Design and Production of Tailored Rear Trunk Covering for Acoustic Applications

H. Baskan¹, B. Isık¹, E. Erarslan¹, P. Ejder¹, S. Sezer² and H. Karakas¹

¹Istanbul Technical University, Textile Technologies and Design Faculty, Textile Engineering Department, İnönü Street 65, 34437, Gumussuyu, Beyoğlu, İstanbul, Turkey
²HP Pelzer Pimsa, TOSB, 1st Street, 14th Avenue, No:4, 41420, Sekerpınar, Cayirova, Kocaeli

Corresponding author: baskan@itu.edu.tr

Abstract. Using recycled nonwovens as sound absorption materials are of great interest because of the increased nonwoven waste. In this study, needle-punched recycled polyester nonwoven was coated with polyethylene film, vinyl-based recycled polymer film and blends of these two materials in order to obtain new sound absorptive materials. Abrasion, tensile and acoustic features of the produced samples were measured and compared with the commercial PP-Fusing sample. It was seen that use of VBR polymer with polyethylene enhanced sound absorption properties of samples as well as their tensile strength and abrasion resistance performance. It is suggested to use needle-punched recycled polyester ‘PET- 50% VBR- 50% PE’ sample for automobile rear trunk where acoustic insulation is required.

Keywords — Nonwoven, recycled polyester, recycled vinyl based polymer, rear trunk, sound absorption

I. INTRODUCTION

A LTERNATION of pressure propagating through an elastic medium like air is called sound [1]. Undesirable and unpleasant sound is defined as noise. Being exposed to noise causes considerable problems like sleep disturbance, hearing loss, decrease in productivity and daily performance, increase in stress and blood pressure etc. [2]. Especially, noise is a big problem in closed space areas such as in automobiles [3]. Therefore, sound absorptive materials have come into prominence. Sound absorption is a process that converts the kinetic energy of the sound to heat energy when the sound strikes the sound absorptive material, which can be wall, cell, fiber, nonwoven, fibrous glass, mineral wools, felt and foams [1, 4]. In automotive industry, textile materials in the form of woven, knitted and nonwoven are used as sound absorptive materials [5].

Acoustic textiles can be bulky, high-loft, behaving as a rigid, porous sound absorber or light-weight, compact woven and nonwoven textiles that behave as porous screen [5]. Since their low production costs, small specific gravity and high total surface, nonwoven textiles are more preferred over woven and knitted types [2]. It was stated that noise absorption coefficients of nonwovens were comparable to rockwool and glass fiber in the high frequency range [3].

Lee and Joo produced thermally bonded nonwoven polyester fabrics with different fiber linear densities and investigated the sound absorption properties of produced samples. It was mentioned that nonwoven fabrics generated by using finer fibers showed higher noise insulation coefficients and absorption properties [3]. Tascan and Vaughn investigated the effect of fiber linear density and shape on the acoustical performance of needle-punched nonwoven fabrics. It was summarized that needle-punched nonwoven fabrics with finer fiber linear densities were superior than nonwoven fabrics with coarser fiber deniers in any fiber shape [6]. Needle-punched nonwoven with jute and blends of jute can be regarded as sound absorptive material. Sengupta tried to reduce sound by using polyester, polypropylene and jute / polypropylene needle-punched nonwovens. It was observed that the best sound reduction was achieved by jute/ polypropylene nonwovens when they were blended in equal amount [7].

On the other hand, using recycled nonwovens as sound absorption materials are of great interest because of the increased nonwoven waste. Using waste textile materials gives the chance for reducing environmental pollution, using the sources more effective and producing a new material for many applications [2, 8]. Factories generally burns or buries the selvages of nonwovens, which causes environmental destruction. For this reason, Kalebek examined the effects of the mass per unit area and thickness on the sound absorption performance of recycled needle-punched polyester nonwoven selvages. It was noticed that increasing the fabric mass per unit area and thickness also increases the sound insulation of the produced fabric [2]. Tiuc et al. tried to improve sound absorption properties of rigid polyurethane closed-cell foam by adding textile waste with changing amounts and measured the sound absorption coefficients of produced samples by impedance tube. According to the test results, it was observed that produced sample comprising 40 % textile waste and 60% rigid polyurethane foam had higher sound absorption coefficient than
pure rigid polyurethane sample [8]. Moreover, Arenas mentioned that by addition of elastomer to needled recycled fibers and spunbonded polyurethane can be considered as a substrate for a foamed rubber material in case of trunk covering.

In this study, a new type of automotive rear trunk covering was designed and produced by coating recycled vinyl-based polymer onto needle-punched polyester nonwoven. It was aimed to measure sound absorption properties of produced recycled polyester-recycled vinyl-based polymer rear trunk covering and compare the results with the available commercial types. In addition to sound absorption test, abrasion test and tensile test were also applied to the samples. According to the test results, it can be suggested to use the sample ‘PET- 50% VBR- 50 %PE’ as a sound absorptive material for rear-trunk covering between 1500-2500 Hz frequencies.

II. MATERIALS

Needle punched recycled polyester (PET) nonwoven fabrics were used as substrate. Vinyl based recycled (VBR) polymer was used as coating film. Polyethylene (PE), polypropylene (PP) and fusing were used as coating film in order to compare the sound absorption coefficient test results with the produced ‘PET-VBR’ sample.

III. METHOD

Recycled polyester nonwoven fabrics were produced by needle-punching process. Polymer films were produced by extrusion process and obtained films were simultaneously attached to recycled polyester nonwoven fabric in the presence of pressure and hot cylinders in extruder, separately.

