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ENVIROMENTALLY BENIGN ACCOUSTICAL AUTOMOTIVE NONWOVEN FLOOR COVERINGS

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Abstract

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. 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. Floor coverings made with natural fibers (kenaf, jute, waste cotton, and flax) in blends with polypropylene (PP) and polyester (PET) were developed as carded needlepunched nonwovens. The acoustic properties of these floor coverings, used either alone or in combination with (a) a rebonded polyurethane foam underpad or (b) a soft cotton nonwoven underpad, were test evaluated by ASTM E 1050 "Impedance and Absorption of Acoustical Materials Using A Tube, Two Microphones and Digital Frequency Analysis System." The measurements demonstrated that each of the natural fiber based nonwoven floor coverings contributed to noise reduction.

Introduction

Countries all over the world are gearing up their manufacturing to produce vehicles to meet expected new markets for automobile sales, Table 1. With each vehicle requiring 14.6 to 20.0 square meters of nonwovens for automotive interiors, one can visualize the demand for such nonwoven composites. Nonwovens can be made in a wide variety of densities and forms, which offer sound insulation, heat insulation and aesthetically pleasing properties. Today, exciting developments are taking place to manufacture environmentally benign nonwovens for auto interior. 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.

We developed nonwoven floor coverings from low cost, biodegradable, environmentally benign natural fibers (kenaf, jute, cotton and flax) in blends with polypropylene (PP) and polyester (PET) as sound-absorbing materials (Table 2). They were test evaluated for their ability to absorb sound energy by the standard test method ASTM E 1050. Also evaluated for their ability to absorb sound energy were (i) a carded needlepunched cotton under pad, and (ii) an underpad of recycled, rebonded polyurethane carpet underlay.

Experimental

Floor coverings of blends containing kenaf, jute, or cotton with PET and PP in weight ratios of 35/35/30, along with nonwovens of PET and PP in weight ratio of 70/30 were produced by carding, followed by needlepunching. The carded webs were needlepunched four times on spunbonded polyester scrim to produce automotive nonwoven floor coverings of target weight of 20 and 30 oz/yd^2 (Table 2). The needlpunching technology was chosen to produce floor coverings because it is best suited to mouldability of the floor coverings (for a good fit.).

A carded needlepunched cotton under pad (thickness of 0.185cm and density of 243 g/m^2) was developed at SRRC-USDA. An underpad of recycled, rebonded polyurethane foam carpet underlay (thickness of 0.794cm and density of 965.0 g/m^2) was obtained from Leggett and Platt, Cold Water, MS.

Table 1. Projected Annual Sales for Cars Globally

USA **Million** 2005: 17.048 2010: 17.796
China 2005: 5.022 2010: 7.312
Brazil 2005: 1.564 2010: 1.937
India 2005: 1.353 2010: 2.373
South Korea 2005: 1.240 2010: 1.693

From: National Geographic, February 2005

Acoustic Testing - The amount of original energy less the remaining unabsorbed energy compared to the original energy results in the measurement referred to as the absorption coefficient. This coefficient is often used to rank the order of different composite materials that reduce the noise level in a vehicle. We used the standard test method ASTM E 1050 - a B & K measuring instrument with a medium measurement tube, to determine the acoustic properties of test samples (of 6.35 cm diameter) in the frequency range of 100 Hz to 3200 Hz. The test method used an impedance tube, two fixed microphones and a digital frequency analysis system, for the determination of normal incidence sound, the absorption coefficient, and normal specific acoustic impedance ratios of materials (Figure 1). These tools create a system that tests a sound absorptive material, processes the results, and reports the results in a graph of the absorption coefficient at various frequencies. ASTM E 1050 provides a fast measurement technique for early evaluation of potential sound absorbing materials.

Table 2. Natural Fiber Based Nonwoven Composites Produced By Carding and Needlepunching

Sample	Material	Blend Ratio	Thickness, mm	Areal Density	
				g/m^2	oz/yd^2
C20-1	Kenaf/PET/PP on scrim	35:35:30	8.00	730	21.54
C30-1	Kenaf/PET/PP on scrim	35:35:30	10.10	1062	31.31
C30-2	Jute/PET/PP on scrim	35:35:30	10.10	1008	29.74
C30-3	Cotton/PET/PP on scrim	35:35:30	10.00	998	29.44
C30-4	PET/PET/PP on scrim	70:30	10.01	1009	29.75

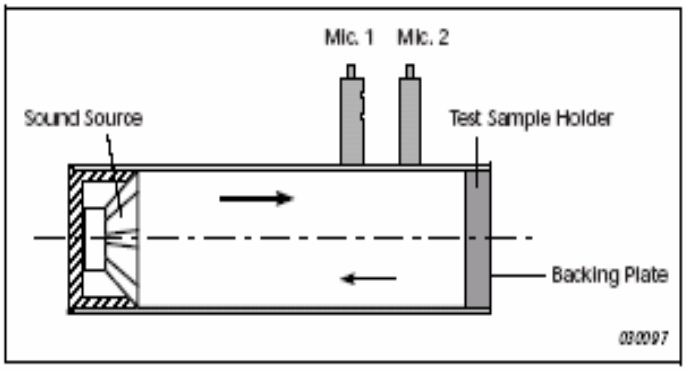
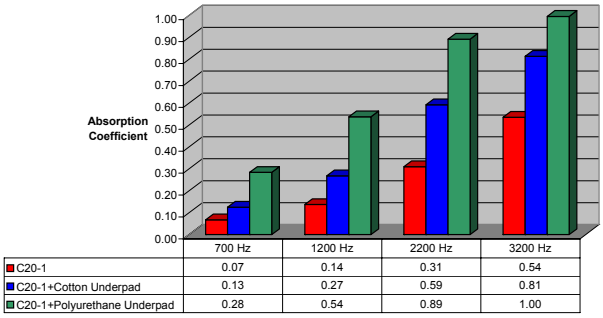


Figure 1. The Two-microphone Standing Wave Impedance Tube Method: ASTM E 1050

Results and Discussion

A floor covering (nearly 3.5 m^2) provides the largest surface area in an automobile for soundproofing. Figure 2 shows the absorption coefficients of a 20 oz/yd^2 carded needlepunched floor covering, and the same floor covering in combination with an underpad of either needlepunched cotton or rebonded polyurethane (PU). Both underpads significantly enhance sound absorption of the floor covering, and thus significantly reduce unwanted noise. Of the two underpads studied, the PU underpad is more effective in reducing unwanted noise. Once only luxury cars had a noise insulation pad under the carpet but as in many cases this is becoming a standard requirement.



	700 Hz	1200 Hz	2200 Hz	3200 Hz
C20-1	0.07	0.14	0.31	0.54
C20-1+Cotton Underpad	0.13	0.27	0.59	0.81
C20-1+Polyurethane Underpad	0.28	0.54	0.89	1.00

Figure 2. Comparison of the absorption coefficients of (a) C2-1 floor covering, (b) C20-1 with a cotton underpad, and (c) C20-1 with a polyurethane underpad at various frequencies.

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