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Development of Non-Woven Composite Materials using Reclaimed Fibers for Sound Absorption

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Abstract

Sound absorption behavior is an important requirement for the human life today, since noise affects the capability of day to day activities and even causes various health problems. Sound absorbent textile materials, especially non-woven composite structure of reclaimed materials have low production costs, low specific gravity and are aesthetically appealing. In this research the use of reclaimed cotton and polyester fiber for the development of sound absorptive non-woven composite materials has been explored. Three different blend ratios of reclaimed cotton and polyester fibers that is 25:75, 40:60 and50:50 have been used. The reclaimed cotton and polyester non-woven composites are characterized for their physical properties, such as thickness, areal density, bulk density, porosity and sound absorption characteristics in the frequency range of 250HZ-2000HZ. The values of sound absorption coefficient and noise reduction coefficient obtained signify that the reclaimed polyester fiber non-woven composite possess very good sound absorption behavior in the entire frequency range. Before compressed reclaimed cotton/polyester nonwoven composite of 25:75 blend ratio with high bulk density and low porosity is found to give the excellent performance when used by provided that air gap behind the reclaimed cotton/polyester non-woven composites.

Keywords: Reclaimed fiber • Areal density • Non-woven composite • Impedance tube method

Introduction

Reclaimed fibers have proven to be suitable reinforcement materials for composites recognition to a combination of good mechanical properties and environmental advantages such as renewability and biodegradability expressed that acknowledged that a composite is a material that consists of more than one component, in which at least one of the components remains in solid state during its manufacture. Several applications of reclaimed fiber composites can be found in construction, packaging, furniture and automotive fields. Says that more environment friendly composite materials for automotive manufacturing have been made by substituting coir fibers for the widely used polyester fibers to make non-woven fabric composites of coir fibers and recycled polypropylene fibers. Stated that the non-woven composite from reclaimed fibers that can be applied in buildings as a filling and facing insulation materials. Structural and insulation materials made of natural raw materials ensure full and active "breathing" of the whole structure element giving users a real feeling of building comfort. Indicate that today much importance is given to the acoustical environment [1]. Noise control and its principles play an important role in creating an acoustically pleasing environment. This can be achieved when the intensity of sound is brought down to a level that is not harmful to human ears. Mention about Noise is a major cause of industrial fatigue, irritation, reduced productivity and occupational accidents. Continuous exposure of 90dB or above is dangerous to hearing. Installation of noise absorbent barriers (made from wood and textiles) between the source and the subjects is one of the main methods of noise control. Measurement techniques used to characterize the sound absorption properties of a material are reverberant field method, impedance tube method and steady state method. Acoustic insulation and absorption properties of non-woven composite depend on fiber was found to increase with the decreasing fiber diameter and length and increasing surface area i.e. large surface area and shorter length increase the absorption of sound. It was also observed that as sound reduction increases with the distance between the non-woven fabric and the sound source, and this effect increases with the increase in the areal density of fabric geometry and fiber arrangement within the fabric structure expressed verified that the sound absorption coefficient. The sound absorption is one of the most important acoustical properties of the porous materials used for sound insulation products having the role of sound barriers, walls, road surfaces. Depending on the type of materials and products, the range of frequencies and applications, the measurement methods of absorption coefficient vary and they can be: the impedance tube method. Stated that through the behavior of few reclaimed fibers has been investigated, the acoustical characteristics of recycled cotton

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and polyester fiber are rarely studied. The reclaimed cotton /polyester fiber has a good physical properties like span length of reclaimed cotton 12.12%, reclaimed polyester13.6% and uniformity ratio of reclaimed cotton 35.46%, polyester37.67% and fineness of reclaimed cotton 3.452(u/inch), polyester 3.456(u/inch) tenacity of reclaimed cotton fiber 24.5(g/tex) and reclaimed polyester fiber 30.56(g/tex) respectively. However, it's found that the technical data on acoustics properties of reclaimed cotton and polyester non-woven composite is not available. Hence, the present research has been carried out to develop and investigate the sound absorption characteristics of reclaimed cotton and polyester fiber nonwoven composites.

