used to know the characteristics of the jute fibres such as fiber diameter, density, porosity, flow resistivity, tortuosity and characteristic lengths are investigated. Some of these characteristics are measured through experiments and others are evaluated by available literature models.

3.1.1. Determination of fiber size

By using the scanning electron microscope, the jute fibre distribution is shown in Fig. 3. Based on the statistical averaging at the various places of different fibres, the effective diameter of the jute fibre was estimated.

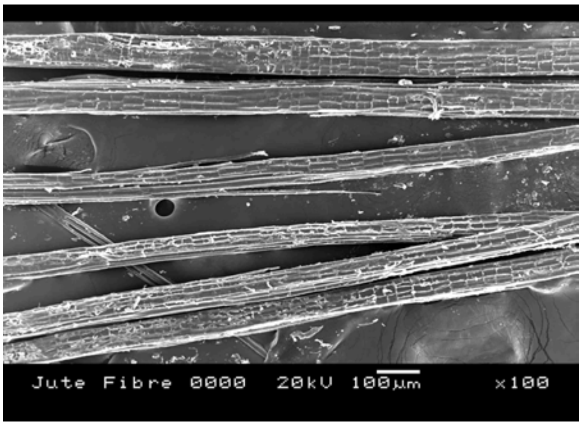

Figure 3: Photomicrograph of jute fibres distribution by SEM

3.1.2. Determination of porosity

The porosity of jute (*H*) is measured through the following relation.

$$\rho = \left(1 - H\right)\rho' \tag{1}$$

where, ρ is the density of the jute sample and ρ' is the density of the jute fibre [Ingard (1994)].

3.1.3 Determination of flow resistivity

The flow resistivity is defined by the ratio of the static pressure difference (∇P) to the product of the velocity *V* and the thickness *l* of the porous sample. Its unit is Ns/m^4

$$\sigma = \frac{\nabla P}{Vl} \tag{2}$$

The set up for measuring the flow resistivity include U tube manometer, air flow meter and the compressor as the source of air. The test specimen of thickness 25.4 mm is mounted in a tube.

3.1.4 Determination of tortuosity

The tortuosity (α_∞) is determined by using the empirical formula in terms of porosity (*H*) as follows [Attenborough (1993)].

$$\alpha_\infty = 1 + \frac{1-H}{2H} \quad (3)$$

3.1.5 Determination of Characteristic lengths

Viscous and thermal characteristic lengths were estimated based on Allard (1993) model and his extensions to Biot theory. Assumption was made that jute fibres are cylindrical. Viscous characteristic length ($\wedge$) depending on the frame geometry was defined as

$$\wedge = \frac{1}{2\pi rl} \quad (4)$$

where $2\pi rl$ is total perimeter of fibre per unit volume of material, r is diameter of fibre and l total length of fibre per unit volume of material defined by eq. (5)

$$l = \frac{1}{\pi r^2 \times \frac{\rho}{\rho'}} \quad (5)$$

ρ and ρ' are density of the sample and density of fibre, respectively.

Allord showed that for the material with porosity close to unity, $\wedge' = 2\wedge$. For the material having pores of triangular cross section, $\wedge' = 1.14\wedge$ where $\wedge'$ is thermal characteristic length.

Observations

The physical properties of these jute felt and jute fibres are tabulated in Table 3. The range of diameter of jute fibres which was measured by scanning electron microscope is 50 – 90 μm. By the statistical averaging of diameter at different locations, the effective diameter of single jute fibre is 68 μm. Density is about 1084.4 kg/m^3.

Table 3: Physical properties of jute samples

Material	**Porosity** (H)	**Flow resistivity** (σ) Ns/m^4	**Tortuosity** (α_∞)	**Characteristic lengths** μm	
				$\wedge$	$\wedge'$
Jute felt	0.91	33190.84	1.05	1.51	3.02
Jute fibre	0.69	20087.72	1.22	5.28	6.02

The values of porosity shows the jute felt is the higher porous than the jute fibre. Jute samples having 25.4 mm thickness are used for measuring the flow resistivity measurement. For jute felt, the value of porosity close to unity, the thermal characteristic length is twice of viscous characteristic length. The pores between cylindrical fibres of the jute fibre sample are of approximately triangular cross section. So, thermal characteristic length is 1.14 times to the viscous characteristic length from Allard model.

3.2 Measured physical properties

By measuring the physical properties, one can know the significance performance of jute based material in environmental conditions. The following tests are carried out to determine the physical properties.

1. Water absorption test
2. Moisture absorption test
3. Thickness swelling in water
4. Biodegradation test
5. Thermogravimetric test

3.2.1 Water absorption test

The water absorption of 5% NR latex jute composite samples was measured according to ASTM D 570. This test is carried out to determine the amount of water absorbed and performance of the materials in water environments. This is very similar to the moisture absorption test. Three square shaped samples of 3.1 cm x 3.1 cm were cut from a sheet of jute-5% rubber composite and kept in an oven at temperature at 100^0C. Then weight of the three samples was measured. After that these samples were kept in a petri disc containing full of distill water. Then 24 hour and 48 hour after, the weight of the samples was taken and the water absorption was calculated using the following formula.

The water absorption is calculated according to this formula

$$\frac{W_1 - W_2}{W_1} \times 100 \tag{6}$$

where W_1 is original weight of the sample and W_2 is final weight of the sample after 24, 48 and 120 hours.

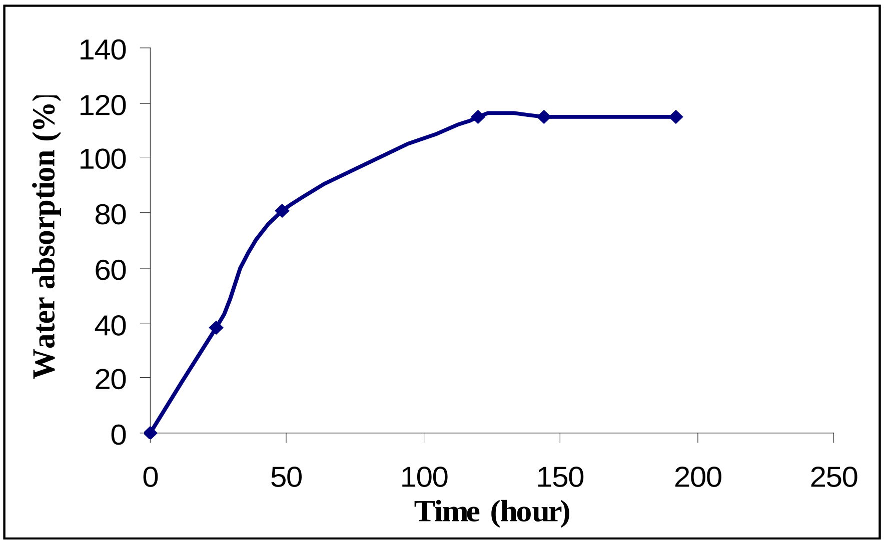

Figure 4: Water absorption (%) of 5% NR latex jute composite at different time intervals

Table 4: Water absorption of 5% NR latex jute composite

Sample no.	Initial wt of sample (gm)	% Water absorption after 24 hour	% Water absorption after 48 hour	% Water absorption after 120 hour	% Water absorption after 144 hour	% Water absorption after 192 hour
1	3.44	39.59	85.63	107.02	106.05	106.78
2	3.44	39.94	78.00	118.88	119.30	118.22
3	3.68	36.11	77.91	118.19	118.05	119.78

The results of water absorption test are shown in Table 4. The graph is shown in Fig 4, which is drawn based on the average of the three sample readings of percentage of water absorption with variation of time. From the graph, the percentage of the water absorption gradually increases and then it reaches saturation point i.e. 114 percent of water absorbed at 120 hour and after that no more water is going to absorb by the sample.

3.2.2 Moisture absorption test

The water absorption of 5% NR latex jute composite samples was measured according to previous ASTM D 570. This test is carried out to determine the amount of moisture absorbed and the performance of the materials in humid environments. Four square shaped samples of 3.5 cm were cut from a 6 in x 6 in sheet. The samples were kept in an oven at temperature 100^{O}C for one hour. Then the weights of the samples were measured. After that the samples were kept in a dessicator containing saturated solution of NaCl. The relative humidity of saturated Sodium chloride is 74.87 ± 0.12 at room temperature (35^0C). The percentage of moisture absorption of samples after 24, 48, and 120 hour were calculated according to the following formula as used in the water absorption test.

$$\frac{W_1 - W_2}{W_1} \times 100 \tag{7}$$

where W_1 is original weight of the sample and W_2 is final weight of the sample after 24, 48 and 120 hour.

Table 5: Moisture absorption of 5 % NR latex jute composite

Sample no.	Wt. of Sample (gm)	% Moisture absorption after 24 hour	% Moisture absorption after 48 hour	% Moisture absorption after 120 hour	% Moisture absorption after 144 hour	% Moisture absorption after 192 hour
1	3.23	9.84	10.15	10.33	10.56	10.89
2	3.42	9.49	10.05	10.11	10.34	10.71
3	3.00	9.51	9.55	10.01	10.52	10.90
4	3.81	9.29	9.55	9.78	10.06	10.25

The results of moisture absorption test are shown in Table 5. The graph is shown in Fig 5, which is drawn based on the average of the four sample readings of percentage of moisture absorption with variation of time. From the graph, the percentage of the moisture absorption gradually increases and then it reaches saturation point i.e. 10.05 percent of moisture absorbed approximately at 120 hours and after that no more water is going to absorb by the sample.

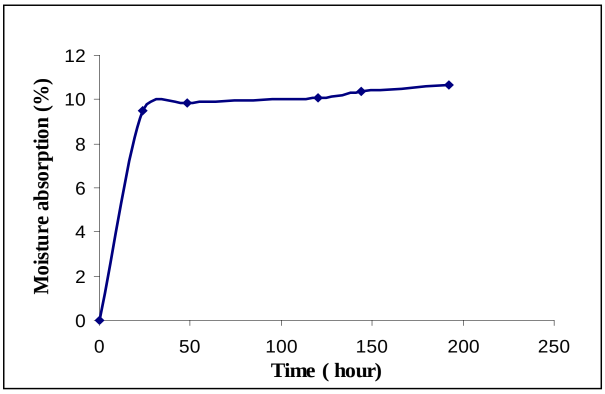

Figure 5: Moisture absorption (%) of 5%NR latex jute composite at different interval

3.2.3 Swelling in water

ASTM D570 standard covers method of determination of swelling in water of 5% NR latex jute composite in cold water. This test is done to determine the hydrophilic nature of 3cm × 2.7cm × 0.4cm jute latex composite. The average of the three values obtained for the change in thickness expressed as a percentage of the original average thickness shall be reported as the swelling value.

Thickness swelling in water was measured according to the following formulae.

$$\frac{T_2 - T_1}{T_1} \times 100 \tag{8}$$

where T_1 is initial thickness and T_2 is the final thickness after water absorption

Table 6: Thickness swelling of 5%NR latex jute composite in cold water at 24 hour

Sample no.	Initial thickness (mm)	Final thickness (mm)	Thickness swelling (%)
1	4.01	8.10	101.99
2	4.02	8.01	99.25
3	4.03	8.02	99.01

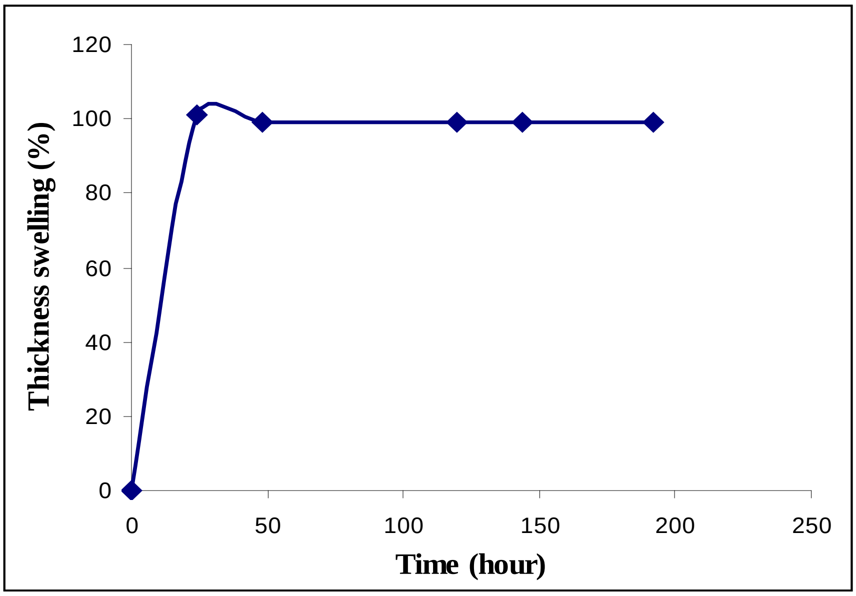

Figure 6: Thickness swelling (%) of 5 % NR latex jute composite

Table 6 gives the percentage of thickness swelling of samples in cold water at 24 hour. The variation of the percentage thickness swelling at different hour is shown in Fig 6. From that graph, the saturation point occurs at 24 hour and thickness swelling is approximately 100 percent.

3.2.4 Biodegradation test

This test is to evaluate microbial biodegradation activities of NR latex jute composite by burying in soil. The biodegradability of 5 % NR latex jute composite was determined by soil burial test. Sample dimensions: 10 cm × 5 cm × 0.4 cm. Weight of 10 pieces of rectangular shaped samples were measured and buried in soil mixture containing garden soil, cow dung and sand (2:1:1, w/w). After 15 and 30 days the samples were removed, cleaned properly and finally kept in oven at 100^0C till a constant weight was obtained. The weight loss of the samples after 15 days is 3.74% and 30 days is 6.28%. the biodegradable sample after 30 days is shown in the Fig 7. From the graph in Fig 8 which is drawn percentage of weight loss of jute sample and time in days, the biodegradation of sample is very slow.

Figure 7: 5% NR latex jute composite after biodegradation test (30 days)

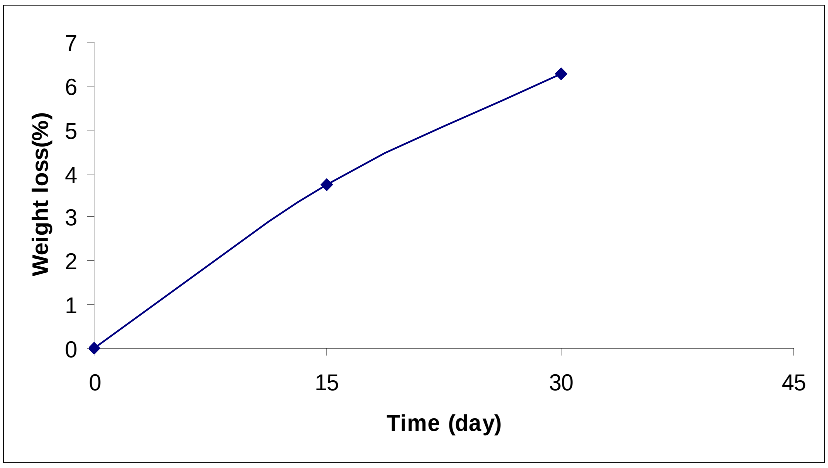

Figure 8: Weight loss (%) of 5% NR latex jute composite in biodegradation test.

3.2.5 Thermogravimetric test

Thermogravimetric test is used to determine the temperature at which the thermal degradation starts and usable temperature range of 5% NR latex treated jute felts. Thermo Gravimetric Analysis (TGA) of raw and 5% NR latex treated jute felts have been carried out in nitrogen gas atmosphere at a heating rate of 10^0C/min from 45^0C to 60^0C temperature by a pyres diamond TG/DTA analyzer. By simply taking the first derivative of the TGA line, a DTG curve was obtained to identify the start, peak, and end temperature. From thermal analysis (TG analysis) it can be interpreted that thermal stability of raw jute felt is 260.92^0C where as NR latex treated jute felt is 269.3^0C.

The variation of percentage of weight loss with temperature in TGA of untreated and treated jute felts are shown in Fig 9 and Fig 10 respectively. For the untreated jute, as temperature increases the percentage of weight loss deceases gradually and approximately at 260.92^0C the variation suddenly drops because after increment in temperature, the jute fibres were separated and burnt after that asses are formed. In case of treated the same trend was followed but the thermal stability point increased to 269.3^0C.

