Applications of Agro Waste Cellulosic Material in Acoustic Absorption

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Abstract - *A needle punching process using Cotton, Kapok, and Areca fibres at a consistent punch density (300), an eco-friendly nonwoven fabric was developed. The effect of cotton, kapok, and areca fibre content (45:10:45, 60:10:30, 30:10:60, and 40:20:40) on the tensile, thermal conductivity, air permeability, and sound absorption characteristics of needle punched non-woven textiles was studied. The tensile strength of nonwoven fabric was observed to be higher, with a tensile strength of 2.56 CN/Tex. The non-woven fabric has a greater thermal conductivity and air permeability than the other nonwoven fabric. In the reverberation time technique, the highest sound absorption coefficient is 0.923 was observed in this study. The nonwoven fabric created in this study can be utilised as a sound insulation material in commercial settings such as theatres, malls, and auditoriums, among other things.*

Key Words: Thermal conductivity, Air permeability, and Sound absorption, Sound Absorption Coefficient, Reverberation Time…

1. INTRODUCTION

In today's world, noise has a significant impact on human health. Noise pollution, in particular, has a significant negative impact on the environment as a result of development. Noise pollution from several technologies and industrial uses has resulted in a slew of issues that have harmed people's live[1].Unknowingly, noise or unpleasant sound disrupts people's everyday routines and health. After conducting a study and survey, the National Institute of Occupational Safety and Health (NIOSH) set a maximum of 85 decibels for eight hours per day[2].

According to the World Health Organization, more than 30% of the population in EU countries is exposed to noise at night. The growing interest in engineering and research to develop sound-absorbing materials for noise reduction. Textile is a key component of sound-absorbing materials. Bulk density, thickness, and fibre arrangement all had a substantial impact on sound-absorbing material. Sound-absorbing materials are often comprised of synthetic fibre, which uses a lot of energy during the manufacturing process. Sustainable materials, on the other hand, are effective sound absorption materials.[3].One of the main engineering procedures used to control environmental noise is the use of sound-absorbing materials[4].

The development of renewable-source acoustical materials as viable alternatives to mineral wool, fibreglass, and other synthetic fibres has gotten a lot of attention, especially in acoustic applications.[5]. Natural fibres are biodegradable in general, and processing them may be made more cost-effective and environmentally beneficial. Natural fibres have also been shown to be safer for human health than most mineral synthetic fibres because they don't require special care. Recent research has focused on the utilisation of natural fibres, such as vegetal and animal fibres, to create eco-friendly sound-absorbing materials.

Several natural fibers suitable as bases for sound-absorption materials, such as bamboo[6], ramie [7], coir and fiber from date palm[8], fiber from oil palm empty bunch[9],flax[10], bagasse[11], corn husk[12], pineapple leaf [13], broom fibers[14], chicken feathers[15], sisal[16], kenaf [17]and other sustainable fibres.

Areca is grown for its fruit nuts in India and other Asian nations. Areca nuts have been utilized in India for medical purposes, as well as paint, chocolate, and chewable gutka. Areca fiber makes up 60 to 70% of the entire weight and volume of the areca fruit. Areca fibers have an average length of 3 to 6 cm. The fiber might be used to make value-added goods like thick boards, soft pillows, non-woven textiles, and thermal insulators, among other things.Because of its high absorption coefficient, Areca Nuts fibre composite is an effective sound proofing material at low and medium frequencies[18]

Hollow structure affects the buoyancy behaviour of kapok fibre. Because of these characteristics, kapok fibre has a high porosity, which improves sound absorption properties. The large cross sectional diameter of kapok fibre increases friction resistance between air and fibre, resulting in energy dissipation.[19]In both the lateral and longitudinal parts of the fibre, the cell wall of kapok fibre differs from that of cotton fibres.[20]

Cotton has an excellent cohesive property and may be utilised to make nonwoven fabrics because of its increased cohesiveness and quietness. Sound absorption increases with a decrease in fibre diameter, resulting in an increase in airflow resistance. The quantity, size, and type of pores on the material's surface are other factors that allow sound to be dissipated through friction. So that the cotton has been selected minimum amount to find the qualities of other fibres.

