Australian Journal of Basic and Applied Sciences, 5(4): 96-101, 2011
ISSN 1991-8178

Characterization of the Acoustic Behaviours of Laminated Polyester Fabric Using Different Adhesion Systems

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Abstract: The noise sources increased day by day and annoying level is strongly violated in different locations by traffic, sound systems, and industries. Noise can be reduced by using new constructed polyester fabric. These constructions include different layers from 1 to 4 layers and laminated by polyurethane adhesive doped with a removable salt. These fabrics can be used in auto interiors, furniture and curtains to reach the permissible levels for many places. The blank and treated fabrics will be tested using the Two-Microphone Impedance tube system to determine the sound absorption coefficient values. The results showed that by incorporation the salt the acoustic behaviors changed and the laminated fabric had good performance in the acoustic applications.

Key words: Laminated textile, adhesive, foam, polyurethane, acoustic behavior, polyester fabric.

INTRODUCTION

A new empirical model (Garai, Pompoli, 2005) to predict the flow resistively, acoustic impedance and sound absorption coefficient of polyester fiber materials. Measurements performed on polyester fiber materials with different density and thickness. The sound absorption characteristics of a porous fibrous material (Wang, Torng, 2001) that is manufactured and used in Taiwan, was investigated.

Sound absorption constitutes one of the major requirements for human comfort today in automobiles, manufacturing environments, and equipment, generating higher sound pressure drives the need to develop more efficient and economical ways of producing sound absorption materials. Industrial applications of sound absorption, generally includes the use of materials such as glass wool, foam, mineral fibres and their composites. Three different layers of tea-leaf-fibre waste materials with and without backing provided by a single layer of woven textile cloth were tested in turkey (Ersoy, Kucuk, 2009), for their sound absorption properties. The experimental data indicate that a 1 cm thick tea-leaf-fibre waste material with backing provides sound absorption which is almost equivalent to that provided by six layers of woven textile cloth. Twenty millimeters thick layers of rigidly backed tea-leaf-fibres and non-woven fibre materials exhibit almost equivalent sound absorption in the frequency range between 500 and 3200Hz.

A simple methodology to estimate the main acoustical parameters of porous materials from very simple experimental tests is developed and validated on several conventional and innovative materials (Braccesi, Bracciali, 1998). It uses a least squares regression based on measured rejection coefficient values of specimens to compute reliable values for sound absorbing materials parameters such as flow resistively and structure factor.

Polyester fiber products are generally known as non-woven or bonded fiber fabrics (Narang, 1995). This industry has grown substantially during this century due to the development of several synthetic polymer fibers, of which polyester is one. Chemically, polyester is a polymeric ester formed by the reaction of an acid (terephthalic acid) with alcohol (ethylene glycol). All synthetic fibers such as nylon, polyester and acrylics now compete with natural fibers such as cotton and wool in the production of textiles. Thermo-binding fibers consisting of low melting point polyester are blended at the feeder stage with other fibers. The bonding is achieved by heating the fiber mixture under controlled conditions to a suitable temperature followed immediately by fast cooling. For a given polyester material, the effect of increasing mass/area can basically be understood in terms of the thickness of the material.

Polyurethane (PU) is commonly used as adhesives to join different materials in the footwear, automotive and general use adhesives (Veg-Baudrit *et al.,* 2006).

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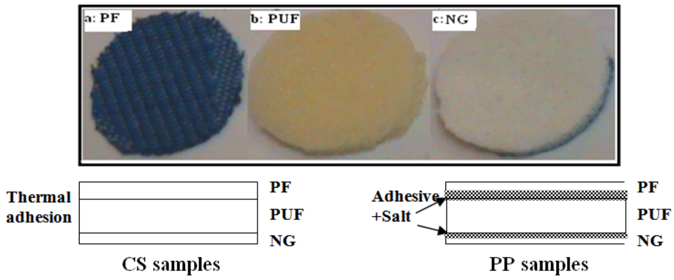
This work aimed at using a laminated polyester fabric composed of different layers from 1 to 4 layers and laminated by polyurethane adhesive doped with a removable salt. These fabrics can be used automobile and interiors applications to reach the sound permissible levels. The blank and treated fabrics will be tested using Two-Microphone Impedance tube system to determine the sound absorption coefficient values.