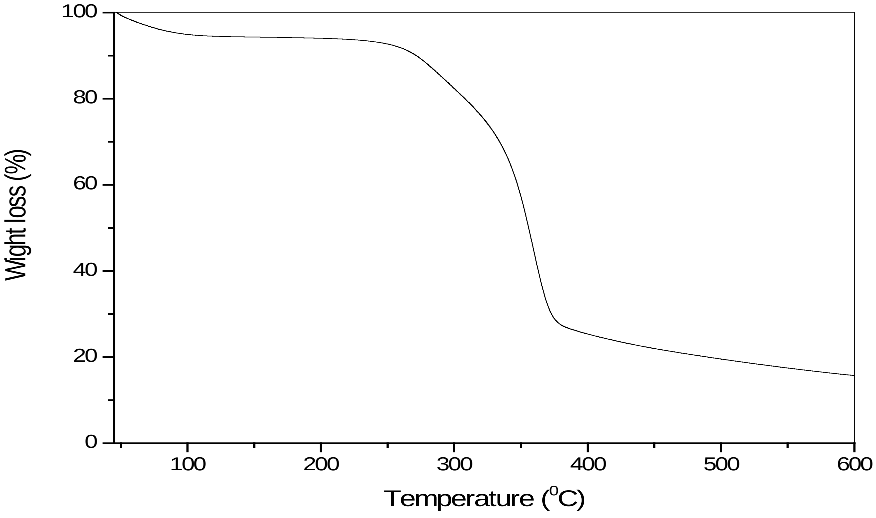

Figure 9: TGA of untreated jute felt

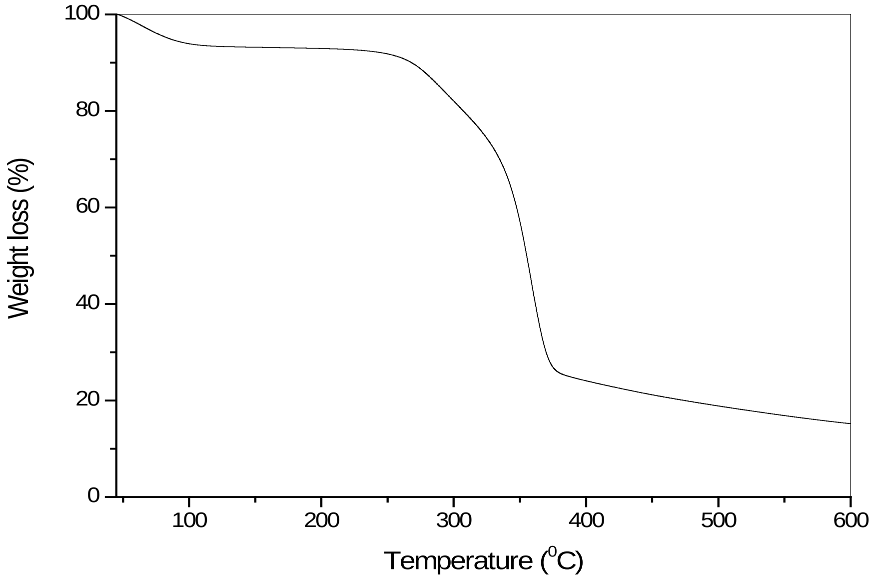

Figure 10: TGA of NR Latex treated jute felt

3.3 Measured fire retardant properties

Flammability test for 2.5 % and 5 % NR latex jute composite had been performed by measuring the three parameter such as limiting oxygen index, flame propagation and smoke density.

3.3.1 Limiting oxygen index test

LOI test carried out to measure the minimum concentration of oxygen that will just support flaming combustion of a material in a flowing mixture of oxygen and nitrogen. Oxygen concentration reported is its volume percent in a mixture of oxygen and nitrogen. Test was performed using LOI test instrument (Stanton Redcroft FTA unit) as per ASTM D 2863-97 standard as shown in the Fig 11. The specimens for the LOI measurement were 152.4 mm × 5 mm × 4 mm in size.

Figure 11: Limiting oxygen index test setup

[Source: *Rubber Technology Center, IIT Kharagpur]*

Table 7: Limiting oxygen index (LOI) of different materials.

Sl.No.	Material	LOI (Volume percent of oxygen)
1	Natural rubber	18.5
2	Cellulose	19
3	Fibreboard	22.1
4	Wool	25
5	2.5% NR latex jute composite	29.3
6	5% NR latex jute composite	30.2

Limiting oxygen index test results for 2.5% and 5% NR latex jute composite are shown in Table 7 and are compared with natural rubber and cellulose (content of NR latex jute) as well as with wool (sound absorbing material) and fibreboard, used for domestic applications .Among these, NR latex jute shows best LOI (30.2) value.

4.4.2 Flame propagation

The rate of flame spread was measured as per Federal Motor Vehicle Safety System (FMVSS) standard shown in the Fig 12. Specimen of 152.4 mm × 5 mm × 4 mm in size was exposed horizontally at its one end to a small flame for 15 s. The distance and time duration of burning or the time to burn between two specific marks were measured. The burn rate was expressed as the rate of flame spread in mm/min

$$B = 60 \times \frac{(L)}{(T)} \tag{9}$$

where B, L and T are burn rate in mm per minute, length of the flame travelled in mm and time in sec for the flame to travel L mm, respectively .

Figure 12: LPG flame propagation of NR latex jute composite.

Table 8: Flame propagation test results of NR latex jute composite.

Sl. no.	Material	Length (mm)	Flame propagation (mm/min)	Self extinguish (No. of times)
1	2.5% NR latex jute composite	100	15.69	—
2	5% NR latex jute composite	100	20.56	—
3	5% NR latex jute composite + 1% sodium phosphate (fire retardant)	100	9.77	7

As concluded from Table 8, 2.5% NR latex jute composite shows poorer flame propagation property than 5% NR latex jute composite, however 1% sodium phosphate (Na_3PO_4; as a fire retardant) treatment on 5 % NR latex composite suppressed its flame propagation property with 7 times self extinguishing ability. Due to better acoustical results of 5% NR latex jute composite, fire retardant treatment was not done for 2.5% NR latex jute composite.

3.3.3 Smoke density

The smoke density for a sample having dimension 120mm × 100mm × 4mm in size was measured by using smoke density chamber as per ASTM D 2843-04.The smoke generated (flaming mode) in the process of burning of sample was measured by the change of light intensity. This test was useful for measuring and observing the relative amounts of smoke obscuration produced by burning or decomposition of material.

Smoke density rating which represents the total amount of smoke present in the chamber for 4 min was measured by following equation.

$$\text{Smoke density rating} = \frac{A}{T} \times 100 \tag{10}$$

where, *A* and *T* are the area under the light absorption versus time curve and total area of the curve, respectively.

Table 9: Smoke density of NR latex jute composite

Sl. no.	Material	Smoke density rating (%)	Max. light absorption (%)
1	2.5% NR latex jute composite	11.36	7.2
2	5% NR latex jute composite	9.89	6.9
3	Fibre glass	20.55	24.7

Figure 13: jute and glass fibre sample after smoke density test.

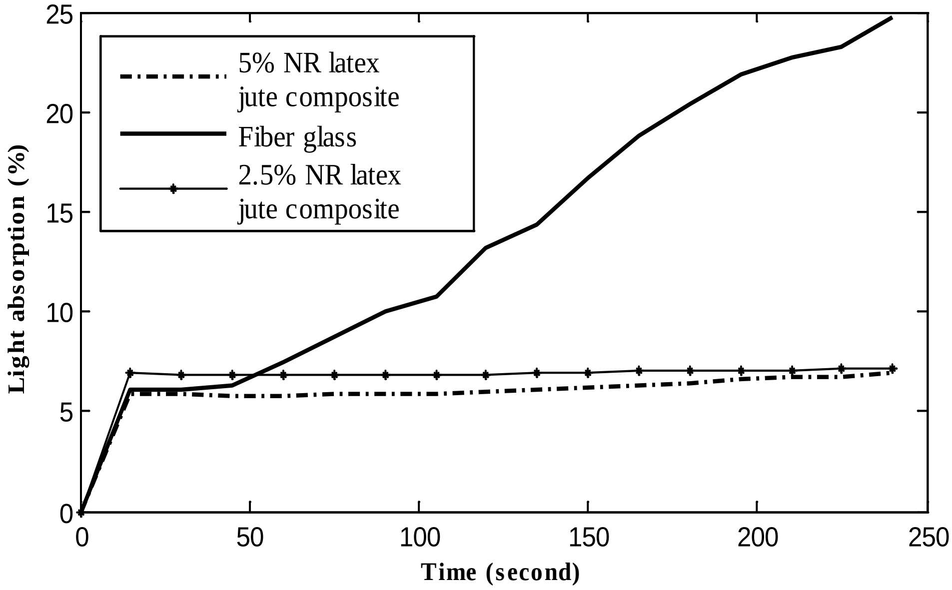

Figure 14: Light absorption (%) versus time (s) curve of different materials.

As shown in Table 9 and Fig. 14, from comparison between NR latex jute composite and fibre glass, 5% NR latex jute composite shows the least smoke density rating and hence better performance in maximum light absorption in percentage. So jute products may not harm the environment. Fig 13 shows the samples of jute and class fibres after smoke density test. Flame spreading in the glass fibre sample is more than the jute.

3.4 Measured Acoustical Properties

Acoustical properties of jute fibre, felt and composites measured in term of Acoustical normal specific absorption coefficient and Acoustical transmission loss

3.4.1 Acoustical Normal Specific Absorption Coefficient

Normal specific sound absorption coefficient of materials has been determined by using impedance tube, two microphones, a FFT analyzer and the IIT Kharagpur developed MATPRO software. Test has been done as per ASTM standard. Noise reduction coefficient (NRC), a simple quantification of absorption of sound by material as shown in the Fig 15, was calculated by averaging the four values of acoustical normal specific absorption coefficient was calculated by using weighted octave band sound levels.

Figure 15: Untreated jute fibre (50 mm x 35 mm Φ) sample for measuring its sound absorbing coefficient.

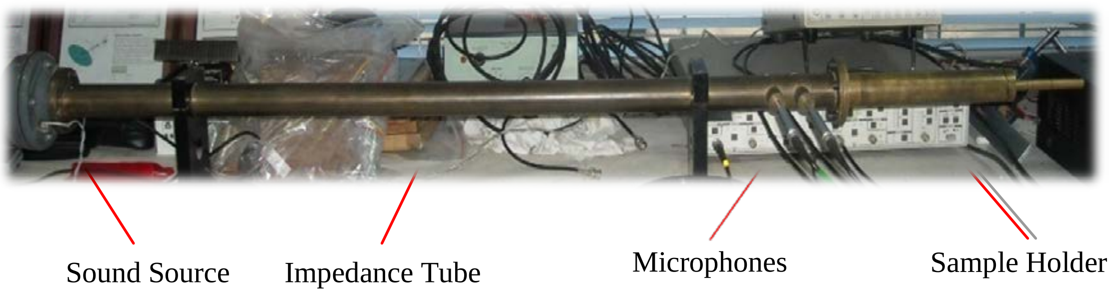

Figure 16: Sound Absorption Coefficient Measurement Set Up

Untreated TD5 and TD4

From the measurements, the calculated NRC values for two types of cylindrical shaped (diameter 35 mm) untreated jute fibres (TD4 and TD5) of thickness 25.4mm and 50.8mm are given in Table 10 and then sound absorption coefficient test setup shown in Fig. 16.

According to results TD5 gives better acoustical absorption property as compared to TD4 which is due to more number of air channels between smooth and thinner strands of TD5 and hence it improvement in sound trapping. Thickness of the samples has a significant effect on NRC. Further acoustical measurement had been done for TD5 and the variation shown in Fig 17.

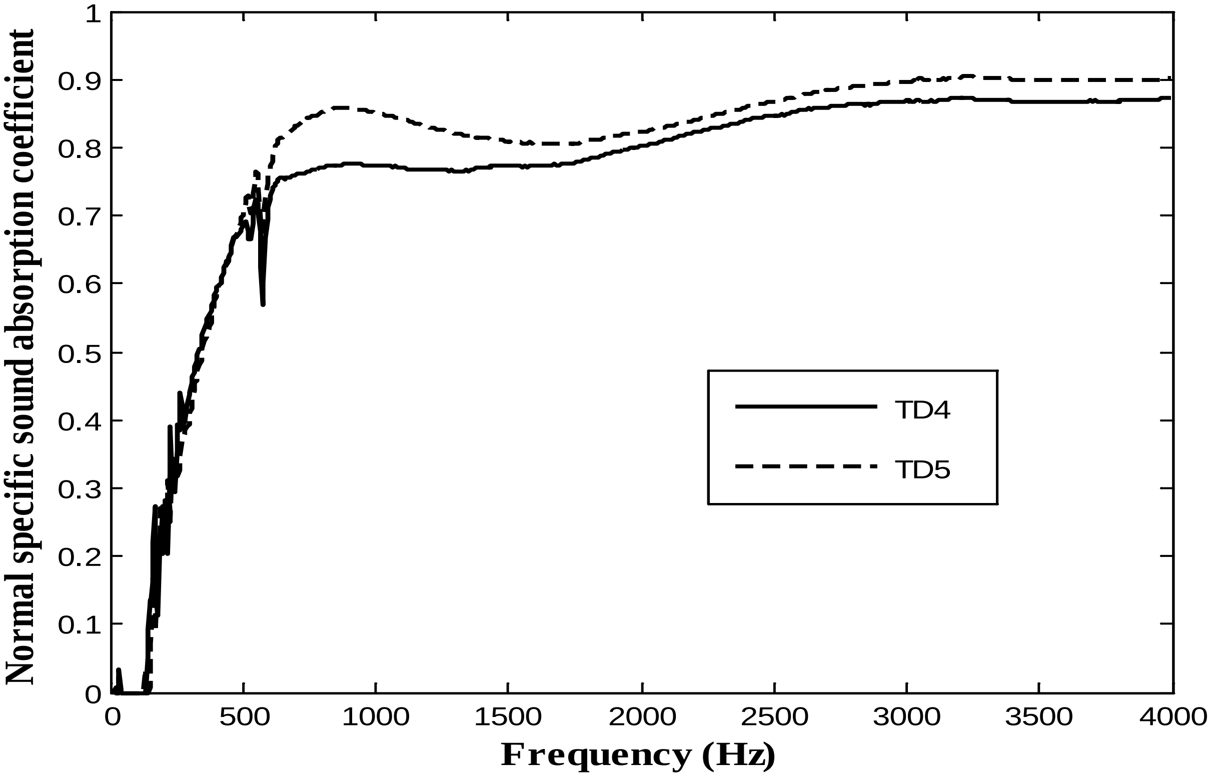

Figure 17: Normal specific sound absorption coefficient of TD4 and TD5

Table 10: Untreated TD5 and TD4 with their NRC value

Grade Name	Thickness (mm)	Density (kg/m^3)	NRC
TD4	25.4	440	0.51
TD5	25.4	426	0.52
TD4	50.8	328	0.72
TD5	50.8	326.8	0.76

Effect of rigid backing and air gap on TD5

In further investigation of acoustical properties of TD5, untreated TD5 samples having different masses and densities were tested for their NRC values under the condition of only rigid backing and air gap of 25.4 mm and 50.8 mm between TD5 and rigid backing, in impedance tube at frequency range of 0-4000 Hz as shown in Fig.18 . The calculated NRC values from measurement results are shown in Table 11 and the normal specific sound absorption coefficient in Figs. 19, 20 and 21. It is interesting to note that, with increasing the air gap, NRC values increase, which is due to loss of acoustical wave energy of transmitted wave in the presence of jute-air passage and of reflected wave from rigid backing, through air-jute passage in the its propagation of acoustical wave. Further, low denser jute samples are shown higher NRC values compared to the high denser jute samples because there should be enough pores on the surface of the material for the sound to pass through and get dampened. Fig. 19 shown that high denser materials does not shown any variation with air gaping.

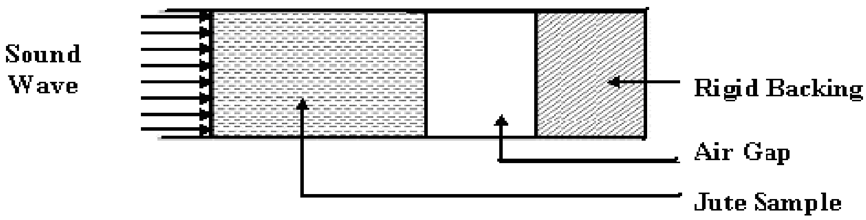

Figure 18: NRC value of jute fibre (TD5) in absence and presence of air gap in impedance tube.