In this study, the sound-absorption properties of areca, kapok and cotton fiber blends different proportions are measured and Sound-absorption coefficients and Noise Reduction Coefficient are measured for the different combinations of fiber mixture by reverberation time method.

2. MATERIALS AND METHODS

2.1 Nonwoven fabric production

Nonwoven fabrics have micron and submicron holes, making them ideal for sound absorption[21]. Many elements, such as fibre characteristics, process parameters, and physical parameters, can increase the sound absorptive capabilities of nonwoven fabric[22].The following processes were used to prepare needle-punched nonwoven fabric. The lab model blow room machines from Trytex were utilised to make homogenous mixing and cleaning in the first stage. To increase the blend's homogeneity, the fibre mixes were ran through the opener two times. Blended fibres were carded in the second stage with a lab model carding machine to remove dirt particles, align fibres, and generate webs. The needle-punching process is used to create nonwoven fabric consolidation. This approach involves repeatedly piercing through the fibre web with an array of barbed needles to mechanically connect fibres.

Figure 1: Lab model carding machine

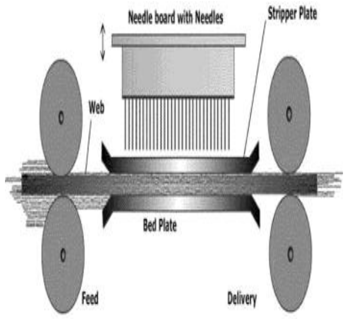


Figure 2 : Needle punching machine

2.2 Sound Absorption Testing by Reverberation Time Method

The sound absorption property is measured by the reverberation time method with the specification of ASTM C-423. The acoustic characterization of the samples is tested under standard testing conditions.

Sabine's reverberation formula is still widely acknowledged as a very practical evaluation method for the reverberation time in rooms, and it is used to determine the material absorption coefficients with the help of reverberation rooms. Sabin is a measurement of sound absorption that measures the area of an open window in square meters. The method's primary idea is that sound energy travelling into an open window in a room is not reflected at all; yet, it completely vanishes in the open air outside. If the open window is replaced with 100 percent absorbent material in the same sizes, the same effect will be attained[23].

$$\alpha = \frac{0.163 \times V}{S}\left(\frac{1}{TR} - \frac{1}{TR_0}\right)$$

Where V is the chamber volume, S is area of the sample, TR is the sound receiving time with the test sample inside the chamber, TR_0 is the sound receiving time without the test sample inside the chamber.

Sabine also came up with a definition for the time it takes for residual sound to decline below detectable levels, T, by starting with a 1,000,000 times larger initial amount, as seen in the equation below.

$$T = 0.163\ V / A$$

Where V is the room volume in m^3 and A is the total absorption area in m^2[24].

The experimental setup is shown in fig. We used a loudspeaker system, a microphone for generating sound signals, a sound pressure level meter, and a reverberation room chamber of volume 64 cubic feet (1.81228 m^3). The testing is carried out under two conditions-without sample(empty room absorption) and with samples(full room absorption).


Figure-3 Experimental setup for measuring sound absorption by reverberation time method

First, the reverberation time of the empty room without sample is measured by the following procedure. A band of random pink noise, a 1/3 octave band noise at 90 dB, was used as a test signal and was turned on long enough for the sound signal to stabilize. When the signal was turned off, the sound pressure level decreased (90-60=30dB) and each frequency band's decay rate was determined by measuring the slope of a straight line fitted to the average decay curve's sound pressure level. The absorption of the empty room was calculated from the Sabine absorption formula,

The specimen of size 18 x 18 inches (0.209032 m^2)(Areca,kapok,cotton blended nonwoven) was installed and the same procedure is repeated for measuring full room absorption. The specimen's absorption coefficients were calculated as follows:

2.3 Noise Reduction Coefficient(NRC)

The arithmetic mean of the absorption coefficients in 1/3-octave frequency ranges is used to compute the noise reduction coefficient (NRC). This number has been rounded to the closest 0.05 multiple. The perfect reflection is shown by the NRC value of zero. The NRC number 1 indicates that perfect absorption has occurred. This parameter can also be measured using reverberation room techniques[25].

