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Development of Needle Punched Non-woven Fabrics for Acoustic Application

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Abstract: Acoustic insulation is an important requirement for the human life today, since noise affects the efficiency of day-to-day activities and even causes various health problems. Materials based on fibrous structures show very good acoustic insulation properties, which however strongly depends on the type of structures used. The present paper focuses on qualitative analysis of the acoustic insulation behaviour of various needle punched nonwoven fabrics. Non – woven fabric shows higher sound reduction than the woven fabric. Produced nonwoven fabric combinations of three types of recycled raw materials like polypropylene 50%, PET 20% and hollow PET 30% were taken blended. webs have been produced by needle punched nonwoven with three different stitch density (punches per square meter)) of 250 , 300 and 450 for the acoustic application. The results shows that the acoustic insulation is better in 250 SD needle punched nonwoven than the other samples. Also non woven made from recycled fibres like PET, hollow PET and polypropylene show better performance than the materials made from jute, wool and wood charcoal.
Keywords: blended fabric, Polypropylene, hollow PET, nonwoven fabric, acoustic, sound reduction.

Introduction

During recent years, the subject of noise has received increasing amount of attention to the scientists, technologists and public as a whole. There is ample evidence showing that the high noise levels cause sleep disturbance, hearing loss, decrease in productivity/ learning ability/ scholastic performance, and increase in stress related hormones and blood pressure. Therefore, unwanted and uncontrolled noise should be reduced using noise barriers and noise absorbers. Properly designed textile materials may be considered as noise control elements in a wide range of applications, including wall claddings, acoustic barriers and acoustic ceilings.

The air inside the pores acts as damper. The most effective way to increase damping is through the use of a viscous interlayer such as soundproofing mat. Bending waves, excited by the incident sound, cause shear strains within the viscous interlayer material. Because the interlayer has inherently high damping, the bending waves are transformed into heat energy. The mass law predicts that the transmission loss will increase by approximately 6 dB for doubling of the surface mass using thicker material or denser material[1].

The sound reduction between two spaces is dependent on all of the elements of the structure separating them. The sound pressure waves cause the fibres or particles to vibrate. These movements are so small that they are not normally visible. This vibration liberates tiny amount of heat due to the friction and thus absorbed sound energy is converted to potential and heat energy. The mass law predicts that the transmission loss will increase by approximately 6 dB for doubling of the surface mass using thicker material or denser material[2].

A numerical method of calculating acoustic performance of nonwovens has been proposed in a study[3] and the noise absorption coefficient of fibre webs is shown as a function of their thickness and porosity. It has been shown4 that the absorption coefficient is higher for the nonwoven having more fine fibres. The use of nonwoven is increasing rapidly in the automobile industry due to its sound insulation property[5]. One of the oldest applications of impregnated jute or shoddy mat is in noise damping[1,6]. The efficacy of the nonwoven materials as sound insulator has been examined by Teli et al[7].

Materials and Methods

The models on sound absorption of fibrous materials, coupled with experimental data will help in modeling sound absorption in single-layer needle-punched nonwoven fabrics containing three different recycled fibers. The blend proportion of the developed material is 50% polypropylene, 20% Polyethylene Terephthalate (PET) and 30% Hollow PET.

Three web samples are produced with non woven needle punch technique with 250, 300 and 450 Stitch Density (SD- punches per square meter). The areal density of all samples was maintained at 550 grams/square meter. The methodology of sample preparation is illustrated in Figure 1.