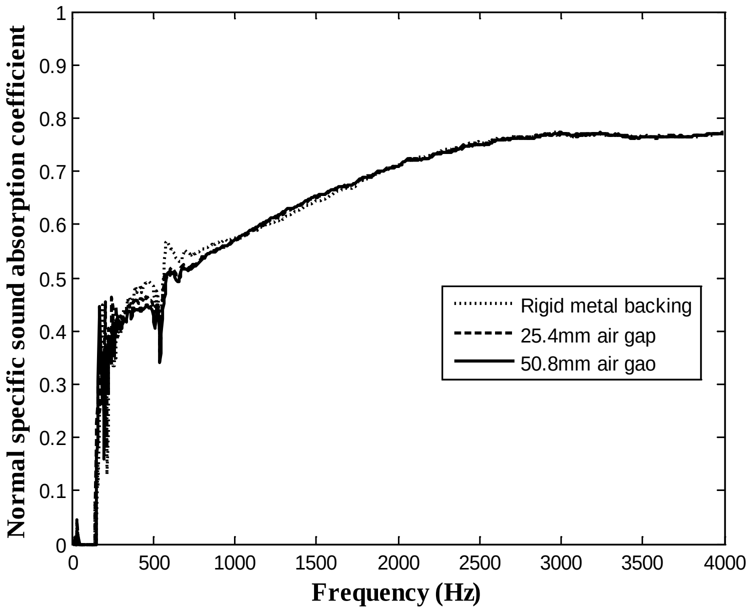

Figure 19: Normal specific sound absorption coefficient of TD5 sample of density, 446.6 kg/m^3

Table 11: Untreated TD5 with their NRC value

Sample	Treatment	Density (kg/m^3)	NRC
1	Rigid backing	446.6	0.58
	25.4 mm air gap		0.58
	50.8 mm air gap		0.60
2	Rigid backing	348.2	0.75
	25.4 mm air gap		0.80
	50.8 mm air gap		0.81
3	Rigid backing	328	0.76
	25.4 mm air gap		0.82
	50.8 mm air gap		0.84

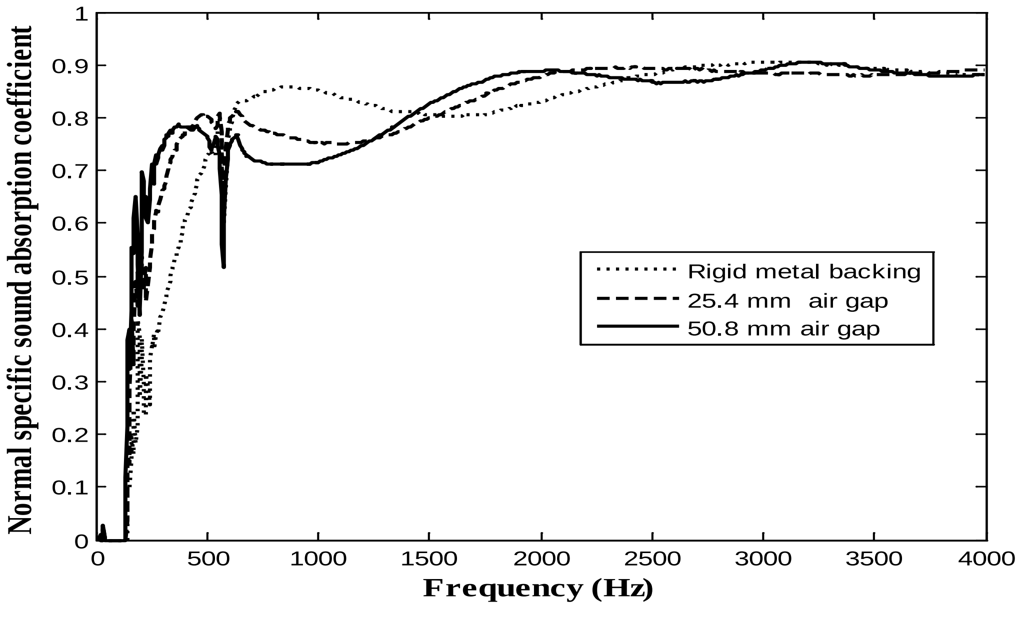

Figure 20: Normal specific sound absorption coefficient of TD5 sample having density of 348.2 kg/m^3

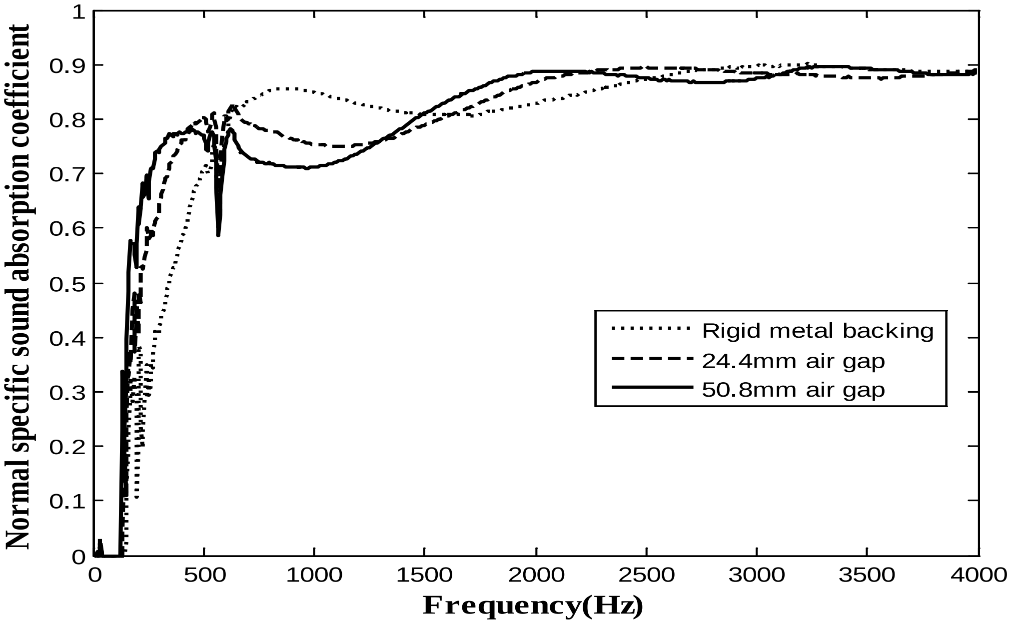

Figure 21: Normal specific sound absorption coefficient of TD5 sample having density of 328 kg/m^3

Effect of alkali treatment on TD5

For getting better result with TD5, fibres were treated with 1%, 2% and 3% alkali solutions to make them finer and separable. Test had been performed under rigid backing condition on cylindrical shaped sample as shown in Fig. 22. As shown in Table 10 and Fig. 23 that there is no significant effect of various percentages of alkali treatment on jute fibre in terms of noise reduction coefficient. Moreover 1% alkali treated Jute fibre gives highest NRC value among 1%, 2% and 3% alkali treated Jute fibre. On higher percentage alkali treatment jute fibres become smoother due to loss in hemi-cellulose content and hence loose its sound absorption property.

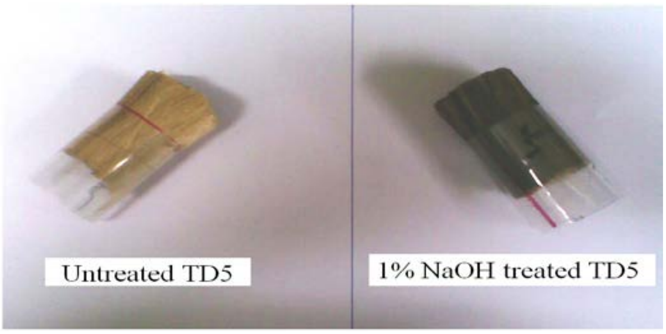

Figure 22: Cylindrical shaped untreated and 1% NaOH treated TD5 sample

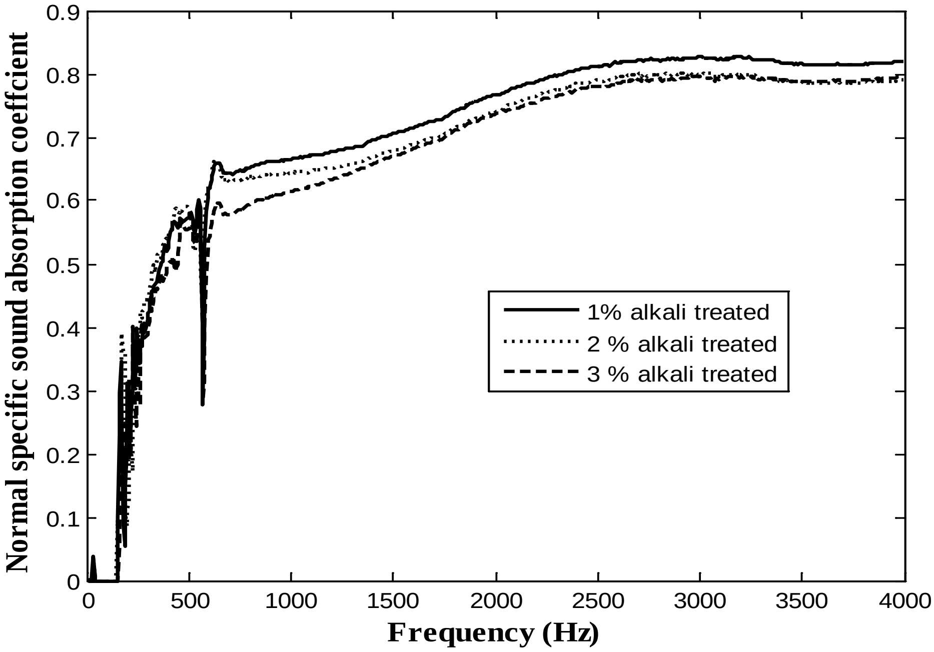

Figure 23: Normal specific sound absorption coefficient of alkali treated TD5

The SEM micrograph of untreated and alkali treated jute fibre is shown in Fig. 24.from this figure we can observe that the significant changes in surface morphology by alkali treatment. The untreated jute fibres are having impurities as in Fig. 24 (a) are removed by the this treatment and the fibre stands are getting separated which lead to the rougher surface which enhance the mechanical and acoustical properties. As increase in the percentage of alkali shown in Fig. 24 (c) & (d), fire stands are separated more and more and this ultimately decreasing the sound absorbing properties. These observations are qualitatively similar to those reported by Saha et al. (2010).

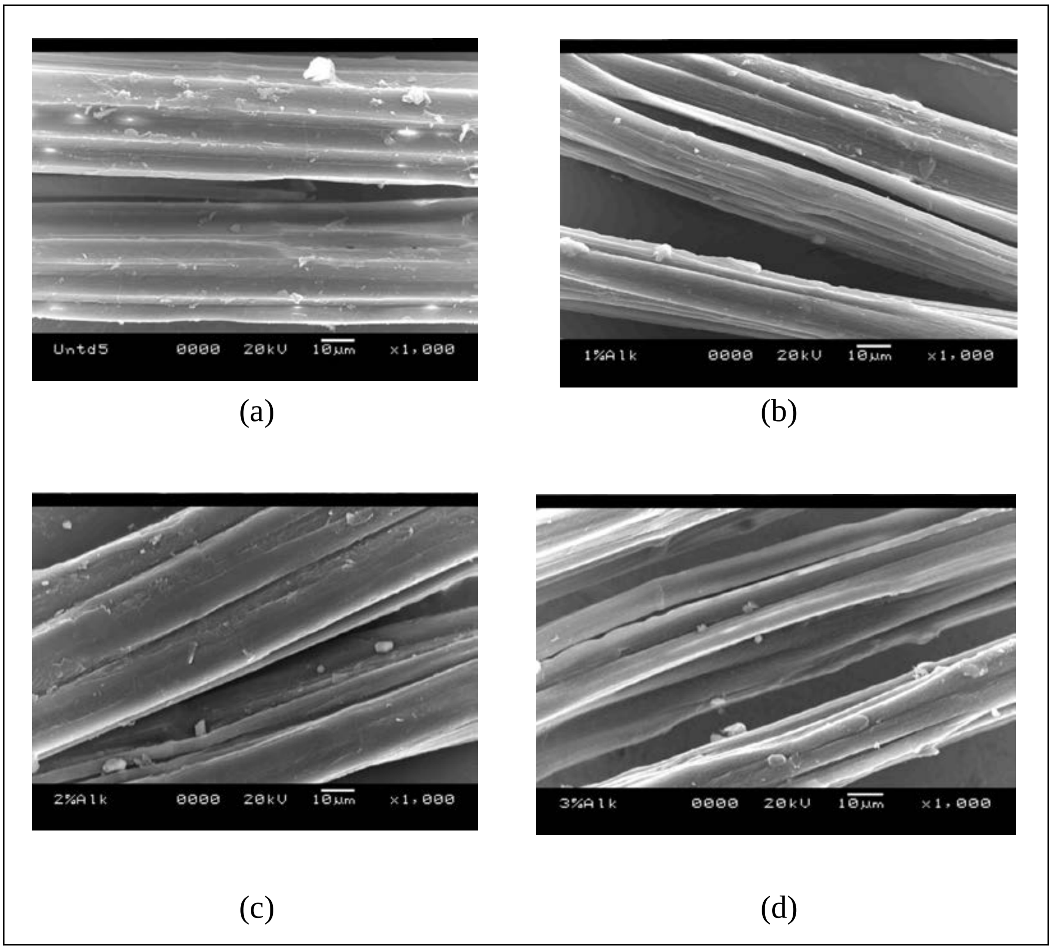

Figure 24: Photographs of the micrographic surface of jute fibre (a) Untreated (b) 1% alkali treated (c) 2% alkali treated (d) 3% alkali treated

From table 12, the NRC values not only depend on the percentage of alkali treatment but also the density of the samples which are manually prepared.

Table 12: Treated TD5 jute with their NRC value

Sample	Treatment with alkali	Density (kg/m^3)	NRC
1	1%	436.2	0.65
2	1%	409.2	0.69
3	2%	446.4	0.64
4	3%	455	0.62

Effect of natural rubber treatment on jute felt

Acoustical normal specific absorption coefficient of 1% and 2.5% natural rubber treated jute felt of varying density had been calculated. Table 13 and Fig. 25 show that untreated jute felt (density 117 kg/m^3) has higher NRC value (0.85) as compared to 1% NR latex jute composite (density 219 kg/m^3). On the other hand, increasing the natural rubber content in jute felt, decreases sound absorption capability of composite.

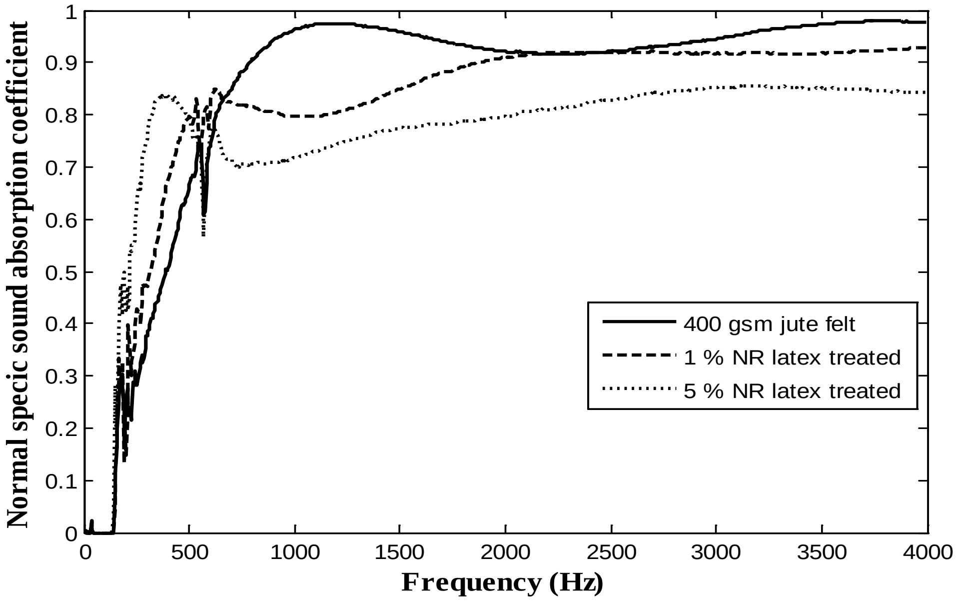

Figure 25: Normal specific sound absorption coefficient of treated, untreated jute felt.

