

PAPER • OPEN ACCESS

Sound absorption of textile material using a microfibrres resistive layer

To cite this article: M P Segura Alcaraz *et al* 2017 *IOP Conf. Ser.: Mater. Sci. Eng.* **254** 072022

View the [article online](#) for updates and enhancements.

Related content

- [Bio-functionalization of conductive textile materials with redox enzymes](#)
M Kahoush, N Behary, A Cayla et al.
- [Study of the stretching force of the needles thread in the work with woollen textiles](#)
Snezhina Andonova and Ivelin Rahnev
- [The reliability of the newly developed bending tester for the measurement of flexural rigidity of textile materials](#)
A Binti Haji Musa, B Malengier, L Van Langenhove et al.

Sound absorption of textile material using a microfibre resistive layer

M P Segura Alcaraz, M Bonet-Aracil¹, J G Segura Alcaraz² and I Montava Seguí¹

1 Universitat Politècnica de València, Escuela Politécnica Superior de Alcoy, Departamento de Ingeniería Textil y Papelera, Plaça Ferrándiz i Carbonell s/n, 03801 Alcoi, Alicante, España

2 Universitat Politècnica de València, Escuela Politécnica Superior de Alcoy, Departamento de Mecánica de los Medios Continuos y Teoría de Estructuras, Plaça Ferrándiz i Carbonell s/n, 03801 Alcoi, Alicante, España

E-mail: maboar@txp.upv.es

Abstract. Acoustic comfort is a basic human need. One of the adverse effects of noise is its interference with speech discrimination. Textile materials are suitable to be used as sound absorptive materials and thus help to improve acoustic comfort in rooms. Micro-fibre fabrics can be considered as better sound absorbers than regular fibre fabrics mainly due to the higher surface of its fibres and bigger contact area with the air thus, allowing greater dissipation of sound energy. In this work, the use of a microfibre woven fabric as an upstream layer is analysed considering acoustic issues. Authors demonstrate it improves the sound absorption of a polyester nonwoven, resulting in a material suitable for absorption at the sound frequencies of the human voice.

1. Introduction

Human beings have a need of comfort. Acoustic comfort is a significant part of this need. Noise interferes with speech discrimination, and can result in problems with concentration, fatigue, misunderstandings, lack of self-confidence, irritation, decreased working capacity, problems in human relations, and a number of reactions to stress [1]. Recently, researchers are focused on developing new products such as new lightweight and even translucent textile curtains that absorb sound very well have been developed [2]. Even though, hollow spheres have been developed and evaluated from the sound absorption [3].

Historically, textile materials have been widely used in public places like theatres in the form of curtains, carpets and upholstery, in order to improve their sound quality. Speech intelligibility is also essential in places like classrooms, restaurants, offices, libraries, factories, and public places in general. Textile materials based on polyester fibre have advantages like low density, flexibility and easy handling. Polyester can be recycled and brings the possibility to vary fibre parameters such as shape and size of its cross section, curling or frizzling, hollow fibres, polished or dull surface, as well as the use of additives to increase its fire or UV resistance. Fibrous materials need to be protected for cleaning, mechanical strength, to avoid particle shedding, or for aesthetical reasons. In these cases, it is very common to cover the fibrous material using a nonwoven veil, light panel or perforated panel in different materials. This upstream layer can modify the absorption of the ensemble [4]. Micro-fibre fabrics are described as better sound absorbers than regular fibre fabrics [5] because of the higher



surface of its fibres and bigger contact area with the air, allowing thus greater dissipation of sound energy.

The aim of this project is to compare the influence of the fabric's structure in the sound absorption properties. For this study two different fabrics were used, a twill and a terry one. Fabrics were placed on the top of a nonwoven structure with different thickness. Results evidence that the selectivity of the absorption depends on the type of fabric used. The twill fabric produces higher selectivity than the terry towel in all combinations tested.

2. Experimental

2.1. Materials

A microfibre fabric is added as a resistive layer onto a polyester nonwoven. Then its sound absorption coefficient is measured in an impedance tube.

Two different fabrics have been tested as a resistive layer. Both are microfibre woven fabrics made with polyester (PES) and polyamide (PA) in the ratio PES/PA 80/20. The first one has a crossed twill design and the second one is a terry towel fabric. They are shown in figure 1.