Materials and Methods

Reclaimed fibers

The raw material for the nonwoven is 'Trimmed waste' of garment industries. Garment industries are producing the garments in a high volume, which in turn gives high volume of trimmed waste. This waste fabric converted in to reclaimed fiber using recycled fabric waste opener machine. These wastes fiber classified in to cotton and polyester for used as raw material to develop adhesive bonded non-woven fabrics.

Web formation

The fed web in this machine is opened further to achieve very thin layer of fiber, which are deposited over the circumference of the condensing cages (by the aerodynamic principle of web formation) and thus the thin fibrous layer is delivered [2]. This web former produces 138 meters of fibrous layer per hour. The fibrous layer from the web former is sprayed with Polyvinyl Acetate (PVA) at a constant pressure and flow as shown. The adhesive add on percentage is taken care to maintain at 20%. Precaution is taken to avoid excessive or lesser flow of adhesive through the sprayer. By the calendar roller pressure, the fibrous layer is converted into nonwoven fabric. The spray adhesive bodings are an exact measure of the amount of binders applied, uniform binder distribution and a soft fabric handle. The preferred samples of proportions with 6-8 mm thick, 80 mm wide and 200 mm long were developed to non-woven composite materials (Figure 1 and 2).

Figure 1: Chemical bonding non-woven.

Figure 2: Impedance Tube Method (ASTM E 1050).

Preparation of non-woven composites

The table 1 shows that the blend proportion of reclaimed non-woven composite with fabric loading was fabricated using chemical bonded non-woven samples with size mound of 28 cm (length, L) × 28cm (width, W) × 0.7 cm (Thickness, T) initially, epoxy and hardener were mixed in ratio of 4:1 to form a matrix. Then, non-woven fabric was spread into mould and covered with the matrix. The curing time of 6 hours was maintained uniformly for the composite materials at (60°C). Two different types of nonwoven composite samples, namely before compressed form (BC) under zero load condition and after compressed form (AC) with the application of 22.27/kg/m2loaded were produced. This load was selected with the view to reduce the thickness of around 20% compared to before compressed form (Figure 3).

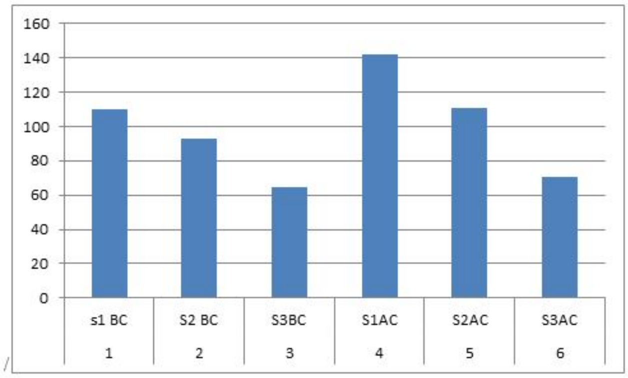

Figure 3: Bulk density of Reclaimed Cotton/polyester non-woven composites.

Analysis on Physical properties of reclaimed non-woven composites

The non-woven composite (t) Fabric thickness (mm) was determined in accordance with ASTM D5729 standard method. Average of 20 observations was taken for each sample. Areal density a study showed the increase of sound absorption value in the middle and higher the frequency as the density of the sample increased. The number of fibers present in the chemical bonded non-woven samples from reclaimed cotton and polyester fibers increases per unit area when the apparent density is large [3]. The areal density was determined in accordance with ASTM D 6242. The developed chemical bonded non-woven composite samples using reclaimed fibers are subjected to bulk density analysis for the influence of sound absorption behavior. The specimen with 12 cm diameter and 80cm2 areas were cut out randomly and weighted. Average of 20 observations were taken for each sample and expressed in kg/m2.The bulk density was calculated by using the following relationship (Figure 4).