Table 13: NRC values of Untreated and NR treated jute felts (400 gsm)

Sample no.	Treatment (400gsm jute felt)	Density (kg/m^3)	NRC
1	untreated	117	0.85
2	1% natural rubber	219	0.80
3	5% natural rubber	311	0.78

3.4.2 Acoustical transmission loss

Figure 26: Setup for measurement of transmission loss

Test was performed as per SAE J1400 standard with some modification in the setup with sample size as 6 inch × 6 inch jute composite. The transmission loss for the NR latex jute composite was measured by exciting the test sample by a broadband (50 Hz to 5000 Hz) random noise driven loudspeaker placed at the bottom of the receiver box. Sound intensity probe was held above the opening of the receiver box by a laboratory stand as shown in Fig. 26. The measured TL of the test sample is the difference between the measured sound intensity with and without the test sample with a correction factor added to it, as described below.

$$TL_{\text{jute}} = TL_{\text{jute experimental}} + CF \quad (11)$$

Determination of TL correction factor (CF)

To determine the correction factor of the experimental setup used, an aluminium plate of 5 mm thickness is used as a test sample. The theoretical transmission loss for the 5 mm aluminium plate is calculated by the mass law equation given in Equation 12.

$$TL_{\text{theory}} = 20 \log_{10} (mf) - 42 \text{ [dB]} \quad (12)$$

where, m is surface density in kg/m^2 and f is frequency in Hz.

The correction factor (CF) for the test setup is calculated as given below in equation 13.

$$CF = TL_{\text{theory}} - TL_{\text{aluminium experimental}} \quad (13)$$

TL of the jute composites

The TL of the jute composites was measured using equation 12, having obtained the CF from equation 13. While measuring the jute samples, it was ensured that the incident sound intensity on the test samples were the sample as during the CF measurements using the aluminium test sample. Table 14 shows the values of the TL by experimental and theoretical at octave band frequency levels

Table 14: Transmission loss in dB of aluminum plate of 5.00 mm thickness, and surface density 13.5 kg/m^2

Sl.no	Frequency (Hz)	SIL without plate	SIL with plate	TL(exp) (dB)	TL (ther.) (dB)	Correction factor (dB)
1	63	34.2	28.1	6.1	16.6	10.5
2	125	49.9	31.2	18.7	22.5	3.8
3	250	58.5	51.1	7.4	28.6	21.5
4	500	58.2	45.8	12.4	34.6	22.2
5	1000	77.1	60.1	17.0	40.6	23.6
6	2000	81.4	63.0	18.4	46.6	28.2
7	4000	84.5	62.5	22.0	52.6	30.6

Table 15: Transmission loss in dB of Jute fibre (TD4) + cloth (152.4mm×152.4mm) of 25.4 mm thickness

Sl. no	Frequency (Hz)	Sample 1 (3.47 g/m^2)	Sample 2 (3.6kg/m^2)	Sample 3 (5.0kg/m^2)	Sample 4 (3.7kg/m^2)
1	63	11.7	10.4	12.1	10.6
2	125	08.3	07.8	09.7	08.4
3	250	24.7	24.6	26.0	25.4
4	500	36.2	24.8	28.7	26.2
5	1000	27.0	26.9	29.1	27.3
6	2000	31.5	32.1	33.7	32.0
7	4000	36.7	37.4	39.5	37.5

Table 16: Sound transmission class (STC) of treated and untreated (Jute fibre with cloth).

Sample	Material	Treatment	Thickness (mm)	Mass (g)	Surface density (kg/m^2)	STC
1	Jute fibre(TD4)+cloth	1% alkali treated (1h)	25.4	80.8	3.5	27.4
2	Cloth+Hessian sliver	Untreated	25.4	82.5	3.6	25.6
3	Jute fibre(TD4)+cloth	2% alkali treated (1h)	25.4	114.2	4.9	27.8
4	Jute fibre(TD4)+cloth	Untreated	25.4	84.4	3.6	26.1

Tables 15 and 16 show the four different type samples of the transmission loss and the sound transmission class based on the average each type of the sample respectively. Square shaped samples of required thickness mentioned in the Table 15 are prepared by placing the jute fibres in jute cloth. Among these samples, few samples are untreated and remaining samples are alkali treated which are shown in table 15. The sound transmission values are higher for the alkali treated sample than others.

Table 17: Transmission loss in dB of untreated jute felt with cloth (samples 5 & 6) and treated jute felt with cloth (samples 7, 8 & 9) (101.6mm×101.6mm)

Sl. No	Frequency (Hz)	Sample 5 (5.4kg/m^2), (17.78mm)	Sample 6 (4.3kg/m^2), (11.43mm)	Sample 7 (7.4kg/m^2), (6.5 mm)	Sample 8 (6.1kg/m^2), (7.0 mm)	Sample 9 (7.1kg/m^2), (25.4 mm)
1	63	15.7	12.3	16.3	16.1	15.2
2	125	13.9	08.1	08.2	11.0	13.9
3	250	27.7	26.5	25.7	26.3	28.7
4	500	30.5	27.0	28.1	28.9	29.8
5	1000	33.6	29.7	31.1	33.0	33.3
6	2000	38.6	32.3	37.3	39.6	37.9
7	4000	45.4	37.7	47.4	49.3	42.9

Table 18*:* Transmission loss in dB of jute felt + cloth treated with composite (sample 10) (152.4mm×152.4mm), surface density (9.3 kg/m$^{2)}$, (W=216.3gm) and (t=12.7mm)

Sl.no.	Frequency(Hz)	TL(dB)
1	63	13.8
2	125	14.4
3	250	27.6
4	500	29.7
5	1000	33.1
6	2000	37.8
7	4000	48.6

Table 17 and 18 shows the Transmission loss (TL) of untreated & treated jute with cloth and jute felt with composites. Sound transmission class values of these samples are not showing better results. So further investigation to be carried out to obtain the higher STC values. Table 19 the transmission class of the same samples.

Table 19: Sound transmission class (STC) of treated and untreated (jute felt with cloth)

Sample	Material	Treatment	Thickness (mm)	Mass(g)	Surface density (kg/m^2)	STC
5	600 gsm jute felt	Untreated	17.8	55.5	5.4	31.6
6	600 gsm jute felt + Cloth	Untreated	11.4	44.2	4.3	26.9
7	600 gsm jute felt	Treated	6.5	75.9	7.4	29.6
8	600 gsm jute felt + Cloth	Treated	7.0	63.0	6.1	31.4
9	400gsm jute felt+bleachedcloth	Untreated	25.4	71.8	7.0	31.0
10	Jute felt+Cloth	Treated composite	12.7	216.3	9.30	31.8

Table 20: Transmission loss in dB of NR latex jute composite (152.4mm×152.4mm)

Sl. no	Frequency (Hz)	1% NR latex jute composite	2.5 % NR latex jute composite	5 % NR latex jute composite	10 % NR latex jute composite	15 % NR latex jute composite
1	63	14.2	13.6	15.6	14.3	14.6
2	125	21.4	18.7	20.8	21.0	21.4
3	250	29.0	28.7	29.1	29.0	29.1
4	500	35.3	35.1	36.1	35.9	35.8
5	1000	40.5	39.9	42.5	43.7	43.2
6	2000	47.5	46.6	48.3	50.3	49.4
7	4000	59.1	56.2	60.2	58.7	56.6

Table 21: Sound transmission class (STC) of NR latex jute composite (152.4mm×152.4mm).

Sample	Material	Thickness (mm)	Mass (kg)	Surface density (kg/m^2)	STC
1	1% NR latex jute composite	5.0	0.075	3.3	38.89
2	2.5 % NR latex jute composite	5.0	0.076	3.3	37.6
3	5 % NR latex jute composite	5.0	0.098	4.2	39.8
4	10 % NR latex jute composite	5.0	0.098	4.2	39.5
5	15 % NR latex jute composite	5.0	0.096	4.2	39.2

Table 20 shows the Transmission loss of different % NR latex jute composites. Table 20 tabulates STC of NR latex jute composite sized 152.4mm×152.4mm, which shows that 5 % NR latex jute composite gives higher STC value and there is no significant variation in STC for percentage above 5% of NR latex jute composites. From acoustical measurement of jute fibres and composites it is concluded that NR latex jute composite (treated with 1% alkali+5% rubber) with NR treated jute felt (1% natural rubber) and/or TD5 jute fibre can be used to reduce noise by controlling sound absorbance and transmittance. Moreover, comparative study of Owens-Corning fibreglass with 5% NR latex jute composite, Owens-Corning of thickness 88.9 mm gives STC 52, on the other hand jute based composite having thickness of 5 mm gives STC 39.5. Fig 27, and 28, shows best TL samples, and the worst sample of TL is shown in Fig. 29.

Figure 27: 5% NR latex jute composite, (254 × 254 × 5) mm, (STC-39.5)

Figure 28: Jute felt+Cloth composite, (152 ×1 52 × 12.7) mm, (STC-31.8)

Figure 29: Untreated cloth, (101.6 × 101.6 ×11.4) mm, (STC-26.9)

4. Case Study-1: Noise Control of Domestic Vacuum Cleaner

From the physical, acoustical and flammability tests of the jute samples, it was decided to use jute felt/cloth for sound absorption and 5% NR latex jute composites as a sound barrier material. In order to identify the noise sources in the domestic appliance a sound intensity mapping of all the five radiating surfaces was done. The SIL measurements were done by a B&K 2260 Investigator system with a sound intensity probe. Once the noise sources were identified and ranked, the appropriate noise control measures either by absorbing or blocking using the developed jute materials were done. There is no appreciable change in the temperature of the appliance after jute treatment.

4.1 Vacuum cleaner specification

A Euroclean wet and dry vacuum cleaner by Eureka Forbes as shown in the Fig. 30 was used for the experiment. The physical dimensions and the weight of this dryer are 415 x 415 x 440 mm and 6 kg.The blower efficiency and suction of motor are 30 litres/second and 1700 mm/wc (16660 Pa).

Figure 30: Euroclean wet and dry vacuum cleaner

4.2 Noise measurement technique

To control noise in the domestic appliances, knowledge about the dominate source locations is desirable. First important step is to identify the sources of noise in the unit of the machines and then ranking them based on the strength of the sound. So then the strongest source should be reduced either directly at the source or at the transmission path must be reduced.

Sound intensity measurement is done instead of sound pressure measurement for determination of sound power because steady background noise level can be tolerated during the measurement. For that reason two microphone sound intensity technique was used to locate the measure noise source location. This technique was performed by using two microphone sound intensity probe B&K 2260 with BZ7205 version 2.1 sound intensity software. This microphone probe consists of two microphones with 12 mm spacer. In general the sound power measurement was carried out as per ISO 9614 standard. This standard is divided into two parts; ISO 9614-1 standard which can apply for point method and ISO 9614-2 for sweep/scanning method [Tandon (1988)].

In point method the control surface is divided into several equidistant point and the intensity measurements are performed at each point. A sufficient number of points should be taken for accurate results [Tandon (1987)].

For the scanning, the intensity probe is moved over the surface with a constant speed covering equal area in equal time. During this procedure, the intensity probe is kept perpendicular to the scanned area all over the time of measurements, and the scanned area should be followed by the centre of the microphone spacer.

Even though sweep method is faster than point method, point method gives stable and accurate result [Tandon (1989)].

4.3 Noise source location

Noise source location is carried out based on the point measurement technique. In this measurement a weighted octave band sound power level was used. Hypothetically, the space surrounded by the vacuum cleaner was divided into five square surfaces which are again divided into 3rows and 3 columns grid as shown in the Fig. 31**.** Overall sound power was measured in the frequency range of 31.5-8000 Hz at each of all the grid points by sound intensity probe at distance of 150 mm approximately.

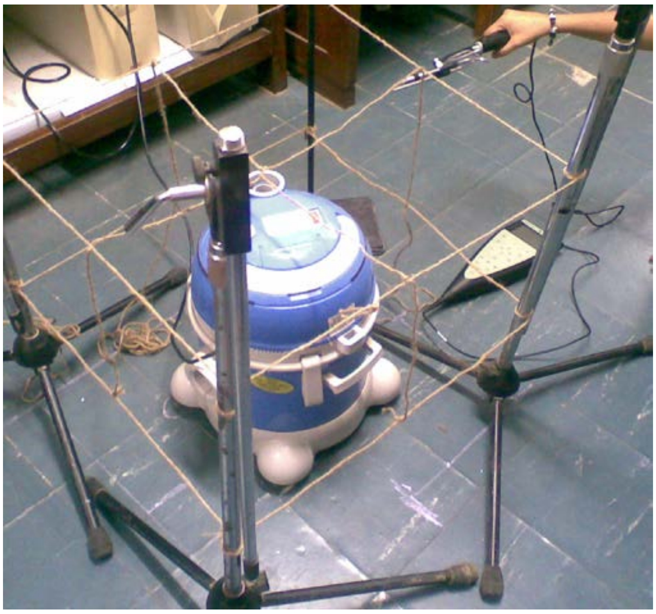

Figure 31: Sound power measurement setup of a vacuum cleaner

Noise source location can be performed by the sound intensity mapping. The intensity was measured at each point of the grid and maps by the Noise Explorer Type 7815 software and which are drawn in the form of the contours by using Matlab software. These contours give the detailed picture of the sound power and are very useful for locating high noise source locations. Fig. 33 shows the mean sound power at individual faces surrounded by vacuum cleaner which was obtained from Noise Explorer software. Fig. 32 shows the contour plot of the SWL (Sound Power Level) in dBA for the top surface of the vacuum cleaner.

Based on obtained contours of all five surfaces, maximum value of sound powers was obtained in the top surface of the vacuum cleaner from Fig. 32, it is seen that the region around the exhaust was the most dominating noise radiator. The SIL level at the region around the vacuum exhaust was 75 dBA.

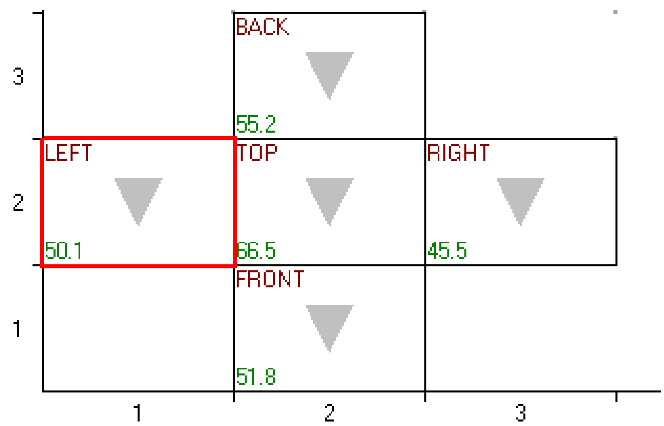

Figure 32: Mean sound power at individual surrounding faces of vacuum cleaner without treatment

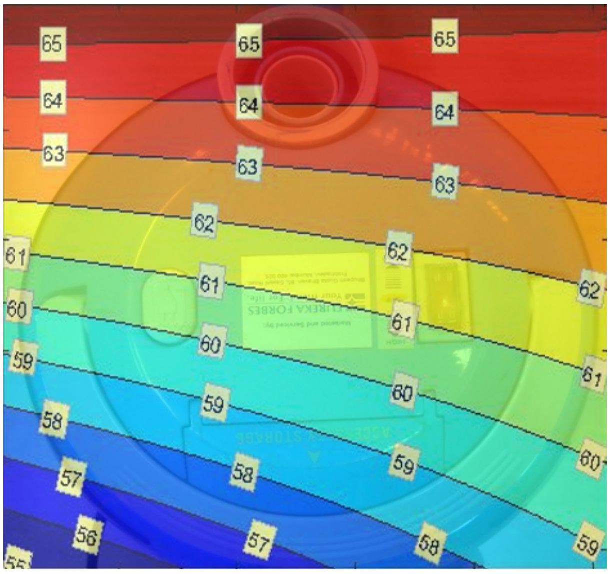

Figure 33: SWL in dBA for top surface of the vacuum cleaner

The same procedure for noise location is repeated based on the scanning method. The overall sound power of vacuum cleaner with no enclosure is 67.3 dBA. This value is approximately similar to 67.6 dBA which is the overall sound power of vacuum cleaner with no enclosure by point method. These two results show repeatability and accuracy. Further measurements are carried out by using point method only.

4.4 Acoustical treatment in vacuum cleaner

Three configurations for applying the jute based acoustical materials to the vacuum cleaner were done for noise reduction. In the first configuration, a box enclosure was used. In the second configuration, 10 mm of untreated jute felt lined enclosure was applied to the inner wall of the box. In the third configuration, a jute dissipative silencer along with jute lined box enclosure was used. For each configuration, the measurement of sound intensity was carried out as previous procedure. In the third configuration, a jute dissipative silencer of 300 mm length with 25.4 mm thickness was used. Fig. 34 shows the views of the vacuum cleaner without any acoustical treatment and with the jute felt lined enclosure along with jute dissipative silencer.