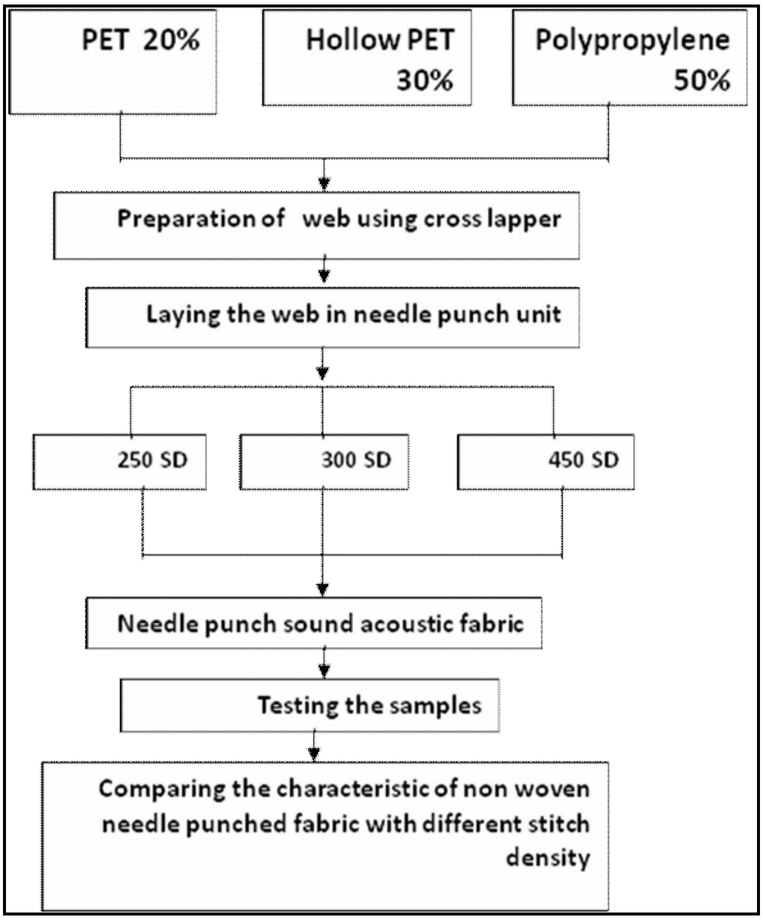

Figure 1. Flow chart for Experimental Method

Measurement of Sound Insulation

A simple testing apparatus, shown in Figure 2, has been set up to measure the permeability of sound through a needle-punched nonwoven fabric. It consists of a sound insulating box made out of thick transparent rigid plastic with removable top lid. Inside one vertical wall of this box a sound source and a decibel meter (S) are fixed. In another movable (to adjust the distance between sound source and receiver) vertical wall, a decibel meter (R) is fixed coaxially opposite to sound generator to measure the sound intensity. In between these two decibel meters, a sliding (to adjust the distance between sound source and fabric) arrangement is there to fix the fabric sample vertically. The sound intensity is controlled by an electrical panel.

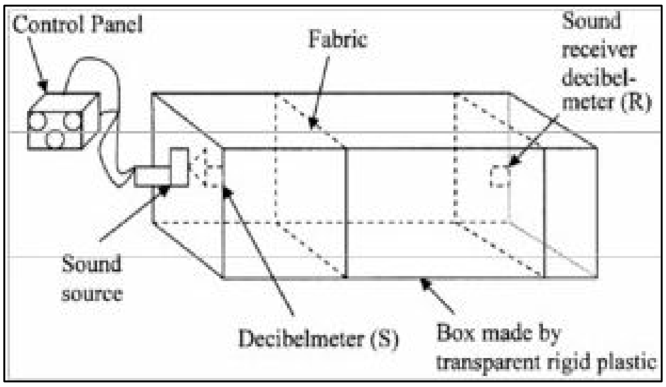

Figure 2. Set-up for measurement of sound reduction

A sound of particular decibel is created by operating the control panel. The source decibel and the receipt decibel have been measured by two decibel meters S and R respectively without and with fabric sample. The sound reduction responsible for fabric which is expressed as the measure of sound insulation can be calculated as shown below:

dbf = (Decibel reduction with sample) – (Decibel reduction without sample)
where, dbf is the sound reduction responsible for fabric.

Sound Impedance Test

The test is required for Automobile carpet / acoustic noise absorption materials. Specifications required for test samples:

- Determination of normal incidence absorption coefficient and normal specific impedance based on ASTM E1050 and ASTM E2611.
- Amount of specimen required 0.5 square meter.
- Sample size is 29.5 mm diameter and 99.5 mm diameter.

Figure 3. Impedance tube

Results and Discussions

The acoustic properties of the needle punched fabrics by performing various tests like sound impedance and thickness. As per the outcome of these results, it is found that the developed material is applicable for high frequency sound absorption.

Fabric Thickness

The thickness of experimental sample fabrics ranged from 2 to 4mm which is shown in Table 1. The fabric thickness was measured using thickness gauge as per the procedures of ASTM D1772. The thickness of fabric increases linearly with the increase of stitch density due to fibre bending at short interval of space.