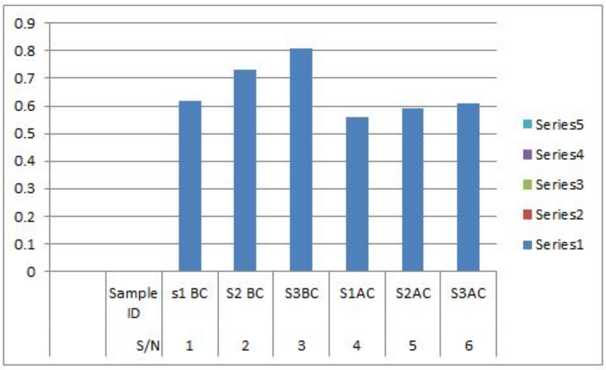

Figure 4: Porosity of Reclaimed Cotton/polyester non-woven composites.

The Sound Absorption Coefficients (SAC) of the nonwovens composite were tested by the impedance tube method on ASTME 1050. A sound source (loud speaker) is mounted at one end of the impedance tube and at the other end the nonwoven and composite materials are placed. The loud speaker generates broadband, stationary random sound. This sound propagates as planner waves in the tube, hits the sample and gets absorbed. Thus a standing wave interference pattern results due to superimposition of forward and backward travelling waves inside the tube. The sound pressure at two fixed location is measured and by using the two-channel digital frequency analyzer. From the results it will be possible to determine the complex reflection coefficient, the sound absorption coefficient and the normal acoustic impedance of the nonwoven composites. The sound reduction coefficient NRC by the specimen can be calculated by the following derivation (Figure 5).

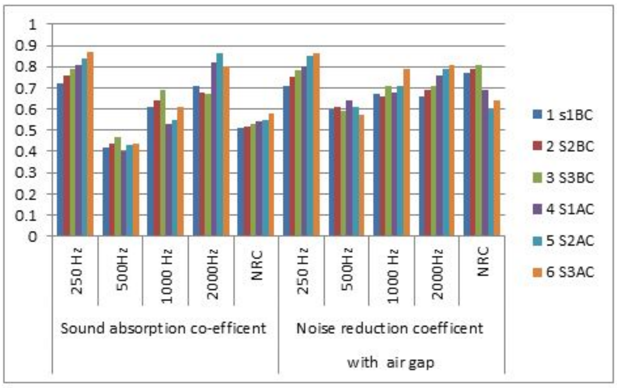

Figure 5: Porosity of Reclaimed Cotton/polyester non-woven composites.

The samples were placed in three different positions: 25 cm, 50 cm, and 75 cm from the sound source and measured for sound source and measured for sound reduction with three decibel value of 60 dB, 70 dB, and 80 dB. The average sound reduction percentage of these three decibel values are calculated and compared for all the samples.

Results

Analysis on physical characteristics of reclaimed nonwoven composites

The content of polyester fiber in the nonwoven composite increases from 20% to 40% (from s1to s3) the result reveals that the increase in thickness of the nonwoven composites. When there is an increase in areal density there is an increase in sound absorption coefficient for reclaimed cotton and polyester non-woven composites. The bulk density of after compressed and before compressed samples decreases.

Further, it can be observed that the bulk density of after compressed composites is higher than that of before compressed composites.

Increase in polyester content in the blend increases the porosity but it decreases on compression. Moreover, they showed the following effects of density on sound absorption behavior of nonwoven fibrous materials, less dense and more open structure absorbs sound of low frequencies (500 Hz). Denser structure performs better for frequencies above than 2000 Hz [4]. The above said results are in line with the bindings (Table 1).