(a)Vacuum cleaner with no enclosure

(b)Vacuum cleaner with closed enclosure

(c)Vacuum cleaner with closed enclosure & jute lining

(d)Vacuum cleaner with closed enclosure & jute lining along with jute dissipative silencer

Figure 34: Different configurations for vacuum cleaner noise control

Figure 35: 300 mm long Jute Dissipative Silencer with 25.4 mm thickness Jute Felt lining enclosed in Jute Cloth

By providing the jute felt enclosure, the sound power values in the mean sound power at individual surrounding faces of dryer decreases significantly as shown in Fig 36. The contours of the each face after acoustical treatment in three different configurations were drawn.

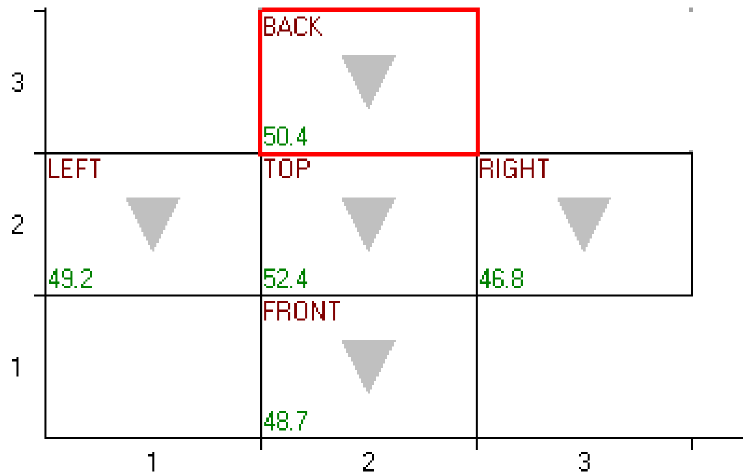

Figure 36: Mean sound power at individual surrounding faces of domestic dryer with acoustical treatment.

4.5 Results and discussions

Table 22: Different cases of sound power measurement of vacuum cleaner

SI.No.	Case	SWL dBA
1	Vacuum cleaner with no enclosure	67.6
2	Vacuum cleaner with box closed enclosure	65.3
3	Vacuum cleaner with closed enclosure with *jute lining*	63.3
4	Vacuum cleaner with closed enclosure and *jute lining* along with jute dissipative silencer	57.1

Sound power level (SWL) were tabulated in Table 22 for the without acoustical treatment and acoustical treatment of different configuration of vacuum cleaner. There was a slight reduction in sound power level with box closed enclosure. But this reduction was not considerable. By jute lining with thickness of 10 mm closed enclosure of box, little more reduction in noise was obtained. Even though jute lining is done throughout vacuum cleaner enclosure, there was large noise location was created at the exhaust. So the next step to decrease the sound power at exhaust. By providing the jute dissipative silencer, a remarkable 5 dB sound power reduction was found. From the third configuration of the acoustical treatment the overall sound power reduced by 10.5 dB.

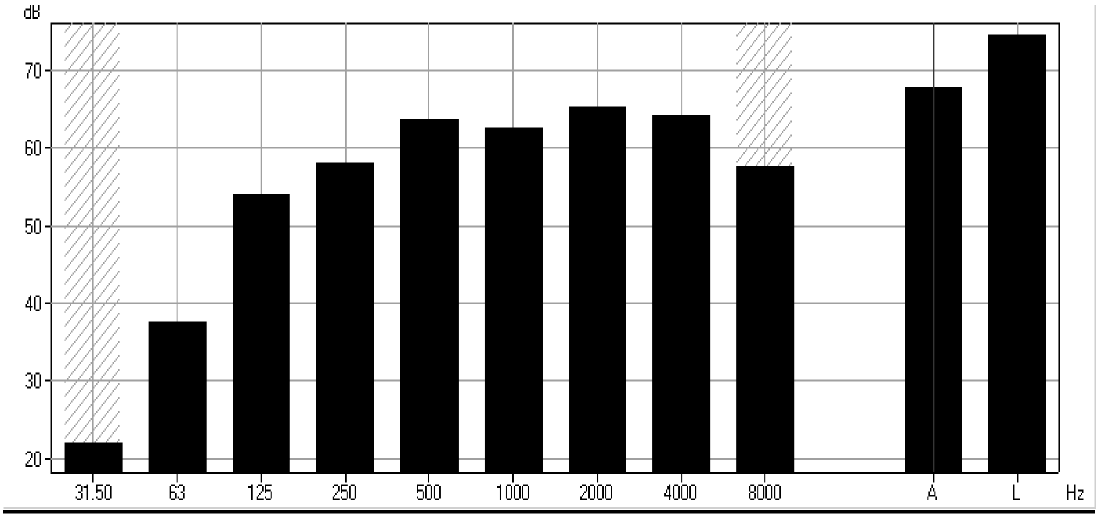

Figure 37: Frequency spectrum of sound power (67.6 dBA) of vacuum cleaner without Jute lining enclosure

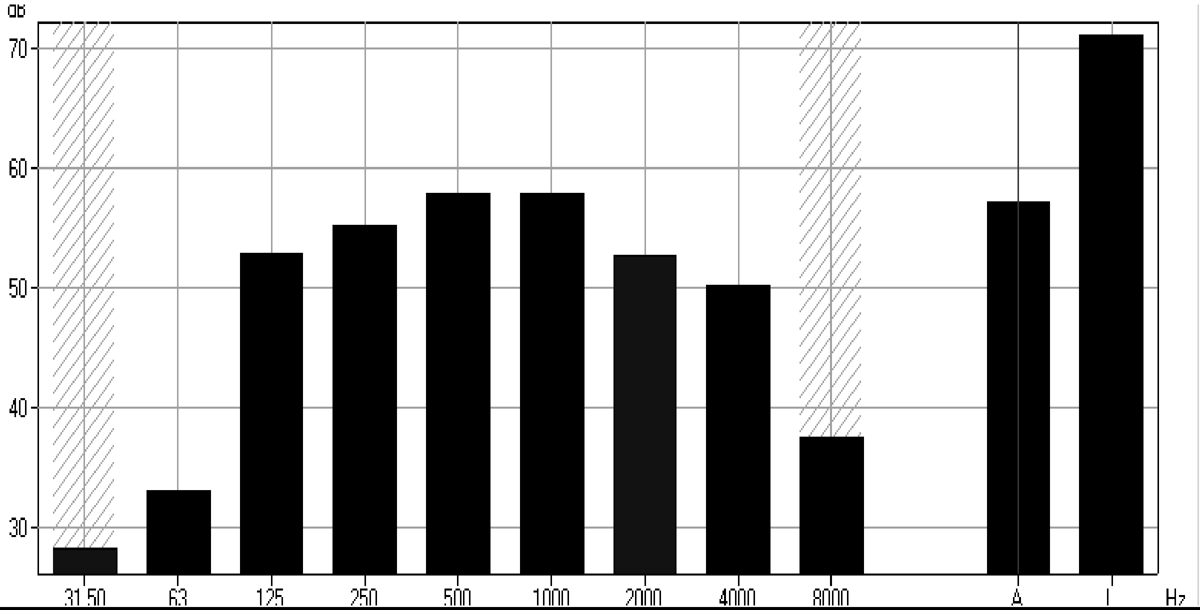

Figure 38: Frequency spectrum of sound power (57.1 dBA) of vacuum cleaner with jute lining enclosure along with jute dissipative silencer

Figure 37 and 38 show the SWL (Sound Power Level) octave band spectra for the vacuum cleaner with and without the acoustical treatment in dB in frequency range of 31.5-8000 Hz. It can be observed that the A-weighed octave band sound power levels peak at a frequency of about 2000 Hz. After the acoustical treatment, the peak was tremendously decreased upto10.5 dB and also there was reeducation in sound power levels at every frequency.

5 Case Study-2: Noise Control of Domestic Dryer

The results obtained from the acoustical treatment of vacuum cleaner are not enough to conclude jute as sound proofing material. For that reason another case study should be necessary. Same acoustical measurement technique was applied for the noise control of domestic dryer. Jute was used as sound absorbing material in this case study also. But main difference of case study 1 and 2 was that acoustical treatment. Acoustical blanket made up of jute was used for the noise reduction in domestic dryer.

5.1 Domestic dryer specification

An IFB Industries clothes dryer was used for the present experiment. The physical dimensions and weight of dryer are 530 cm×600 cm×720 mm and 26 kg respectively. Motor rating and Heater rating are 300 W and 1.8 kW, respectively. The drum used inside the dryer for placing the wet clothes is epoxy coated; a maximum of 5.5 kg of wet clothes can be dried in this dryer in an operation cycle. The dryer has a safety cut-off which limits the temperature inside the drum to 105^0C. All the experiments were done in the clothes dryer was running empty.

Figure 38: IFB clothes dryer

5.2 Noise source location

For the noise source location, previously measurement technique was used. In this technique 3 rows and 3 columns grid was carried out for all five faces of dryer as shown in Fig 39. Overall sound power was measured in the frequency range of 31.5-8000 Hz at each of all the grid points by sound intensity probe which is held at distance 150 mm from the dryer surface approximately.

Figure 39: Sound power measurement setup of a domestic dryer

Mean sound power at individual surrounding faces of domestic dryer without treatment was shown in Fig. 39. The matrix of sound power grid which is obtained at all point in a grid of the back surfaces is shown in Fig 40. Based on the obtained values of sound power, the contour plot of the SWL (Sound Power Level) in dBA for the all five surfaces of the dryer is shown in Fig. 41.

From Fig. 41, it is seen that the region around the motor driving the drum by a belt drive was the most dominating noise radiator, followed by the dryer exhaust at the rear top location. The SIL level at the region around the motor was 68.6 dBA and that around the dryer exhaust is 67 dBA.

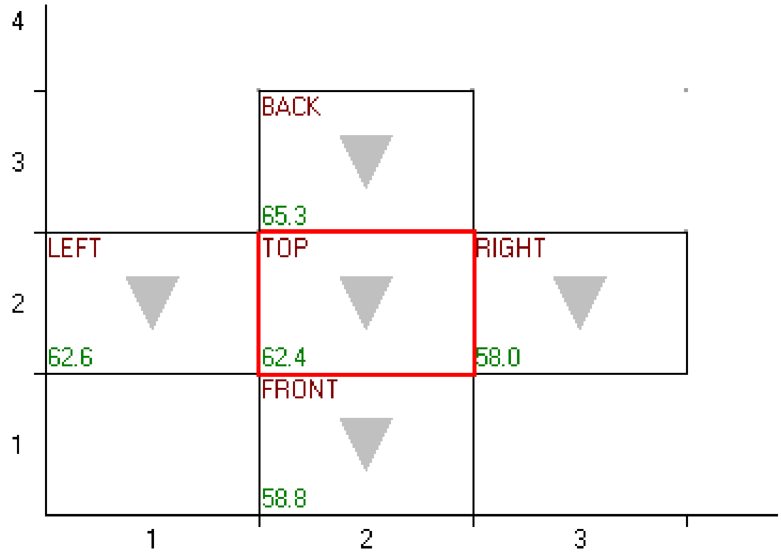

Figure 40: Mean sound power at individual surrounding faces of domestic dryer without treatment

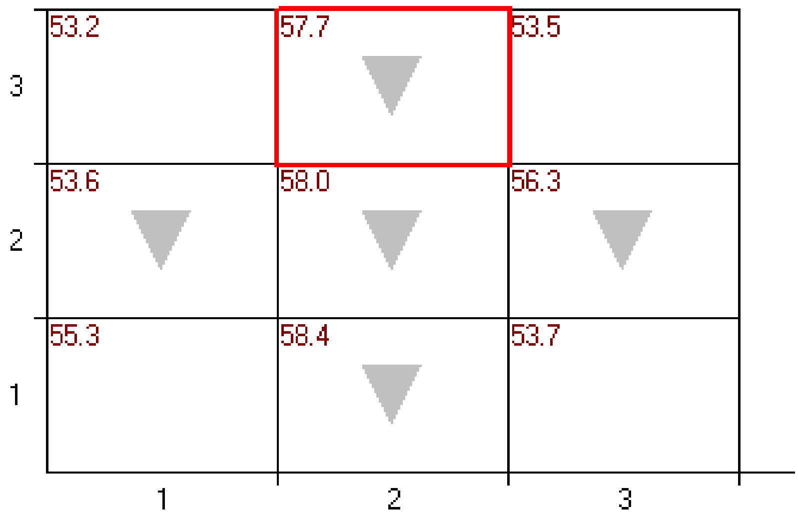

Figure 41 Matrix of sound power grid of back surface of dryer

By repeating this measurement with 4 × 4 grid, the value of the overall SWL of domestic dryer without treatment is 69.6 dBA, which somewhat approximately 69.4 dBA obtained from the 3 × 3 grid measurement. This shows the repeatability and accuracy. Further measurements are carried out with 4 × 4 grid size.

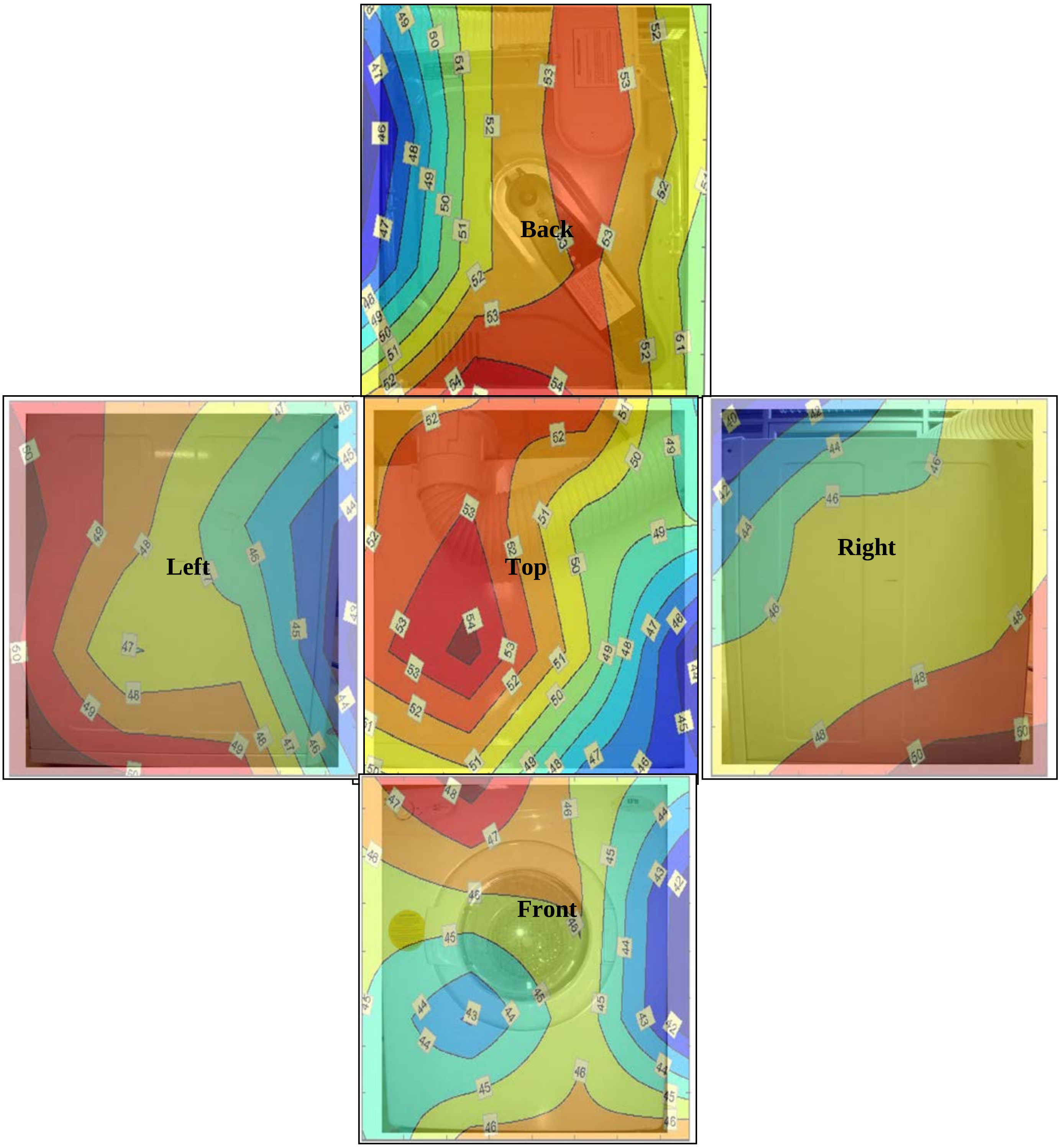

Figure 42: SWL in dBA of domestic dryer

5.3 Acoustical treatment in domestic dryer

Two configurations for applying the jute based acoustical materials to the dryer were done. In the first configuration, jute felt was applied to the inner wall of the rear of the dryer. In the second configuration a jute cloth acoustical blanket was put all around the dryer, with only the top and the rear of the dryer having jute felt filling.