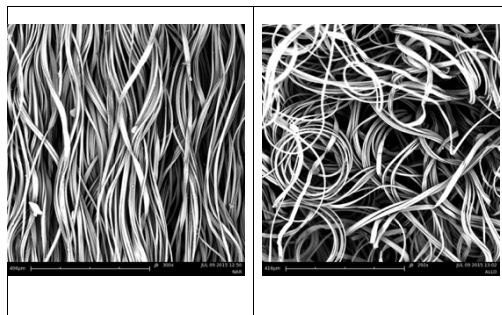


Figure 1. Microfibre fabrics. Twill on the left and terry towel on the right

The nonwoven is made of 63 mm long polyester fibres with circular cross section and without crimp. After analyzing them using a Lenzing Instruments Vibroscope, their fineness is found to be 12,33 dtex. The nonwoven is obtained by dry-laid method from stapled fibres, with thermal bonding by employing some fibres with a lower melt point in the mix. Nonwoven thickness is 15 mm.

The essayed combinations of fabric and nonwoven are as shown in figure 2:

- a) One layer of 15 mm non-woven.
- b) One layer of fabric plus one layer of 15 mm nonwoven, being the fabric layer on the side of the sound source.
- c) Two layers of fabric and between them one layer of nonwoven.

Combinations b and c are also tested using 30 and 45mm of nonwoven instead of 15mm.

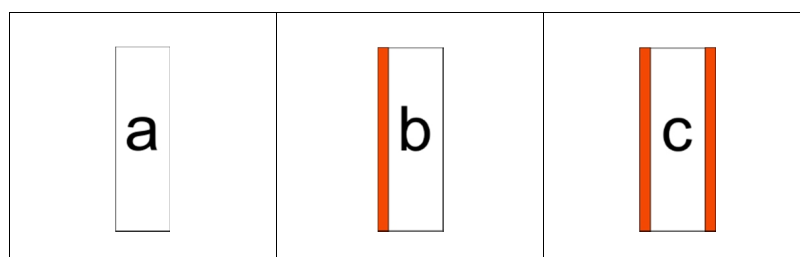


Figure 2. Combinations of fabric (coloured) and nonwoven (white).

2.2. Sound absorption coefficient

Sound absorption coefficients are measured following the method described in ISO 10534-2: Acoustics. Determination of sound absorption coefficient and impedance in impedance tubes. Part 2: Transfer-function method. In this method, a sound wave strikes the material perpendicularly, allowing to measure the normal incidence sound absorption coefficient. It requires an impedance tube, two microphones and a digital system for the signal treatment. Every test is conducted with 3 samples, which are tested for each combination of fabric-nonwoven. Measurements are performed at 2950 different frequencies between 400,390625 Hz and 4000,244141. These frequencies are chosen due to the diameter of the available tube (40mm).

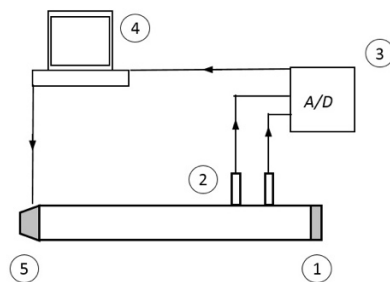


Figure 3. Scheme of the apparatus used to measure the sound absorption coefficient, where:

- 1) is the sample
- 2) the two microphones (G.R.A.S. model 40AO)
- 3) the data acquisition system (NI-9233)
- 4) the PC, and
- 5) the sound source

To perform the test the sample is placed at the end 1 of the impedance tube as shown in figure 3. The sample should fit snugly to the sample holder without being compressed or improperly adjusted so firmly that it is convex. It is possible to use vaseline or interstices sealing wax, grease or cover the entire edge. Plane waves are generated in the tube by the sound source, and the pressure in two near positions is measured. Using a Matlab function designed for this purpose, the transfer function of the complex acoustic signals at the two microphones, used in this case to calculate the absorption coefficient from normal incidence, reflection coefficient is determined. As explained in the above mentioned ISO 10534-2 standard, this coefficient is determined according to equation 1:

$$r = \frac{H_1 - H_t}{H_R - H_1} \cdot e^{2 \cdot j \cdot k_0 \cdot x_1} \quad (1)$$

Where:

H_{12} = complex transference function,

H_R = transference function from the reflected wave,

k_0 = complex wavenumber

x_1 = distance between sample and microphone.