Experimental Work:

Blank laminated samples were composed of bottom layer **(NG)** made of nylon plain fabric of weaving structure (1/1) of weight of 50 g/m^2; upper layer made of polyester fabric **(PF)** of satin weaving structure of weight of 80 g/cm^2. These two fabrics constructed upper and lower layers occupy polyurethane foam **(PUF)** layer of 0.475 mm thickness in sandwich form. The conventional laminated composed sample was thermally bonded as purchased. For studying the effect of adhesive (polyurethane adhesive) and salt content effect on sound absorption characteristic a further samples were prepared were bonded using synthetic adhesive doped with different salt contents.

Individual blends of salt (magnesium chloride) and polyurethane adhesive **(PUA)** that was kindly supplied by Mardiny co, Egypt. The adhesive/salt blends were prepared in a clean and dry100 ml beaker. The adhesive blends with and without salt were applied with a film applicator to a thickness of ca 0.1 mm. adhesive's hardener was added to the salt/adhesive polymer mixture and mixed with a spatula. It was then poured in-between fabric and foam then cured at 120 for 6 min in a drying oven (Verdejo, 2009). The cured sample had thickness of 0.801 mm (including the nylon gauze background, foam, polyester fabric and the adhesive film). Figure 1 shows photographs and the construction of the sample's components. Different blending ratios of adhesive and salt were prepared as indicated in table 1.



PF, Polyester fabric (upper layer) + PUF, Polyurethane foam + NG, Nylon gauze (bottom layer) + thermally bonded → purchased samples (CS).
PF, Polyester fabric (upper layer) + PUF, Polyurethane foam + NG, Nylon gauze (bottom layer) + polyurethane adhesive (with salt and with dissolving salt) → prepared samples (PP).

Fig. 1: Photographs and construction of experimental samples

Table 1: Identification and sample codes

Samples code (PP)	Salt (g)	Adhesive (g)	Salt state
1	0.000	20.000	No salt
11	0.005	20.000	With salt
2	0.000	20.000	No salt
22	0.015	20.000	With salt
3	0.000	20.000	No salt
33	0.040	20.000	With salt

3.1. Method and Technique:

Over the past two decades significant research effort has been devoted to the development of experimental techniques dedicated to the measurement of local absorbing characteristics (Ersoy, Kucuk, 2009). Many of these involve the combination of direct and indirect methods to solve Biot s, equations which govern the propagation of acoustic and elastic waves in porous media.

The material measurements were based on a two-microphone transfer-function method according to ISO 10534-2 and ASTM E1050-98 international standards, which is for horizontally mounted orientation-sensitive materials. The testing apparatus was part of a complete acoustic material testing system, featuring Bruel & Kjaer, as it is seen in Fig. 2 (Verdejo, 2009 & Jiang, 2009).

A small-tube setup was used to measure different acoustical parameters for the frequency range of 500–6300 Hz. Small impedance tube kit from Bruel & Kjaer Type 4206 was consisted of a 29 mm diameter tube (small tube), sample holder and an extension tube at the same diameter. A frequency-weighting unit is also provided within the tube, in which different types of weighting are available; high pass, for high frequency measurements in the small tube, linear for measurements in the large tube, and low-pass for additional measurement accuracy below 100 Hz. At one end of the tube, a loudspeaker is situated to act as a sound source. At the other end of the tube, the test material is placed to measure sound absorption properties.

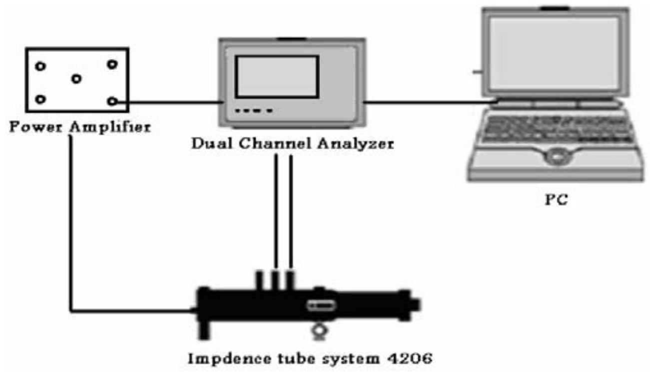


Fig. 2: PC-controlled measurement system

RESULTS AND DISCUSSIONS

Impedance tube measurement of purchased samples **(CS)**.of 29 mm diameter and 5, 10, 15, 20 and 25 mm thickness were prepared for testing. Fig.,3, shows the variation of absorption coefficient of **(CS)**.material as a function of frequency. A steady increasing in sound absorption coefficient in the frequency range from 500–5000 Hz with a maximum sound absorption coefficient of 0.65 at 5000 Hz., that due to an increasing in samples thickness from 5 to up to 15 mm. Increasing the thickness from 15 up to 25 mm increasing the of the sound absorption coefficient of 0.58 at 2000 Hz with increasing in sound absorption until 0.75 at 5000 Hz.