Figure 43: Outer Shell of Dryer

In the first configuration, jute felt liner was placed entire inner case of the dryer as shown in Fig 43. By the noise measurement, very high sound power levels were obtained because the liner of 5mm thickness causes the more instability to dryer. There is no point to carry out the noise control of dryer based on this configuration.

Figure 44: Dryer Shell lined with Jute Composite

In the second configuration, jute acoustical blanket placed entire the dryer as shown in the Fig 45 (b). At the back side jute blanket was filed with 25.4mm untreated jute felt because from previous results noise is to be reduced back surface which is prominent noise source zone of dryer.

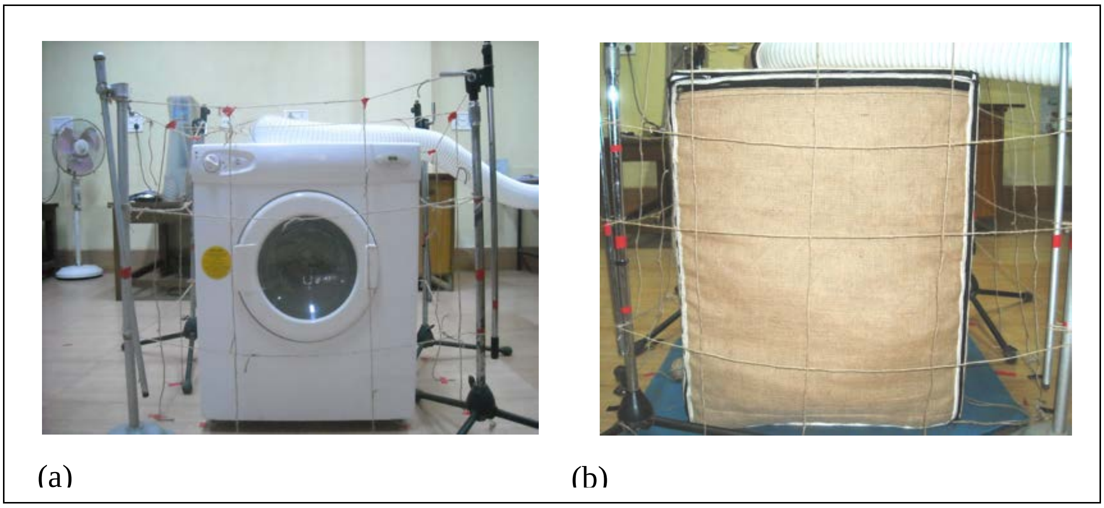

Figure 45: Domestic dryer (a) without acoustical treatment (b) with jute acoustical blanket

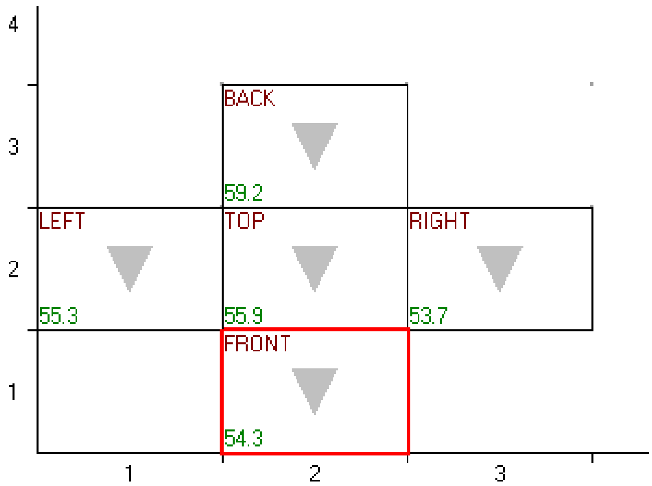

Figure 46: Mean sound power at individual surrounding faces of domestic dryer with acoustical blanket

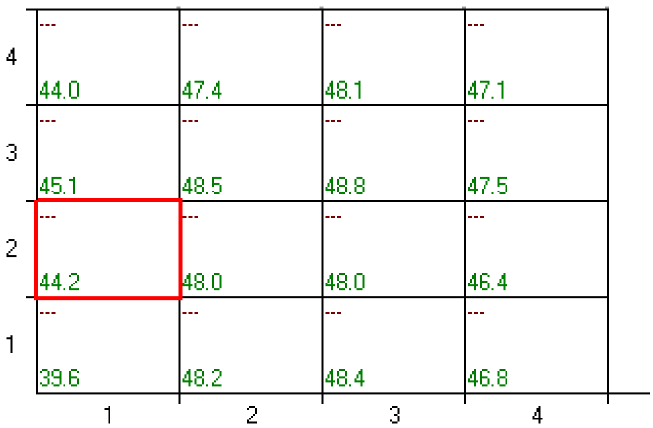

Figure 47: Matrix of sound power of back side of dryer.

Mean sound power at individual surrounding faces of domestic dryer with acoustical blanket is shown in fig. 46. Matrix of the sound power of back surface was shown in the fig. 47.

5.4 Results and discussion

Table 23: Different cases of sound power measurement of domestic dryer.

Sl.No	Case	SWL (dBA)
1	Domestic dryer without treatment	69.4
2	Domestic dryer with rear inner wall having 5 mm jute felt lining	68.7
3	Domestic dryer with jute acoustical blanket	63.5

Sound power level (SWL) were tabulated in Table 23 for the without acoustical treatment and acoustical treatment of different configuration of dryer. By using 5mm 400 gsm jute felt lining, slight reduction in the sound power which is to be not considered and causes instability to the dryer. In the second configuration of the acoustical treatment that is dryer with acoustical blanket gives 5.9 dB sound power reduction was obtained.

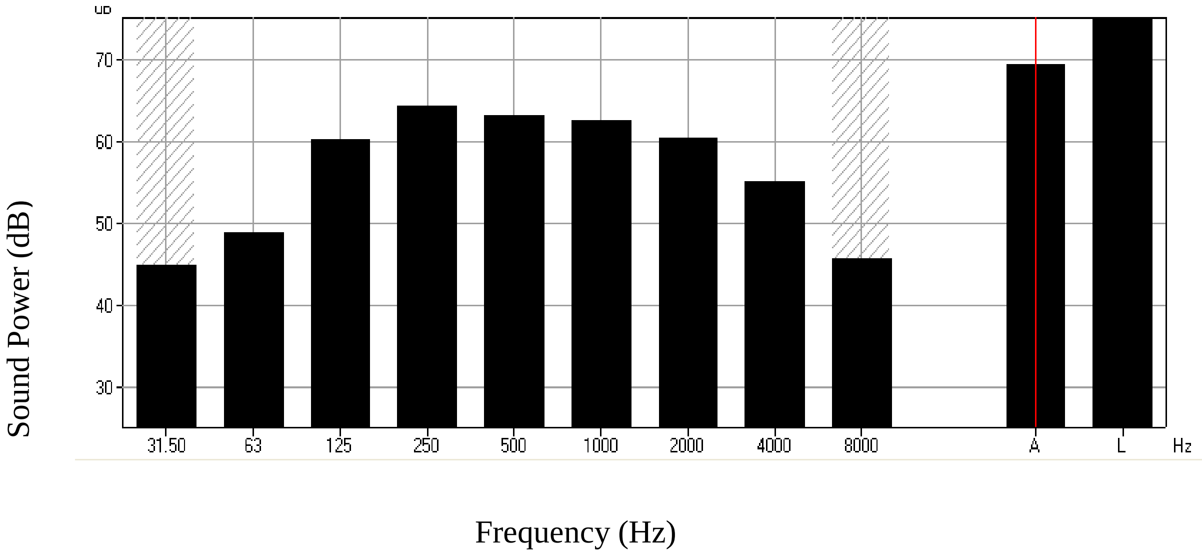

Figure 48: Radiated sound power of dryer without treatment (69.4 dBA)

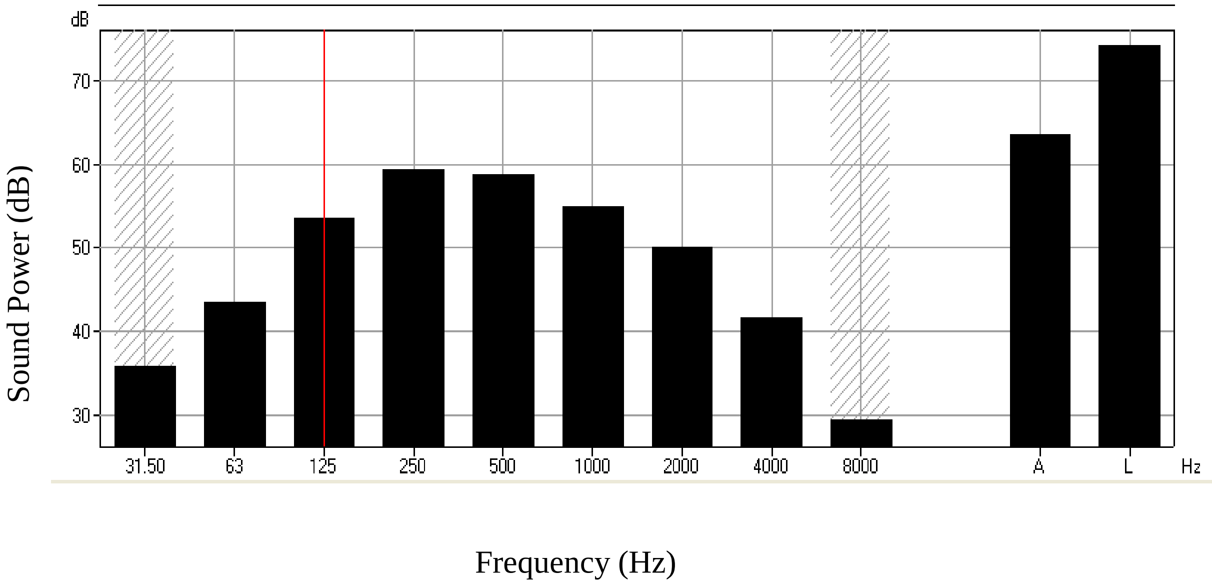

Figure 49: Radiated sound power of dryer with acoustical blanket (63.5 dBA)

Fig. 48 and 49 show the SWL (Sound Power Level) octave band spectra for the domestic dryer with and without the acoustical treatment in dB. The measured SPL at a distance of 1 m from the dryer without the treatment was 65.5 dBA and with the treatment was 59.6 dBA. The peak was observed at about frequency of 250 without acoustical treatment. By the providing acoustical treatment, not only the sound power reduction was obtained but also the peak was decreased remarkable upto 5.9 dB.

6 Case Study-3: Acoustical Soundproof Ceiling Applications

Another important application of jute is to use in form of sound proofing panels for room noise control application. Recently the usage of the sound proofing panels and tiles for noise control ceiling application by using synthetic materials is increasing significantly. There is lot of scope to implement jute as sound proofing material in this application. Jute ceiling panels can precisely control the noise control of reverberation and background noise in any building structures from small class rooms to large coliseum and auditoriums and also control the noise pollution caused by industries.

6.1 Mounting of absorbing materials

The mounting of sound absorbing material is important because the absorption coefficient varies widely with frequency for different mountings.

Some example of mounting of absorption materials are:

1. Attach jute panels directly against a rigid solid surface with no air space
2. Attach jute panels directly against a rigid solid surface with air space
3. Use as a backing material with perforated sheet metal facing.

Typically, the ceiling application requires designing of light fixtures and ventilation systems which can be provided by placing the material in perforated metal sheet. If the material cannot cover the surface of the ceiling, sound-absorbing units hanging from the ceiling can be used: however, they generally provide less absorption than the surface cover. For low frequency absorption application roof hanging panels and furring can be used.

6.2 Protection of absorbing materials

It is often necessary to cover the absorbent materials since jute using in the form fibers. For industrial application, wire meshes, perforated metal or hardboard is most practical. A perforated covering will have little effect on the absorption efficiency of the materials provided that it has only trivial air-flow resistance.

6.3 Effect of thickness of panels

For a material placed directly over a solid backing, a thickness of at least one-length of the wavelength of impinging sound is required. So the thickness of panels is important factor for the absorption material. The extent of the dependence of sound absorption on the thickness depends greatly, however, on the particular frequency range being considered.

The experimentation on the effect of thickness of perforated jute panels by using closed acoustical chambers covered by these panels is done. The Fig. 50 shows the two different panels of thickness 1inch and ½ inch. The dimension of the panels is 18 x 18 inches. Fig. 51 gives the application area of the perforated jute panels in ceiling of Acoustic lab, IIT Kharagpur. The panel overall cost and cost effectiveness is discussed in following section. The process feasibility and cost effectiveness are higher compared with available synthetic acoustical ceiling panels. Choice of the thickness of the panels depends on the application for noise reduction.

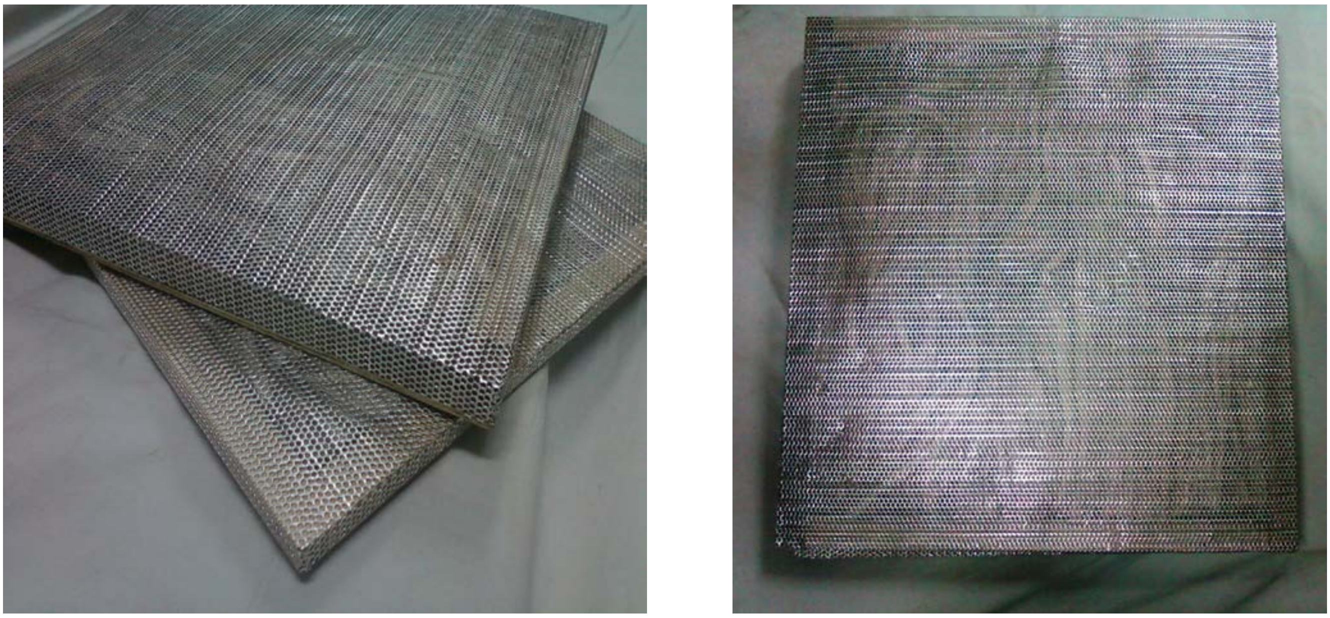

Figure 50: Jute fiber panels of 1” and ½”and Jute panel (18” x 18”)

Figure 51: Acoustics laboratory, Mechanical Department, IIT Kharagpur
Mineral Fiber Board Ceiling Replaced by Jute Acoustical Ceiling.