Knowing this, then the sound absorption coefficient for normal incidence can be obtained by the equation 2:

$$\alpha = 1 - |r|^2 \quad (2)$$

3. Results

Results show that when one or two layers of microfibre fabric are added to the nonwoven, combinations b and c, a significant increase in the absorption coefficient is obtained, as shown in figure 4.

In the case of twill, the addition of a first layer of fabric, combination b, produces a high increase in the absorption, especially at frequencies near to 400 Hz. This increase is less noticeable as frequency approaches to 4000 Hz. When adding a second layer of twill fabric, combination c, the frequency of maximum absorption decreases about 400 Hz as shown in table 1. Besides, the shape of the curve is narrower for absorptions from 0,7 to 1. Another effect shown in figure 4 is that the absorption

obtained using combination c (two layers of twill and between them one layer of nonwoven) is lower than that obtained using combination b in all frequencies over 1155 Hz.

When terry towel is used in the combination, the addition of a first layer of fabric also increases the absorption, but in this case the maximum absorptions are above 2300 Hz. In this area, the sound absorption coefficient stays over 0,9 though all the frequencies up to 4000 Hz. When a second layer of terry towel is added to form the combination c, the variation of the sound absorption coefficient is minimum, as shown in figure 2. The frequency of maximum absorption is placed around 3000 Hz in both combinations b and c as seen in table 1.

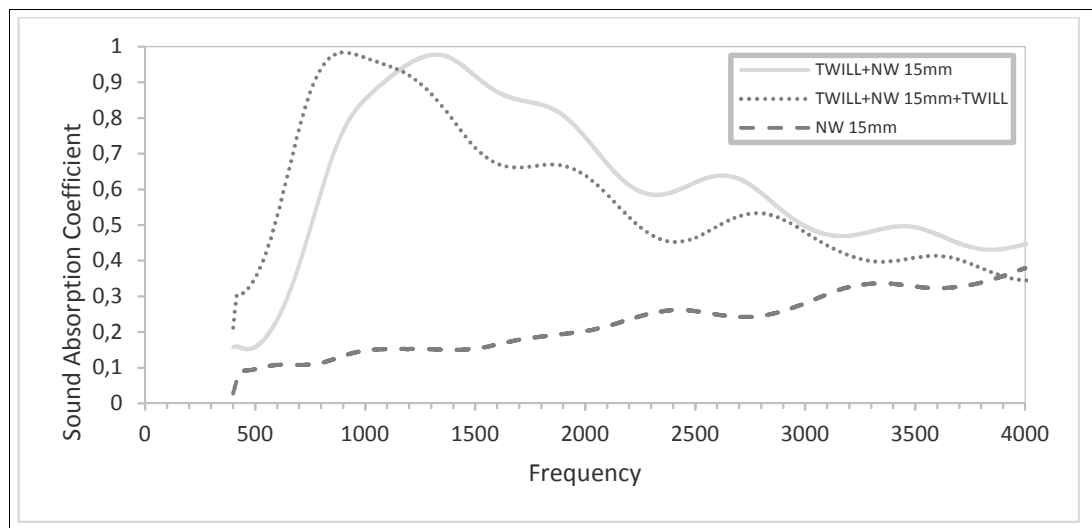
Table 1. Frequency of maximum absorption in combinations a, b and c, using twill and terry towel fabrics.

Combination	Frequency Twill (Hz)	Frequency Terry (Hz)
a) nonwoven 15mm	4000	4000
b) fabric+ nonwoven 15mm	1322	2982
c) fabric+ nonwoven 15mm+ fabric	903	3020

Considering that the sound absorption coefficient of a material must be higher than 0,5 [6] to be considered as an absorbing material, this level is not achieved by the nonwoven by itself (combination a).

When combining one layer of fabric plus one layer of 15 mm nonwoven, being the fabric layer on the side of the sound source (b) or two layers of fabric and between them one layer of 15 mm nonwoven (c), the total number of frequencies in which the sound absorption coefficient is higher than 0,5 is different for each type of fabric.

When the layer of nonwoven is 30 and 45 mm thick, the figure 5 shows how the addition of a second layer of fabric does not vary the curve significantly.