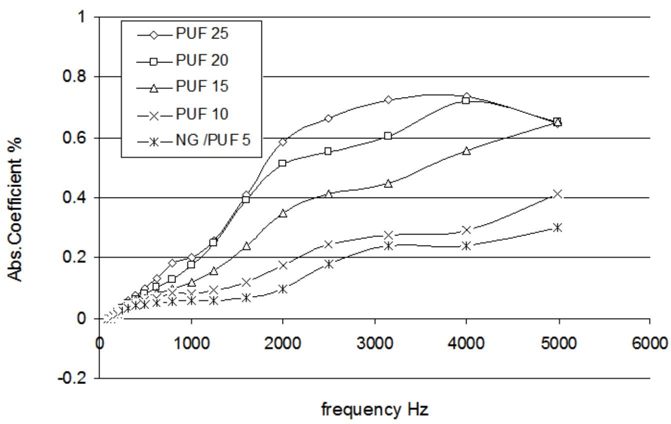


Fig. 3: Effect of polyurethane foam (PUF) thickness on the sound absorption coefficient

To understand the difference between the Nylon gauze layer (NG bottom layer) and what happened if a polyurethane foam layer (PUF) with a 5mm thickness was added on it (NG/PUF5) by thermally bonded method. Fig. 4, appears that a better sound absorption coefficient of polyurethane foam with nylon gauze layer (NG/PUF) than the sound absorption of (NG bottom layer) alone. Due to the construction of (NG/PUF) of increasing in the sound absorption coefficient of (NG/PUF) as the frequency increasing from 2000 up to 5000 Hz. That due to absorbing of sound in the pores of (PUF) in the (NG/PUF) sample.

Figure 5 shows Effect of polyurethane adhesive with and without salt on the sound absorption coefficient of polyurethane foam with nylon gauze layer (NG/PUF). As a result of a polyurethane adhesive and salt indicate to a rigid wall backing to the sample, the incident sound pass through the sample part of it absorbed in the incident pass and part reflect from the backing , the reflected sound , part of it absorbed when reflected through the sample, which appears in increasing in the sound absorption of (PP33) sample in the frequency range from 800-3000Hz. In other hand as salt extracted from sample (PP3), the sound absorption appears for the incident sound alone, so the values of the sound absorption of (PP3) appears lower than the sound absorption of (PP33).

In order to analyze the difference in sound absorption of (NG) than (NG/PUF) of (CS) samples, it appears in the frequency range from 2000 – 5000Hz that due to pores of the Polyurethane foam (**PUF**), and its thickness. of porous Polyurethane foam (**PUF**), and according to the effect of salt aggregates (Wu, 2003), and polyurethane adhesive, the absorption coefficient was measured for each frequency using an impedance tube. The measurement results are shown in Fig.6. It can be seen from (1) the results that for the salt aggregates of 0.04 g, the absorption coefficient became highest in the frequency range of 800-2500 Hz; (2) for the for the salt aggregates of 0.005 it became highest in the frequency range of 3150-5000 Hz.

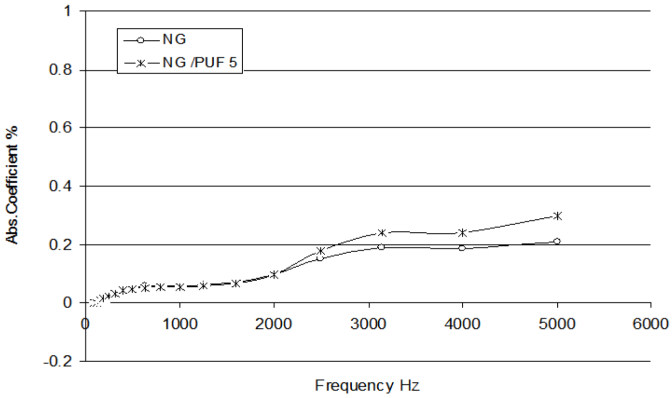


Fig. 4: Sound absorption coefficient of polyurethane foam with nylon gauze layer (NG/PUF) of (CS) and the sound absorption coefficient of nylon gauze layer alone (NG).