7 Process Feasibility and Cost Effectiveness

7.1 Vacuum Cleaner

The process feasibility and cost effectiveness of the jute based products for the noise reduction of the vacuum cleaner are checked at lab level. The process feasibility these jute products seem to be high because these products are mainly based on the raw jute so that the no additional treatment is required. At the other hand, the cost per product can be low. The cost effectiveness of the jute product is very high compared with fiber glass. Based on these observations, the scope of mass production of jute based products for noise dissipation of vacuum cleaner is high.

7.2 Domestic Dryer

The product cost of 5% rubber coated Jute composite (150 mm x 150 mm x 5 mm) is ₹15 and cost of 5% rubber coated jute composite (250 mm x 250 mm x 5 mm) is ₹20. From the results of domestic dryer, the jute products such as blanket and jute felt lining are derived directly from raw jute. No additional treatment is required. For this case also the process feasibility and cost effectiveness are high.

7.3 Acoustical Ceiling

The perforated jute panels for acoustic ceiling applications are developed and tested in Acoustic lab, IIT Kharagpur. The overall prototype development cost per panel and individual cost of materials are tabulated in Table 24. The cost of a perforated jute panel of (2” x 2” x 0.5”) is ₹ 369 which is quite high comparing with ordinary mineral fiber board for ceiling which is ₹70. On the other hand, the cost effectiveness of these jute panels is very high in comparison with synthetic material such as fiber glass for noise reduction in industrial application.

Table 24: Individual cost of materials for perforated jute panel

SI.No.	Material	Rupee ₹
1	Perforated aluminum sheet	224
2	Jute fiber	33
3	Wooden board	44
4	wood	23
5	Nail	5
6	Labor charge	40
	Total	369

8. Bulk Trails in Units/Mills

The bulk trails of the developed jute based product for sound proofing were conducted in three places: Acoustics laboratory, IIT Kharagpur; IFB Industries, Goa; Israil plywood, Kolkata. The bulk experimentation of these jute products on domestic appliances such as vacuum cleaner, dryer and acoustic ceiling application was carried in Acoustics labortaory, IIT Kharagpur. After getting encouraging results, the bulk trials were done on domestic dryer at IFB, Goa. Further experimentation was carried out at Israil Plywood for production of jute composites. Additionally, the information regarding the mass production was obtained. This information encouraging us to go for mass production of jute based products for noise reduction. On observing the results obtained in our trials, the commercial units have expressed their strong desire to commercially use the jute based composites for sound proofing applications.

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APPENDIX A

As suggested by JMDC in February, amarket survey has been carried out by VGSOM, IIT Kharagpur and the market potential of jute in automobile industries is around 30000 tonnes per annum.

Market Potential of Jute Composite in India

Automotive Applications

5/11/2009

Table of Contents

Introduction

Environmental and economical concerns have stimulated research in the development of new materials for construction, furniture, packaging and automotive industries. Examples of such raw material sources are jute fibers which have been used for hundreds of years for many applications such as ropes, beds, bags, etc. The materials made through the combination of jute fibers with Polypropylene (PP) are composites that have wide application possibilities and have a potential of developing new industries in the near future using local crops, wastes and labor. Primary areas of application include the automotive industry, the construction and building sectors, furniture (such as terrace floor boards), as well as industrial and consumer goods.

Sound Insulation in Automotive Industry

It is important to **automobile** manufacturers to eliminate unwanted noise in passenger compartments of vehicles. The ability to reduce noise inside the vehicle enhances the perceived value of the vehicle to the consumer. The existing constraints in the industry are

- Engine, transmission, drive shaft, tire and exhaust noise invade the floor.
- Heat from the sun radiates into the passenger cabin.
- Air conditioning system does not effectively reduce temperatures.
- Noise from the trunk compartment and package shelf invades the passenger cabin.
- Heat and noise comes through the firewall

Areas of Application

- Package trays and luggage compartments in auto interiors.
- Door Panels
- Overhead systems (Headliners: interior roof)
- Floor Pan
- Interior trim (lift gate trim; scuff plates; energy absorption systems; pillar trims and assist handles)

Acoustic Materials used

- Dampening Material: sticks onto the panel to lessen vibrations
- Concealing Material: conceal the music and quietness of car's interior within the car
- Absorbing Material: disperse vibrations evenly when it come into contact with the material
- Sealing Material: to seal up the small holes and openings to block out noise

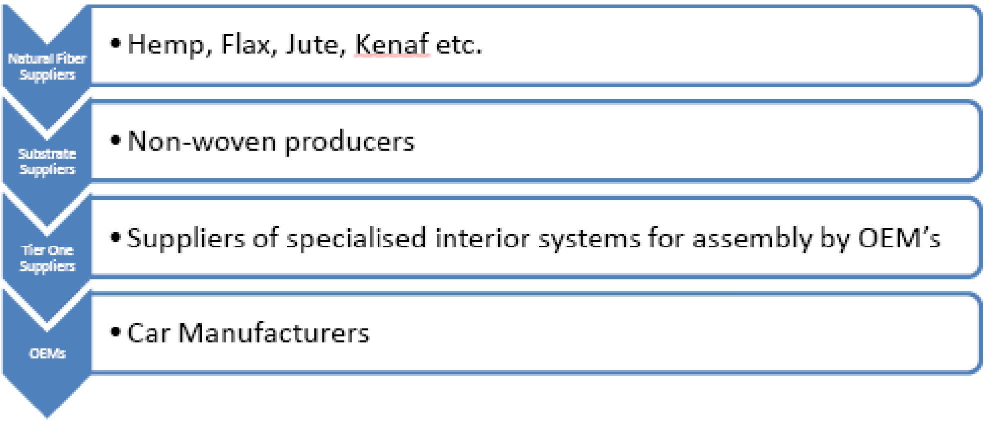
One of the methods to make passenger compartments free from noise is to use sound absorbing materials such as floor coverings, package trays, door panels and luggage compartments in auto interiors. **Natural fibers** are noise absorbing materials that are renewable and biodegradable. A large variety of carpet-type nonwoven materials is seen in floor coverings, luggage areas, and rear shelves in today's passenger cars. The floor covering system is laid on the floor of the **automobile**. Acoustically, the floor covering system blocks road noise filtering from outside to inside of the car.

Properties of Materials Used

Carbon fiber	Glass Fiber	Natural Fibers
Lightweight (Density: 1.5-1.8)		Low density
High strength to weight ratio	High strength-to-weight ratio	High tensile properties

Very High modulus elasticity-to-weight ratio	High modulus of elasticity-to-weight ratio	Higher specific modulus than glass fiber
High Fatigue strength	Good insulating properties	Stiffness
Good corrosion resistance	Low thermal resistance (as compared to metals and ceramics)	
Very low coefficient of thermal expansion	Good corrosion resistance	
Low impact resistance		
High electric conductivity		
High cost		Low cost

Structure of the Auto Component Industry



Market Opportunity

Composites currently represent about five percent, or about 35 kgs, of the weight of vehicles and are used especially in body panels, underbody components, dashboard inserts, door modules, seats, backrests and engine parts.

Current applications, with typical weights of natural fiber used, include:

- Front door liners 1.2 – 1.8 kg
- Rear door liners 0.8 – 1.5 kg
- Boot liners 1.5 - 2.5 kg
- Parcel shelves up to 2.0 kg.
- Seat backs 1.6 – 2.0 kg
- Sunroof sliders up to 0.4 kg
- NVH material min 0.5 kg
- Headliners avg 2.5 kg
- Floorpan not known.

Current BMW 3, 5 and 7 series models use about 20–24 kg of natural fibers and thus validate the approximate figures.

Potential in India

The type of natural fiber selected for manufacture is influenced by the proximity to the source of fiber, thus panels produced in Europe tend to use flax or hemp fibers, panels from South America tend to use sisal, curaua, and ramie and hence **panels from India and Asia should contain jute, ramie and kenaf.**

The Indian automobile production (passenger cars) in 2007-08 is 1286432. The total natural fiber consumption can be estimated to be 28301 tonnes per annum.

The automotive market is also attractive from the point of view of jute producer because the model platform life is usually a minimum 5 years, and last up to 7–8 years.

Jute fiber has several advantages over other natural fibers [sisal, coir, cotton, etc.] due to its low density, high tensile properties, Young's modulus and lower cost. The specific

modulus of jute fiber is higher than that of glass fiber and modulus per cost of jute fiber is also high. In addition, the jute fiber production is less energy intensive than glass fiber composites.

Constraints with Jute

Jute has an internationally recognized quality grading system comprising White (A–D), Tossa (A–D) and cuttings, in descending order. The principal quality problem for jute is the ease of substituting inferior grades to increase margin, notably pulled or recovered jute, which contains many residues and dyes and is quite unsuitable for automotive applications. Impact strength and odour can also be a problem for jute composites.

While increasingly common in the automotive industry, the use of fiber has still to reach its full potential in automotive applications.

APPENDIX B

Publications

1) Fatima, S., and Mohanty, A. R., (2011), Acoustical and Fire-retardant Properties of Jute Composite Materials, Journal of Applied Acoustics 72, 110-114.

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Acoustical and fire-retardant properties of jute composite materials

S. Fatima [1], A.R. Mohanty *

Department of Mechanical Engineering, Indian Institute of Technology, Kharagpur, West Bengal 721 302, India

A R T I C L E I N F O

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Sound transmission
Jute composites
Noise reduction
Flammability

A B S T R A C T

This research aims to study the acoustical and flammability properties of biodegradable and easily disposable natural fibre jute and its composite for noise reduction in house hold appliances, automotive and architectural applications. Acoustical properties of jute fibre and felt (natural rubber latex jute composite) were measured in terms of normal specific sound absorption coefficient and sound transmission loss whereas fire retardant tests included limiting oxygen, flame propagation and smoke density test. The results illustrate that low density jute is a better sound absorber as compared to high density jute material, moreover natural rubber latex jute composite gives higher sound transmission class value than jute felt/cloth. Results were also compared with commercially available synthetic, non-biodegradable, glass fibre which indicates that the noise reduction coefficient value and sound transmission class rating of natural rubber latex jute felt are comparable to that of the popular fibre glass. Fire retardant tests show composite's high limiting oxygen index value as compared to fibreboard and other natural sound absorbing material, wool, low smoke density rating and low light absorption with respect to fibre glass as well as self fire extinguishing ability.

1. Introduction

Increasing use of electrical and mechanical appliances at home and industries has created a concern for noise pollution created by them. Urbanization and heavy growth of construction work in every neighborhood further emphasize the need of new technologies for noise reduction. Noise created by different machines can be controlled either by suppressing the noise generating factors or by using the noise proofing materials which help to reduce the acoustic wave's energy by blocking or absorption. Traditionally, noise is controlled by using expensive and non-biodegradable sound absorbing materials such as glass wool, polymer foams, fabric filler and polymer fibres, posing an additional harm to the environment [1,2]. As an alternate, natural fibres like jute, cotton, flax, ramie, sisal, and hemp obtained from renewable resource can be used as a cheap, biodegradable and recyclable sound absorbing materials. Although composites made of jute fibre/felt with other fibres [3] are being used for various applications in automotive industry, construction, building sectors, furniture etc., yet jute's application as a sound absorbing/blocking material have to be explored as a solution for noise reduction problem.

The health risk factors associated with glass-and mineral-fibre materials, also provide an opportunity to develop the sound proofing material made of natural fibres. In line with above, sound absorption panel produced from particle composite boards using agricultural wastes [4–6], industrial tea-leaf fibre [7] waste materials, have challenged researchers to develop novel enhanced sound proofing material made up of natural fibre [8]. At present the focus, is to develop a cheap, renewable and biodegradable sound proofing material with the help of jute (natural fibre) fibre/felt which is a non abrasive, porous, good insulator, hygroscopic and combustible material for automobile, home appliances and architecture applications [9]. This research carries out study of acoustical and flammability properties of jute and its composites and development of natural rubber (as a binding agent for jute felts/fibre) jute composites based sound proofing material.

2. Methods of measurement

Two different forms of jute, jute felt and jute fibre were used for acoustical and flammability test. Before going to perform these tests, physical properties of the jute fibres such as porosity, flow resistivity, tortuosity and characteristic lengths are investigated. For acoustical properties of jute, normal specific sound absorption tests were carried out on cylindrical jute fibre of TD4 and TD5 (TD4 and TD5 are commercial grades of jute available in India) and jute felt as shown in Fig. 1, alkali treated jute fibre (TD5), and natural rubber latex jute felt whereas flammability and sound

* Corresponding author. Address: Professor, Mechanical Engineering Department, Indian Institute of Technology, Kharagpur. Tel.: +91 3222 282944; fax: +91 3222 255303.
E-mail address: amohanty@mech.iitkgp.ernet.in (A.R. Mohanty).
[1] Tel.: +91 9333847021.

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2) Fatima, S., and Mohanty, A. R., (2012), Noise control of home Appliances –The Green Way, Noise and Vibration Worldwide 43(7), 26-34

Noise control of home appliances – the green way

S. Fatima and A. R. Mohanty*
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur
*Corresponding Author

Shahab Fatima, Research Scholar, Acoustics and Condition Monitoring lab, Indian Institute of Technology, Kharagpur, West Bengal, India, 721302
Email: fatima.iitkgp@gmail.com

Amiya Ranjan Mohanty*, PhD, Professor, Mechanical Engineering Department, Indian Institute of Technology, Kharagpur, West Bengal, India, 721302
Email: amohanty@mech.iitkgp.ernet.in
Contact No: +91 - 3222 - 282944

Abstract
Material used for noise control applications should possess good sound absorption and dampening properties. In this work, the authors have focused on noise control applications of novel material made of jute which is a readily available, cheap and biodegradable natural fiber. Based on physical, flammable and acoustical properties, jute felt shows good sound absorption properties which has been used for noise control in a domestic clothes dryer and a vacuum cleaner. The noise sources in these appliances were ranked by measuring their radiated sound intensity levels. An overall reduction of radiated noise levels of 6 dB and 10 dB were obtained in the domestic dryer and the vacuum cleaner, respectively, by using the developed jute felt.

Keywords: Sound power, Sound intensity, Vacuum cleaner, Domestic dryer, Noise Control, Jute felt

1. Introduction

In recent years, the usage of domestic appliances has increased exponentially and noise associated with it is a major concern of human life in the residential areas. The effect of noise pollution disturbs the human life; is annoying, produces speech interference, sleep interference and decreases work performance. These problems can be overcome by introducing sound proofing materials in home appliances which are good absorber, barrier and dampener. Another important aspect to be considered is the impact of the consumable goods on the environment. The importance of the usage of the green materials has been recognized and implemented by recent authors in possible fields of applications. Fatima and Mohanty [1] focused on developing a cheap, renewable and biodegradable sound proofing material using jute as the source of natural fiber which is widely cultivated in the eastern part of India. Composites made through the combination of jute fiber/felt (natural fiber) with natural rubber can also be used for applications in automotive industry, construction, building sectors, furniture etc.

1.1 Noise Control Materials

1.1.1 Traditional materials

On the one hand, the technology based on synthetic fibre composites made up of glass, kelvar or carbon has played a vital role in noise reduction applications in the aerospace industry since 1950. The advances in composites design after reaching the aerospace requirements is targeted for the general industrial and domestic sectors. In contrast, the increased usage of electrical and mechanical appliances at home and in industry has created a concern for noise pollution. Even though synthetic composites possess specific properties like lightness, high strength-to-weight ratio and stiffness, they are not ideally applicable for the industrial and domestic sectors due to the cost of the raw materials. Further these materials are harmful when decomposed in the open environment.

On the other hand, noise reduction can be effected by isolating the vibration of machinery by providing auxiliary systems comprising special devices – vibration isolation or vibration isolating mounts. The common isolating materials are steel, foam rubber, cork. The objective of vibration

.

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1) Fatima, S., and Mohanty, A. R., (2009), Jute as an eco-friendly noise control material – A case study, Proceedings of National Symposium on Acoustics, 2009, RCI Hyderabad, Nov 26 to 29, (Received Best paper Presentation Award).

Jute as an eco-friendly noise control material – A case study

S. Fatima and A. R. Mohanty

Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur

Abstract

Some of the existing sound absorbing materials for noise control are the expensive non-biodegradable materials like glass wool, polymer foams, fabric filler and polymer fibers. Whereas jute fiber/felt which is relatively cheap, biodegradable, easily disposable and plenty available natural fiber in India, can be a substitute for the above mentioned non-biodegradable materials. Acoustic properties of jute felt/fiber were measured in terms of normal specific sound absorption coefficient and its sound transmission loss (STL). Experimental results show that loosely packed or low density jute is a better sound absorber as compared to high density jute material in terms of normal specific sound absorption coefficient and transmission loss respectively. Natural rubber (NR) latex jute composite gives higher sound transmission class (STC) value compared to jute felt /cloth sandwich. Here a closed enclosure with jute lining along with jute dissipative silencer shows significant reduction in the radiated sound power of a domestic vacuum cleaner.