Three samples consisting different amounts of VBR polymer, ‘PET- 100 % VBR’, ‘PET- 50 %VBR- 50 % PE’, ‘PET-100 % PE’ were produced. On the other hand, PP-Fusing commercial sample was supplied in order to compare the acoustic and abrasion performance of the produced samples with the commercial one. Fig. 1 shows the produced needle-punched recycled polyester samples containing different amounts of VBR polymer.

Figure 1: Produced samples a) PET-100 % PE, b) PET- 50 %VBR- 50 % PE, c) PET- 100 % VBR

For determining the sound absorption coefficient of the samples, impedance tube method was conducted according to the ASTM E1050 standard using a tube, a microphone and a digital frequency analyzer. A sound source is mounted at one end of the impedance tube and the material sample is placed at the other end [4]. Fig. 2 demonstrates impedance tube used for analyzing sound absorption coefficients.

Figure 2: Impedance tube used for analyzing sound absorption coefficients

In addition to acoustic tests, tensile and abrasion properties of the samples were also measured according to the standards EN ISO 1421:2000 and ISO 5470-2: 2003, respectively. Fig. 3 displays the tensile strength test and Fig. 4 shows abrasion test devices.
IV. RESULTS

Sound absorption coefficient test results were conducted between 16 and 6300 Hz frequencies. When all frequency ranges were considered, it can be said that PET-100 % VBR sample had the lowest sound absorption coefficient. However, when it had the highest sound absorption coefficient between 1500-2500 Hz frequencies. The sample composed of PP-Fusing had the highest sound absorption coefficient value in the range of 4000-4500 Hz. PET-100 % PE sample had average value in all frequency ranges. Fig. 5 shows the sound absorption coefficients of polyester samples consisting 100 % PE, 100 % VBR, 50 % PE-50 % VBR and the sample PP-Fusing versus frequency.

Figure 5: Sound absorption coefficients of polyester samples consisting of 100 % PE, 100 % VBR, 50 % PE-50 % VBR and the sample PP-Fusing versus frequency (Hz).
Tenstile and elongation test results of the polyester samples consisting different amounts of VBR polymer are summarized in Table I.

TABLE I
TENSILE AND ELONGATION TEST RESULTS OF THE PRODUCED POLYESTER SAMPLES CONSISTING OF DIFFERENT AMOUNTS OF VBR POLYMER.

| Sample | Tensile Strength (N) | Elongation (%) |
|--------|----------------------|----------------|
|        | Warp Direction       | Weft Direction | Warp Direction | Weft direction |
| PET-100% PE | 742                  | 720            | 105           | 114            |
| PET-50% PE-50% VBR | 622                   | 695            | 107           | 118            |
| PET-100% VBR | 599                   | 568            | 159           | 134            |

According to the results given in Table I, it can be seen that addition of VBR polymer into the PET-PE structure decreased the tensile strength in both warp and weft direction. However, a slight increase was observed in elongation for both warp and weft direction. Further increase in the amount of VBR also allowed elongation to increase but tensile strength to decrease.

It was seen from the abrasion test results obtained according to the standard ISO 5470-2:2003, no abrasion occurred although 10,000 cycle abrasion application. Fig. 6 shows the samples after the abrasion testing.

![Figure 6: Polyester samples consisting a) 100% PE, b) 50% PE-50% VBR and c) 100% VBR](image)

V. CONCLUSION

In this study, recycled needle-punched polyester nonwovens were coated with 100% PE film, 50%-50% PE-VBR film and 100% VBR film in order to generate novel structures with satisfactory sound absorption features. Acoustic features of samples were tested as well as abrasion and tensile properties. It was observed that using VBR polymer with polyethylene enhanced sound absorption properties of samples. In addition, it was seen that the produced samples had good abrasion, tensile and elongation properties when compared with the commercial types. As a conclusion, it can be suggested that using the sample containing ‘PET-50% VBR-50% PE’ can be an appropriate candidate for automobile rear trunk where acoustic insulation is desired.

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REFERENCES

[1] V.K. Midha, MD. V. Chavcan, “Nonwoven Sound Absorption Materials”, *International Journal of Textile and Fashion Technology*, vol. 2, no.2, pp. 45-55, June 2012.

[2] N. Avcioğlu Kalebek, “Sound Absorbing Polyester Recycled Nonwovens for the Automotive Industry”, *Fibres & Textiles*, vol. 24, no. 1(115), pp. 107-113, 2016.

[3] Y. Lee, C. Joo, “Sound Absorption Properties of Recycled Polyester Fibrous Assembly Absorbers”, vol. 3, no.2, pp.1-7, June 2003.

[4] R.S. Kumar, S. Sundaresan, “Acoustic Textiles-Sound Absorption”, *Textile Technology*, pp. 1-10.

[5] J.P. Arenas, *Acoustic Textiles*: Singapore: Springer, 2016, ch. 7.

[6] M. Tascan, E.A. Vaughn, ‘‘Effects of total Surface Area and Fabric Density on the Acoustical Behaviour of Needle-Punched Nonwoven Fabrics’’, *Textile Research Journal*, vol. 78, no.4, pp. 289-296, 2008.

[7] S. Sengupta, “Sound Reduction by Needle-Punched Nonwoven Fabrics”, *Indian Journal of Fibre and Textile Research*, vol. 35, no. 3, pp. 237-242, September 2010.

[8] A.E. Tiuc, H. Vermeşan, T. Gabor, O. Vasile, “Improved Sound Absorption Properties of Polyurethane Foam Mixed With Textile Waste”, *Energy Procedia,*
vol. 85, pp. 559-565, January 2016.