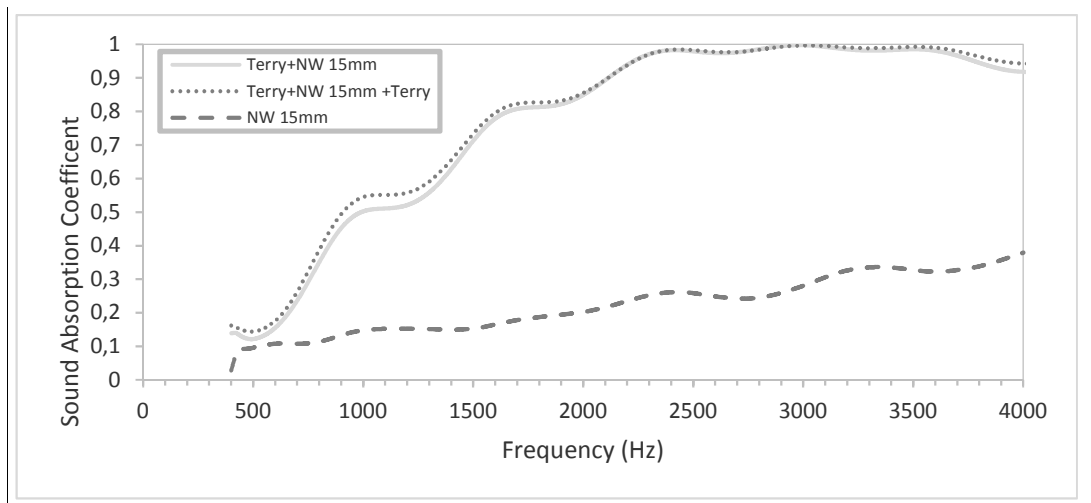


Figure 4. Sound absorption coefficients of combinations a, b and c of fabric and 15mm nonwoven.