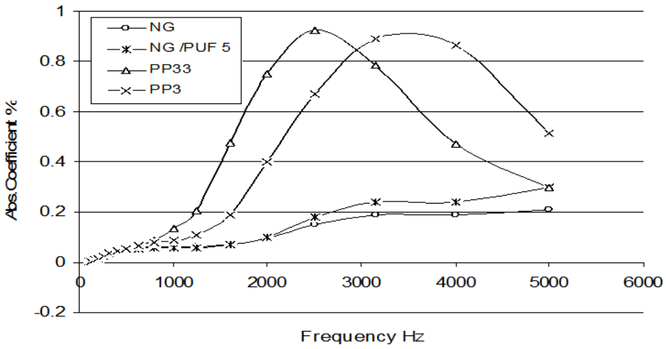


Fig. 5: Effect of polyurethane adhesive with and without salt on the sound absorption coefficient.

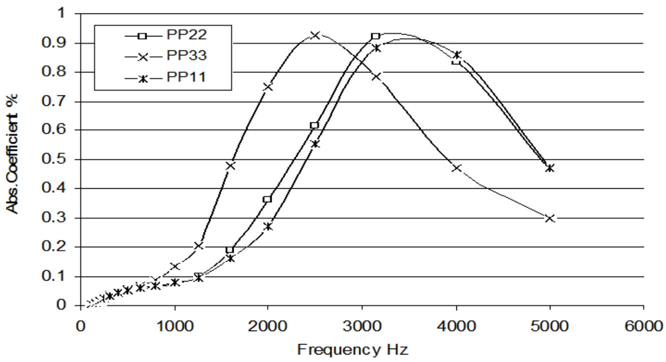


Fig. 6: Effect of salt concentration in polyurethane adhesive on the sound absorption coefficient of prepared samples (PP).

This signifies that the frequency of the highest absorption coefficient was obtained sound as the salt aggregates increased. This is because absorption became higher as the specific surface area of voids increased. Therefore, the specific surface area of the voids increased as the TVR of the porous concrete increased resulting in the highest sound absorption coefficient. Moreover, it was found that when the TVR remained the same, the increase in the content of the recycled aggregate had very slight influence on the

Figure 7 illustrates the effect of extracting the salt from polyurethane adhesive on the sound absorption coefficient of prepared samples (PP). It shows that the sound absorption coefficient increased due to be attributed to the ability of porous to convert the incident sound energy into heat energy and other types of energy by vibration, friction, air viscosity. As well, consumption of the energy was improved since the void created inside the specimen increased as the salt extracting increased.

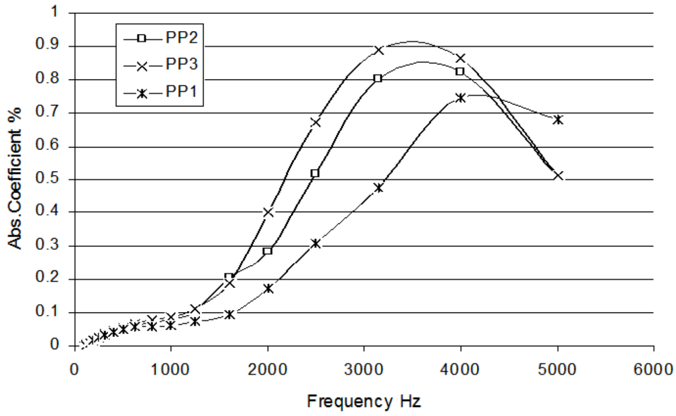


Fig. 7: Effect of salt extracting from polyurethane adhesive on the sound absorption coefficient of prepared samples (PP).

Conclusion:

The addition of salt and gaps to the adhesive layer between the fabric and foam in the laminated polyester fabrics improve the acoustic behaviors. This improvement due to the dense layer of salt which behaves as a shield to the acoustic wave and produce the duplication of the sound pathway in the foam layer. While in the samples subjected to salt extraction leaving air gap in the adhesive layer, these gap is well known its acoustic insulation. These behaviors were proofed by the sound absorption coefficient of polyurethane foam of different thickness (10 mm to 25 mm), polyurethane adhered to nylon gauze layer, nylon gauze alone, laminated fabric thermally adhered and laminated fabric with adhesive layer doped with salt and air gap due to salt extraction. This research found that the laminated fabric can replace successfully the very thick foam layer in the many acoustical applications.

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