3. RESULT AND DISCUSSION

This chapter summarises all of the test results as well as the nonwoven fabric samples that were investigated. The test results and details have been examined, and an attempt to explain the findings has been made. All of the chosen fibres include the largest quantity of cellulose components, and they are all biodegradable waste from agricultural applications.During the purpose testing, each sample is tested 10 times and the average is calculated and tabulated in table 1.The relationship between air permeability and heat conductivity is seen in Figure 4. According to this research, when air permeability is high, thermal conductivity is higher. The reverberation time RT 60, as shown in figure 5, is dependent on the thickness and areal density of the material used in nonwoven manufacture

Table1: List of tests and reports

Sample ID	Blend ratio	Thickness mm	GSM	Rt_{60} sec	[illegible]	Tenacity CN/tex	Air permeability $m^3.m^{-2}.min^{-1}$	Thermal conductivity, W/m.K
ACK 1	45:10:45	5.315	442	0.189	0.923	1.34	40.89	0.02991
ACK 2	60:10:30	5.195	456	0.192	0.891	1.51	47.31	0.04288
ACK 3	30:10:60	4.967	427	0 .195	0.737	2.56	46.63	0.03177
ACK 4	40:20:40	5.505	448	0.198	0.648	1.32	48.29	0.03643

Figure 4: Air permeability and thermal conductivity

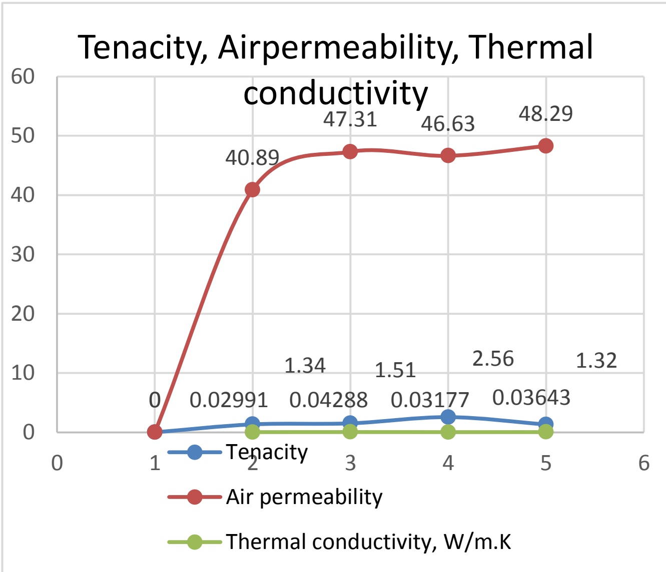
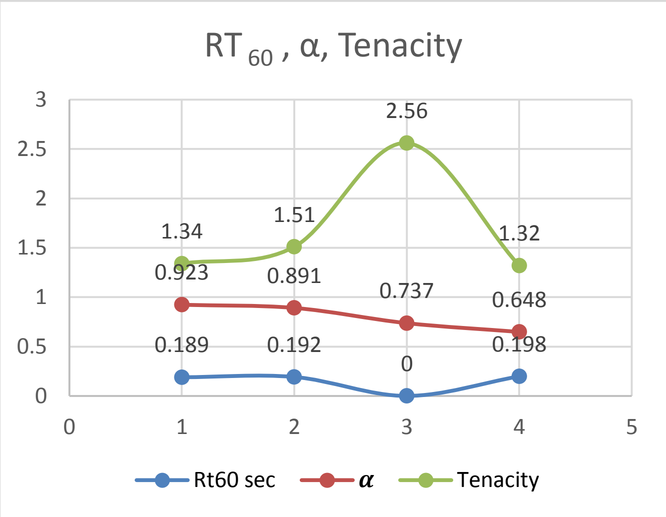


Figure 5: RT 60 and Tenacity



4. CONCLUSION

The Areca, Kapok, Cotton blended nonwoven was produced with four different blend ratios of 45:10:45, 60:10:30,30:10:60 and 40:20:40. The effect of fibre content on tensile strength, thermal conductivity, air permeability, and sound absorption qualities was investigated.The results show that when mixed with kapok fibre, areca fibre nonwoven fabric has the maximum tensile strength. Because of the kind of fibre and changes in composition, the thickness and areal density of the nonwoven material varies.This study's needle punched non-woven cloth can be employed for acoustic applications in industries.

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