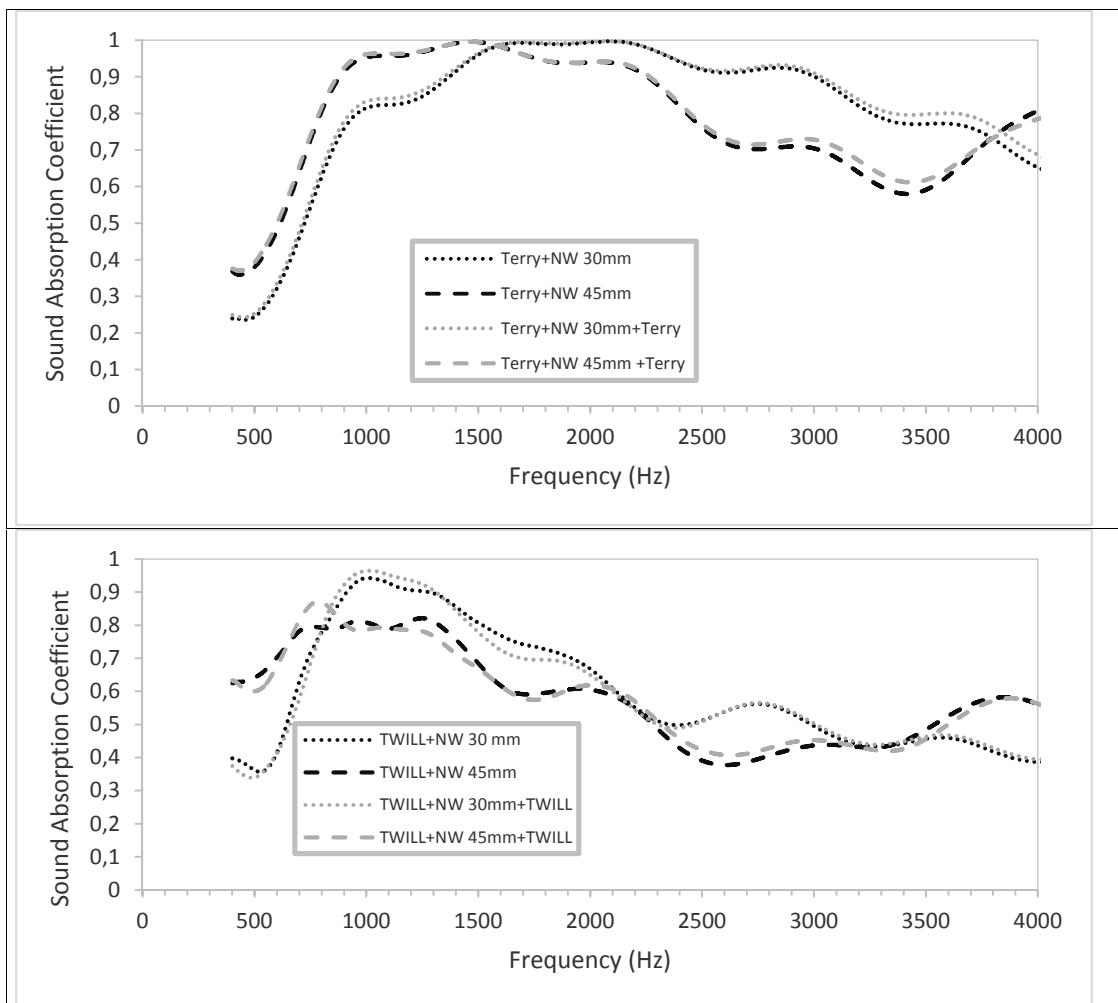


Figure 5. Sound absorption coefficients of combinations of fabric and 30 and 45 mm nonwoven.

4. Conclusions

The addition of a microfiber fabric to a layer of 15,30 or 45 mm nonwoven, being the fabric layer on the side of the sound source (combination b) brings a modification of the acoustic absorption of the system fabric-nonwoven. The cause of this increase can be the formation of a Helmholtz resonator assembly. In this sort of resonators the neck is of special interest, as it is the area in which the speed of the wave is higher and the viscous effect is more important for the dissipation of the sound energy. In this case, the neck is formed by the microfiber yarns of the fabric.

When the layer of nonwoven is 15mm thick, the modification of the absorption is different depending on the type of fabric. Twill, with all floats of yarn perpendicular to the direction of the wave sound, forming numerous micro slits of various sizes offers better absorption at lower frequencies. On the other hand terry towel, in which some yarns create loops, being a part of these loops in the same direction as the wave, increases the absorption at higher frequencies. The effect of adding a second layer of fabric to the assembly is also different depending on the type of fabric. In the twill assembly, there is a movement of the curve towards lower frequencies. As this fabric is right in contact with the rigid wall, no absorption for friction is expected, so possibly this is produced by the vibration of the floats of the fabric, that probably are similar to the strings of a guitar. This effect does not appear in the terry towel assembly. In this case the yarns are looser, forming loops with a free end that move with less restriction than floats and do not absorb so much energy.

When the layer of nonwoven is thicker, like 30 or 45mm, the effect of moving the curve towards lower frequencies does not appear, independently of the type of fabric. In these cases, the results are very similar when combining one layer of fabric plus one layer of nonwoven, being the fabric layer on the side of the sound source like in combination b, or two layers of fabric and between them one layer of nonwoven like in combination c.

The selectivity of the absorption depends on the type of fabric used. The twill fabric produces higher selectivity than the terry towel in all combinations tested. The effect of adding a second layer of microfiber fabric to the assembly on the side of the rigid wall (combination c) causes a movement of the curve towards lower frequencies. As this fabric is right in contact with the rigid wall, no absorption for friction is expected, so possibly this is produced for the vibration of the floats of the fabric. This desirable effect is counteracted by the narrowing of the curve which shows an increase in its selectivity, and the decrease of the absorption at higher frequencies.

References

- [1] Berglund B, Lindvall T and Schwela D H 1999 *Guidelines for community noise* Geneva: World Health Organisation [24 March 2017] Available from <http://www.who.int/iris/handle/10665/66217>
- [2] Reto Pieren, Beat Schäffer, Stefan Schoenwald and Kurt Eggenschwiler. *Sound absorption of textile curtains – theoretical models and validations by experiments and simulations*. Textile research Journal. 2016. DOI: 10.1177/0040517516673337
- [3] Zhou Hong, Li Bo, Huang Guangsu. *Sound absorption behavior of multiporous hollow polymer micro-spheres*. Materials Letters **60** (2006) 3451–3456
- [4] Chevillotte F 2012 Controlling sound absorption by an upstream resistive layer *Applied Acoustics* **73** 56–60
- [5] Na Y, Lancaster J, Casali J and Cho G 2007 Sound Absorption Coefficients of Micro-fiber Fabrics by reverberation room method *Textile Research Journal* **77** 330-335
- [6] Crocker M J 1998 *Handbook of acoustics* New York: J. Wiley & Sons Inc.