Keywords: Sound Absorption, Sound transmission, Jute Composites, Sound Power, Noise reduction, Enclosure, Dissipative Silencer.

2) Mohanty, A. R., and Fatima, S., (2010), Jute as an acoustical material for noise control of a domestic dryer Proceedings of the 17th International Congress on Sound and Vibration, Cairo, July 18 to 22.

ICSV 17
THE 17th INTERNATIONAL CONGRESS ON SOUND & VIBRATION
CAIRO 18 - 22 JULY, 2010

JUTE AS AN ACOUSTICAL MATERIAL FOR NOISE CONTROL OF A DOMESTIC DRYER

A. R. Mohanty and S. Fatima
Department of Mechanical Engineering, Indian Institute of Technology, Kharagpur 721302, INDIA
e-mail: amohanty@mech.iitkgp.ernet.in

Traditional sound absorbing materials for noise control are made up of expensive non-biodegradable synthetics such as glass wool, polymer foams, fabric filler and polymer fibres. In this research work, an alternative material made up of biodegradable natural fibre composite is investigated for sound absorption properties. Such natural fibres are jute, flax, ramie, sisal, and hemp. Cheapest of all such available materials was found to be jute, which is cultivated in large quantities in the eastern part of India and Bangladesh. The acoustical properties of jute fibre and felt (natural rubber latex jute composite) were measured in terms of normal specific sound absorption coefficient and its sound transmission loss (STL). Experimental results show that loosely packed or low density jute is a better sound absorber as compared to high density jute material in terms of normal specific sound absorption coefficient. Natural rubber (NR) latex jute composite gives higher sound transmission class (STC) value compared to jute felt /cloth material. Fire retardant tests show that jute composites have high limiting oxygen index value in comparison to fibreboard and other natural sound absorbing material such as wool. Tests also show a low smoke density rating, low light absorption and self fire extinguishing ability of jute compared to fibre glass. A 6 dB reduction in the overall radiated sound power was obtained by using a jute filled acoustical blanket on the domestic clothes dryer.

1. Introduction

Due to our excessive dependence on electrical and mechanical appliances at home and industries, noise pollution has become a major concern. The demand of home appliances is increasing day by day and so is the need to reduce the noise radiated by them. Noise created by different machines can be controlled either by proper design of the noise generating sources or by using sound proofing materials which help in reducing the acoustic wave's energy either by blocking or absorption. Traditionally, noise is controlled by using expensive and non-biodegradable sound absorbing materials such as glass wool, polymer foams, fabric filler and polymer fibres which pose an additional harm to the environment and the users [1-3].

APPENDIX C

Lists of Standards

SAE Standard, Laboratory Measurement of the Airborne Sound Barrier Performance of Automotive Materials and Assemblies, SAE 1990 Standard J 1400.

ASTM Standard, Standard Test Method for Impedance and Absorption of Acoustical Materials using a Tube, Two Microphones and A Digital Frequency Analysis System, ASTM Standard E 1050 - 98.

ASTM Standard, Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index), ASTM Standard D 2863 - 06a.

ASTM Standard, Standard Test Method for Density of Smoke from the Burning or Decomposition of Plastics1, ASTM Standard D 2843 - 99 (Reapproved 2004).

FMVSS Standard, Flammability of interior materials passenger cars, multipurpose passenger vehicles, trucks and buses, FMVSS 1990 Standard 302.

APPENDIX D (Communications)

ISRAIL PLYWOOD

BWR/MR Grade Plywood • BWR/MR Grade Block Board • Fancy Plywood • Flush Door • Film Face Plywood • MDF Board • Particle Board • Gypsum Board etc.

157/C, Lenin Sarani, Kolkata 700013 (INDIA). Phone: +91 33 2215 0585/6244, +91 33 3022 1585
Email: israilplywood@hotmail.com ; Website: www.israilplywoods.com

To,
Prof. A. R. Mohanty
Professor of Mechanical Engineering
Indian Institute of Technology, Kharagpur
Kharagpur 721 302, West Bengal

25th March, 2011

Sub: Commercialization of Jute Panels for Acoustical Applications

Dear Professor Mohanty,

This is in regards to the discussions with you and your research team on the commercialization of Jute Panels for Architectural Applications. We have evaluated the jute products developed by you and have the following to state:

1.) The jute panels developed at IIT, Kharagpur for acoustical applications can be used commercially in Architectural applications.
2.) There is a strong potential of developing this material commercially in the sizes of 8'x4' in thickness ranging from 9mm to 20mm, since no such product or manufacturing plant exists in eastern India for such products
3.) We are agreeable to manufacture such products in our new plant as per the technology developed by you at IIT, Kharagpur on mutually agreeable terms.

We look forward to interacting with IIT Kharagpur in this joint venture.

Thanking you,

Yours Sincerely,

Md. Israil

Md. Israil
Proprietor

Prof. A. R. Mohanty

From: "B. M. Shetye" <bm_shetye@ifbglobal.com>
To: <amohanty@mech.iitkgp.ernet.in>
Cc: "Rajshankar Ray" <rajshankar_ray@ifbglobal.com>
Sent: Wednesday, June 30, 2010 10:08 AM
Subject: Fw: Washing Machine Noise Control using Jute Material

Dear Prof. Mohanty,

We have forwarded our communication along with draft copy of NDA to our Legal Cell. This Cell is in Corporate Office and it may take some time to get their comments. Regret for the delay.

Regards,
B. M. Shetye
----- Original Message -----
From: Prof. A. R. Mohanty
To: B. M. Shetye
Sent: Tuesday, June 29, 2010 5:29 PM
Subject: Fw: Washing Machine Noise Control using Jute Material

Dear Mr. Shetye:
I am looking forward to hear from you on our proposal.

Thanks & Regards,

A. R. Mohanty

****
Prof. A. R. Mohanty (Ph.D., University of Kentucky, USA)
Professor of Mechanical Engineering
Indian Institute of Technology, Kharagpur
Kharagpur 721 302, West Bengal
INDIA

Tel: 03222-282944
Fax: 03222-255303
Cell: +(91)-94340-16966
Email: amohanty@mech.iitkgp.ernet.in
ACOUSTICS & CONDITION MONITORING LABORATORY
****
----- Original Message -----
From: Prof. A. R. Mohanty
To: B. M. Shetye
Cc: Rajshankar Ray
Sent: Tuesday, June 15, 2010 11:21 AM
Subject: Re: Washing Machine Noise Control using Jute Material

Dear Mr. Shetye:
Thanks for your reply. Following are my responses.

1.) IIT will require from IFB the washing machines and cabinets on a returnable basis for the research. IIT will seek technicain help from IFB. IIT will meet the expenses for conducting the research (Pilot trials at IIT) for the first 6 months from its own research funds. If the project needs to be extended beyond December, 2010 additional budget may be required from IFB.

The air travel and local hospitalilty of the two member IIT Team for trials at Goa has to be borne and arranged by IFB during the initial 6 months research period. The transport/freight cost of the washers has to be borne by IFB.

2.) The deliverables by IIT are the design knowhow/implementation of using jute for noise control of the washing machines. Benchmarking of the present BECO washing machine from noise control point of view. Identification of a suitable jute supplier for large scale supply of jute to aid in the mass production. Assist in the field trials at IFB on the developed prototype. IIT will provide the liason with the Ministry of Textiles, Jute Suppliers and IFB. A licensing fee will be charged by IIT if the technology is accepted by IFB, on a mutually agreeable price.

3.) I have enclosed a copy of the secrecy agreement form which has to be signed by both the parties. You can sign the same and send it across to me. We can plan the research for the next 6 months from July to December, 2010.

Thanks & Regards,

A. R. Mohanty

****
Prof. A. R. Mohanty (Ph.D., University of Kentucky, USA)
Professor of Mechanical Engineering
Indian Institute of Technology, Kharagpur
Kharagpur 721 302, West Bengal
INDIA

Tel: 03222-282944
Fax: 03222-255303
Cell: +(91)-94340-16966
Email: amohanty@mech.iitkgp.ernet.in
ACOUSTICS & CONDITION MONITORING LABORATORY
****

----- Original Message -----
From: B. M. Shetye
To: amohanty@mech.iitkgp.ernet.in
Cc: Rajshankar Ray
Sent: Friday, June 11, 2010 10:59 AM
Subject: Fw: Washing Machine Noise Control using Jute Material

Dear Prof. Mohanty,

Thanks for the e-mail. We reviewed opportunities of this project with our colleagues from factory and marketing. Inorder to proceed further, kindly give following:

a) What are the commercial points related to this project

b) Brief definations on project deliverables.

c) Since it is related to new series of washing machines under development, we would like to have NDA. Need a draft copy of NDA executed by IIT for such and similar projects in the past.

Regards,
B. M. Shetye

----- Original Message -----
From: Prof. A. R. Mohanty
To: bm_shetye@ifbglobal.com
Cc: fatima haider
Sent: Tuesday, June 08, 2010 11:26 AM
Subject: Washing Machine Noise Control using Jute Material

To,
Mr. B. M. Shetye
Vice President & Chief Technology Officer
IFB Industries Limited
Home Appliances Division
L1, Verna Electronic City, Verna
Salcete, Goa-403722

No: IIT/ME/ARM/479/2010
8th June, 2010

Sub: Washing Machine Noise Control using Jute Material

Dear Mr. Shetye:

At the outset I would like to thank you and your team for the nice hospitality shown to myself and my student during our visit to your plant on the 4th of June, 2010. As discussed with us I propose the following plan of action for conducting the trials on the 1200 RPM IFB washer for noise control using the jute composites developed by us at IIT, Kharagpur.

1. Evaluate the thermal and acoustical properties of the noise control material being used by competitors, which has been provided to IIT, Kharagpur on the 4th June.
2. Sound power level measurements and noise source ranking of the 1200 RPM (BECO) washer to be done at IIT, Kharagpur. IFB will arrange to send the washer along with two additional cabinets to IIT, Kharagpur.
3. In July, 2010 IFB will provide one of the prototypes of the 1200 RPM washer along with two additional cabinets for evaluation at IIT, Kharagpur with the developed jute meaterials. IFB will provide a technicians help during the above trials.
4. Following the measurements/trials at IIT, extensive life-cycle tests will be carried out at IFB on the prototype.

IFB Engineers are welcome to witness all the trials at IIT, Kharagpur. On successful conclusion of the above exercises, IIT will coordinate with the National Jute Board of the Ministry of Textiles for the availability of jute as a noise control material to IFB for use in washing machines.

I look forward to your views on the same, so that we can proceed accordingly.

Thanking you,

With Warm Regards,

Yours Sincerely,

5/5/2011

A. R. Mohanty

****
Prof. A. R. Mohanty (Ph.D., University of Kentucky, USA)
Professor of Mechanical Engineering
Indian Institute of Technology, Kharagpur
Kharagpur 721 302, West Bengal
INDIA

Tel: 03222-282944
Fax: 03222-255303
Cell: +(91)-94340-16966
Email: amohanty@mech.iitkgp.ernet.in
ACOUSTICS & CONDITION MONITORING LABORATORY
****

5/5/2011

APPENDIX E (Marketing Leaflet)

SOUND PROOFING JUTE COMPOSITES FOR NOISE CONTROL APPLICATIONS DEVELOPED AT IIT, KHARAGPUR

Range of Products

Jute acoustical Ceiling for Sound Absorption (2' x 2' x 0.5")

Jute Panel for Sound Blocking (10" x 10" x 0.2")

Jute blanket for Sound Absorption

Key Selection Attributes:
Natural, Eco-friendly, Biodegradable, Cost effective, Self-extinguishing

Typical applications:
Buildings Acoustics, Automobiles, Home appliances, HVAC, Generator Enclosures.

Physical and Acoustical Properties:
Excellent Fire Retardant Properties, High NRC and STC Values for Sound Attenuation (Values available on request).

For Details Contact:
Prof. A. R. Mohanty
Professor of Mechanical Engineering
Indian Institute of Technology, Kharagpur
Kharagpur 721302

APPENDIX F

<u>Summary of the R&D Project as per Proforma</u>

A. Title of the project

- Development of sound proofing composites materials using jute products

B. Objectives of the project

- The main objective is to develop the jute products for the noise control application like home appliance, industrial noise, acoustical ceiling based on the acoustical, flammability, and physical properties.

C. Whether products / processes under the project have been developed?

- Yes. We developed and tested jute products in laboratory level and industrial level for the noise reduction in home appliances such as vacuum cleaner, domestic dryer and acoustical ceiling application.

D. If yes, then, whether the products/ processes standardization done?

- Yes. The products/processes are standardized by conducting lab/industry trials.

E. If yes, please give the details with respect to the parameters along with product photographs or process flow chart etc.

- *Jute products for home appliances:*
  Material: Untreated jute felt

Figure F1: Vacuum cleaner with jute enclosure and jute muffler

Figure F2: Domestic dryer with jute acoustical blanket

- *Perforated jute ceiling panels:*
  Material: Untreated jute fiber inside perforated Aluminum sheet

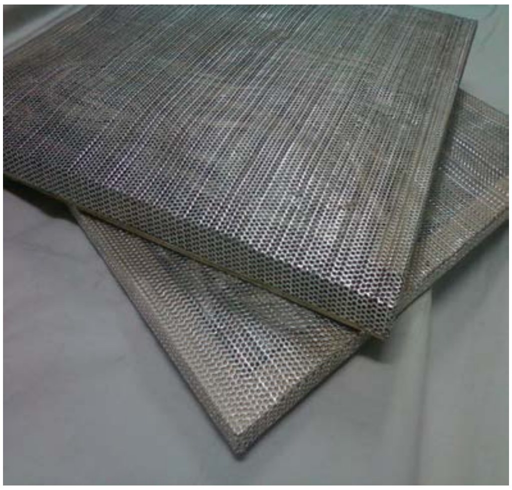

Figure F3: Jute fiber panels of 1inch and ½ inch

F. If no, when it is likely to be completed?

- NA

G. Whether process feasibility and cost effectiveness studied?

- Yes. Based on the lab/industrial level experimentation, the process feasibility and cost effectiveness were studied as follows:
- *Vacuum cleaner*
  The process feasibility these jute products seem to be high because these products are mainly based on the raw jute so that the no additional treatment is required. At the other hand, the cost per product can be low. The cost effectiveness of the jute product is very high compared with fiber glass. Based on these observations, the scope of mass production of jute based products for noise dissipation of vacuum cleaner is high.
- *Domestic dryer*

The product cost of 5% rubber coated Jute composite (150 mm x 150 mm x 5 mm) is ₹15 and cost of 5% rubber coated jute composite (250 mm x 250 mm x 5 mm) is ₹20. From the results of domestic dryer, the jute products such as blanket and jute felt lining are derived directly from raw jute. No additional treatment is required. For this case also the process feasibility and cost effectiveness are high.

- *Acoustical ceiling applications*

  The perforated jute panels for acoustic ceiling applications were developed and tested in Acoustics laboratory, IIT Kharagpur. The overall prototype development cost per panel and individual cost of materials are tabulated in Table 1. The cost of a perforated jute panel of (2” x 2” x 0.5”) is ₹ 369 which is quite high comparing with ordinary mineral fiber board for ceiling which is ₹70. On the other hand, the cost effectiveness of these jute panels is very high in comparison with synthetic material such as fiber glass for noise reduction in industrial application.

Table F 1: Individual cost of materials for perforated jute panel

SI.No.	Material	Rupee ₹
1	Perforated aluminum sheet	224
2	Jute fiber	33
3	Wooden board	44
4	Wood	23
5	Nail	5
6	Labour charge	40
Total		369

H. If yes, please give the details in a tabular form.

Application	Jute Product	Cost effective	Process feasibility
Vacuum Cleaner	Untreated jute felt	No additional treatment cost	High because of the use of raw jute and no additional treatment
Domestic Dryer	Untreated jute felt	No additional treatment cost	High because of the use of raw jute and no additional treatment
Acoustic Ceiling	Untreated jute fiber	Additional panel making cost which can be further reduced in bulk production	High because of the use of raw jute

I. Name of the units/ mills where bulk trials conducted.

- IIT Kharagpur
- IFB, Goa
- Israil Plywood

J. Whether the unit has any comment/ remarks on the bulk trial?

- Agreeable by IFB Industries, Goa and Israil Plywood. Please see details of communication in Appendix D.

K. If yes, please attach the copy.

- Please refer to Appendix D