Table 1 Thickness of the fabric and Stitch Density

Sample	Thickness of the fabric (mm)	Stitch Density (punches/ sq.mt)
Sample A	2.45	250
Sample B	3.17	300
Sample C	3.61	450

Absorption Coefficient of Experimental Samples

Using impedance tube, the experimental samples of needle punched non-woven fabrics are tested for absorption coefficient values for a range of frequency from 16 to 6300 Hz. The freqency range covers the general environmental conditions of industry and house-hold. The measured values are shown in Table 2.

Table 2. Absorption coefficent of samples for a freqency range

S. No	Frequency (Hz)	Absorption coefficient		
		Stitch density 250	Stitch density 300	Stitch density 450
1	16	-1	-1	-0.61
2	20	-0.83	-0.83	0.06
3	25	0.48	0.48	-0.66
4	31.5	-2.62	-2.62	0.14
5	40	-0.71	-0.71	0.1
6	50	0.04	0.04	0.06
7	63	-0.04	-0.04	-0.08
8	80	0.06	0.06	0.08
9	100	0.01	0.01	0.02
10	125	-0.01	-0.01	-0.02
11	160	0.04	0.01	0.04
12	200	0.04	0.03	0.04
13	250	0.04	0.03	0.05
14	315	0.05	0.04	0.05
15	400	0.05	0.04	0.05
16	500	0.06	0.05	0.06
17	630	0.06	0.05	0.07
18	800	0.07	0.06	0.07
19	1000	0.07	0.06	0.08
20	1250	0.09	0.06	0.09
21	1600	0.11	0.07	0.1
22	2000	0.14	0.09	0.12
23	2500	0.19	0.11	0.15
24	3150	0.26	0.19	0.2
25	4000	0.36	0.32	0.29
26	5000	0.46	0.41	0.38
27	6300	0.6	0.53	0.49

Figure 4 shows the absorption coefficient of 450 stitch density fabric at frequency range of 16 – 6300 Hz. It is clearly known that the absorption coefficient is normal. Only if higher frequency passed, the absorption is good. When comparing to other stitch density samples, the absorption level of 450 SD is poor due to more punches.

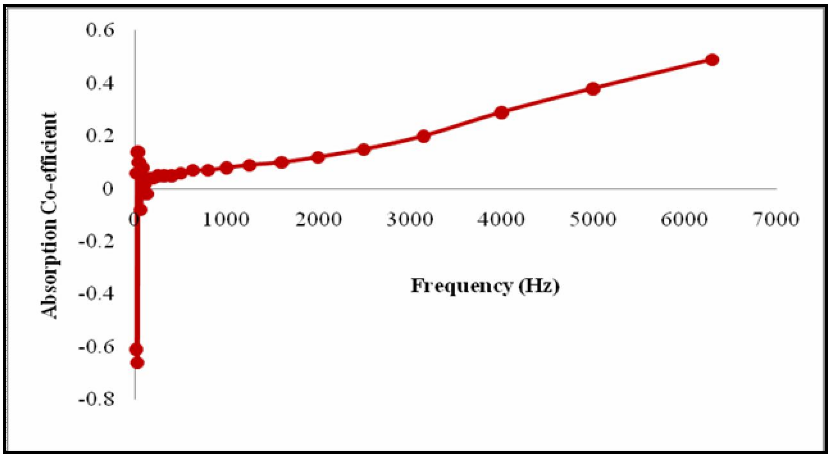

Figure 4. Absorption coefficient of SD 450 at various frequency levels

Figure 5 shows the relationship between frequency and absorption coefficient of SD 300 for a range of 16 – 6300 Hz frequency level. It is seen that the absorption coefficient is moderate. This sample is effective in sound absorption at higher frequncy level.