S/N	Sample	Blend R/C	Ratio R/P
1	S1 BC	25	75
2	S2 BC	40	60
3	S3BC	50	50
4	S1AC	25	75
5	S2AC	40	60
6	S3AC	50	50

Table 1: Reclaimed cotton polyester blend ratio.

Performance in the without air gap

Before compressed reclaimed non-woven composites:

The increase in the reclaimed polyester content in the reclaimed non-woven composites does not show significant changes in SAC, at all the frequencies. These composites have superior absorption behavior towards 250 Hz and 2000 Hz and reasonable to low behavior at average frequency levels. However, the diversity in behavior of the non-woven composites with respect to frequency levels is not reflected in its NRC. This same trend was observed (Table 2).

Physical properties of Reclaimed C/p non-woven composites

S/N	Sample	Thickness (mm)	Areal density g/m2	bulk density g/m3	porosity (H)
1	s1 BC	7.72	330.5	110.29	0.62
2	S2 BC	8.21	653	92.61	0.73
3	S3BC	8.42	980.77	64.71	0.81

4	S1AC	4.34	323.11	142.31	0.56
5	S2AC	4.64	648.1	110.72	0.59
6	S3AC	4.71	960.21	70.22	0.61

Table 2: Physical properties of reclaimed non-woven composite materials.

After compressed reclaimed non-woven composites:With respect to reclaimed polyester content, theses composites are found to perform like before compressed composites. Their behavior on sound absorption at dissimilar frequency levels is also found to be the same as in before compressed composites. But absorption at lower and average frequency levels and at high frequency level is lower and higher than in before compressed composites respectively. The NRC values obtained are found to be approximately the same as in before compressed composites findings of sound absorption with combination of nonwoven fabric of reclaimed fiber other natural fibers.

Performance in the with air gap

Before compressed reclaimed non-woven composites:

The increase in reclaimed polyester content in composites does not have effect at low and upper middle, and high frequencies, whereas it has a distinctive effect at lower middle frequency (500 Hz).These composites have greater sound absorption behavior at higher middle and high frequency levels compared to that at low average frequency. However, these effects are not significantly reflected in the NRC values. The overall performance of these non-woven composites with respect to SAC and NRC is enhanced than that of before compressed and after compressed samples in the without air. In their findings Fibers interlocking in nonwovens are the frictional elements that provide resistance to acoustic wave motion.

After compressed reclaimed non-woven composites:

Reclaimed polyester content in these composites does not show any effect at low and high frequency levels, whereas it decrease at low average frequency and increase at high average frequency levels. Sound absorption is originated to be high at low frequency levels compared to that at all other frequency levels. It is all so found that the sound absorption of these composites is lower than that of before compressed samples at all frequencies. In this case also, the difference with respect to sound absorption at dissimilar frequency levels is not establish to reflect significantly in NRC but the values obtained are lower than that of before compressed reclaimed non-woven composites [5]. In his research findings in designing a reclaimed nonwoven web to have a high sound absorption coefficient, porosity should increase along the propagation of the sound wave.

Conclusion

Considering reclaimed polyester content in non-woven composites and the role of compression on the behavior of composites in the with and without of air with respect to SAC at dissimilar frequency levels and NRC, it can be understood that the highest sound absorption at any particular frequency between 250 Hz and 2000 Hz and highest absorption of sound waves with varying frequency in higher than frequency range can be obtained from the before compressed reclaimed cotton/polyester non-woven composite of 25:75 blend ratio having high bulk density and low porosity. This strength has resulted in high frequency of the non-woven composite a preferred property for sound absorption, in with of air gap behind the composite. As the prospective for sounds absorption appears bright, further examination in the direction of understanding the reclaimed polyester fiber behavior in the composite would positively lead to a superior solution for noise decrease. The same trend was in their research work developed a porous laminated composite material by molding of premix, pre heating and lamination exhibited a very high acoustic coefficient property on the frequency range of 250 Hz and 2000 Hz.

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