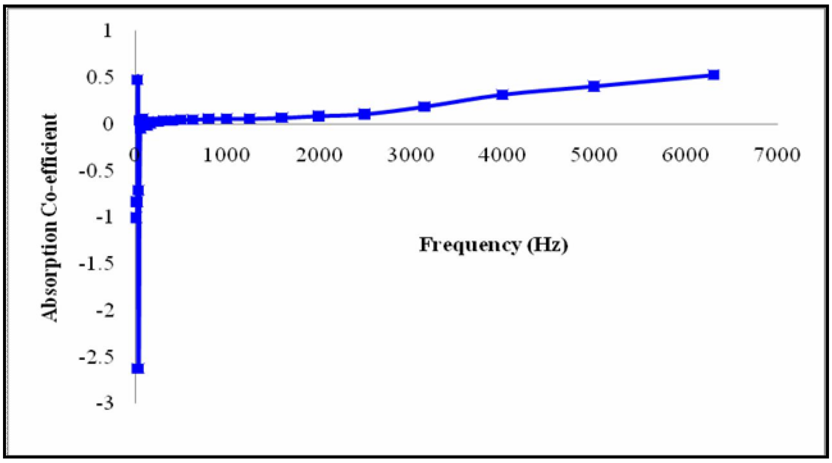

Figure 5. Absorption coefficient of SD 300 at various frequency levels

Figure 6 shows the performance of 250 SD sample with respect to absorption coefficient at various frequency levels. It is clearly known as absorption coefficient is higher which indicates the material absorbs maximum energy from incident sound. When comparing to other stitch densities, this sample exhibits very good absorption property.

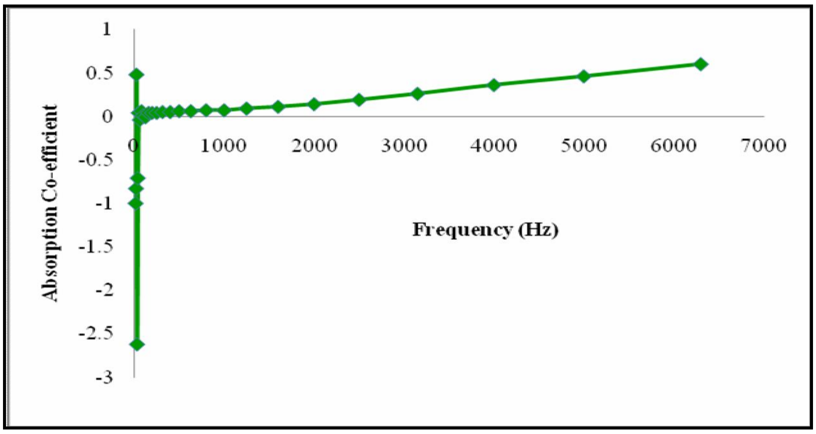

Figure 6. Absorption coefficient of SD 250 at various frequency levels

Figure 7 show the comparison of three stitch density like 450.300 and 250 SD with absorption coefficient. The absorption coefficient, 250 stitch density shows better performance when compared to 450 SD and 300 SD. Human ear detect sound between 20 Hz-20,000 Hz and the sensitive in the range of 10,000 Hz. According to this standard result, the newly developed material can be used in tweeter and super tweeter.

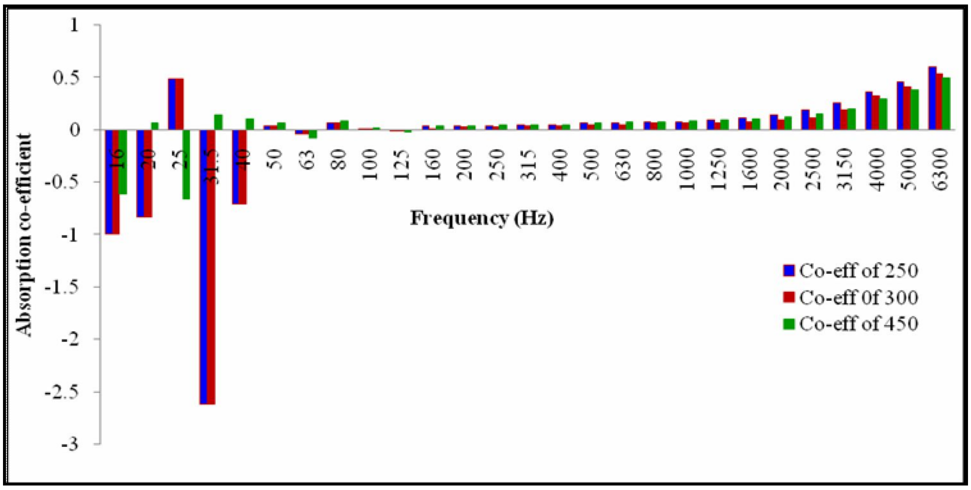

Figure 7. Comparison of Absorption coefficient for diiferent stitch density

Conclusion

Sound reduction is observed in the following materials Polypropylene - 50%, PET - 20% and Hollow PET - 30% with three different stitch density 450, 300 and 250. The sample 250 SD has good sound absorption than compared to other two. Decrease in needle punch density increase the sound absorption efficiency. According to the standard test results, this material is suitable for absorbing sound produced by tweeter and super tweeter. This needle punched non woven material can also use in air filters and geo textiles.

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