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Use of textile nanofibers to improve the sound absorption coefficient of drilled panels for acoustic applications

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Nowadays combinations of textile materials are common solutions in acoustics applications as absorbent acoustic materials. Researches developed previously makes possible to assert that the nanofibers textile veils combined with the textile wools, will improve the acoustic proprieties of the latter. These kind of nanofibers textile veils are made with a process known as ”electro-spinning process” Furthermore, these kinds of combinations present an airflow resistivity value within the range established by the Technical Edification Code in Spain, so that, we can use these kinds of materials in sound insulation applications to reduce sound waves confined between two walls in a multi partition or in many other applications such as noise reduction in air conditioning systems or in the design of the electroacoustic systems In this work we have studied the application of nanofibers as a cover of the polyester wools which are placed under drilled panels. We can assert that an increase of just 1% of the absorbent material thickness with nanofibers veils is enough to improve the acoustic absorption at low frequencies, in the cases submitted.

1 Introduction

Nowadays, the textile industry field needs to focus on innovation as a way of developing. However, the publication in Spain of the Basic Document about Noise (DB-HR) which is part of the Technical Edification Code (CTE) [1] has boosted the development of new acoustic materials or different combinations of them. These new acoustic materials could give solutions to several problems that we usually have in building acoustic.

Textile materials have very interesting characteristics for application in the field of Architectural Acoustics. Most of textile materials are lightweight, resistant and adaptable and can be treated with coating technology to improve their acoustic characteristics. On this matter, we have, for example, the electro-spinning of polymeric nanofibers which provide a coating with high porosity, high sound absorption coefficient and a mass and thickness negligible

On the other hand, the acoustic properties of polyester wools are well known [2] [3]. Moreover, these materials are more sustainable and recyclable than mineral wools and are less dangerous for users.

In this paper we submit a feasibility study, from the acoustic point of view, about the use of textile materials or combinations of them, to improve the sound absorption coefficient of drilled panels. In order to obtain this objective, the acoustic behavior of polyester wools and combinations of polyester wools with nanofibers has been studied. We tested several compositions (Drilled panel without absorbent material in the plenum, DP, drilled panel with absorbent material (polyester wool) in the plenum, DPP, drilled panel with absorbent material (polyester wool combined with nanofibers veil); DPPV and drilled panel with mineral wool in the plenum, DPMW). The tests have been done in a reverberant chamber and the results have been compared.

2 Development

2.1 Characterization of acoustic materials

In order to carry out our objective and study the feasibility of using textile materials as acoustic materials, we need to know two parameters that characterize a material as an acoustic material. These two parameters are the sound absorption coefficient of normal incidence and the airflow resistivity of the material.

The sound absorption coefficient is defined as the ratio of the acoustic energy absorbed by the material and the incident energy. In order to obtain this parameter we used the transfer function method, according to the International Standard UNE-EN ISO 10534-2:2002 [5]

The airflow resistivity is other parameter which provides information about the material. This parameter is one of the most important parameters for the description of porous materials and it can be defined as the difficulty that a material presents for air streaming through it. In order to obtain this parameter we use the Ingard and Dear method, a simpler alternative to the method defined in the International Standard UNE-EN ISO 29053:1994 [7]

All acoustic tests carried out to obtain the parameters which characterize a material as an acoustic material have been developed in the laboratories of the Escuela Politécnica Superior de Gandia (Universidad Politécnica de Valencia). In figures 1 and 2 we can see the experimental devices that we have used to obtain the sound absorption coefficient of normal incidence and the airflow resistivity of the material.

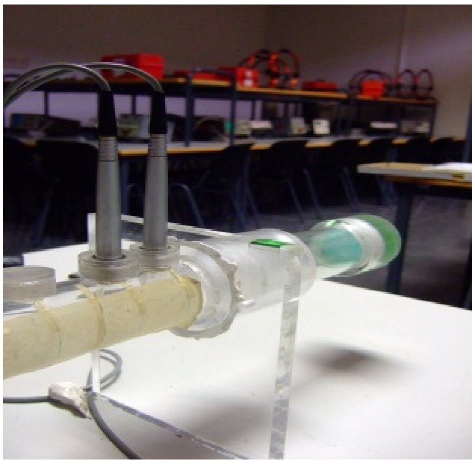

Figure 1. Experimental device to measure the sound absorption coefficient for normal incidence according to standard UNE EN ISO 10534-2:2002

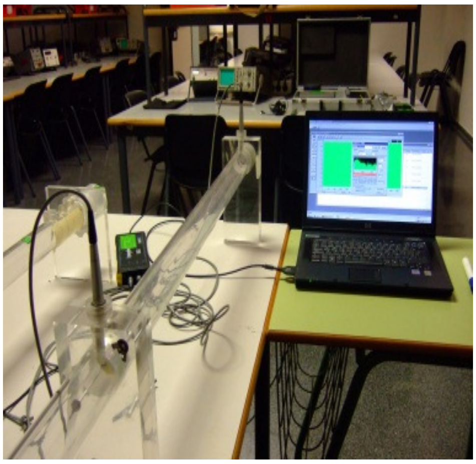

Figure2. Experimental device to measure the airflow resistivity according to the Ingard&Dear method

This first part of the work allows us evaluate the acoustic behavior of polyester wools or combinations of polyester wools with nanofibers. After that, the combinations that offer better results, from the acoustic point of view, have been selected.

In the second phase of the work, the materials with best acoustic properties will be used as absorbent materials placed in the rear of drilled panels. The aim of this second part was the study into the acoustic behavior of the absorbent material and the drilled panel as a whole.

In figure 3 we can see a picture about the kind of drilled panel that we have used in this work.

Figure 3. Drilled panel used in this work.

2.2 Measurement of the acoustic absorption in reverberant Chamber

We have previously said that the main objective for the second part of the work was to obtain the acoustic absorption in reverberant chamber for several combinations of absorbent materials and drilled panels as a whole.

In order to obtain this parameter we had to work according to the Standard UNE-EN ISO 354:2004 [4]. This Standard describes a method to obtain the sound absorption coefficient of acoustic materials used as acoustic treatment on walls and ceilings. The results we have obtained, according to the Standard, can be used for compare and design purposes.

These tests have been carried out in the reverberation chamber of the *Escuela Politécnica Superior de Gandia (Universidad Politécnica de Valencia).* This reverberant chamber counts with the shape and volume characteristics which have been defined in [4]. In figures 4 and 5 we can see pictures about the tests that have been made in the reverberation chamber during this work.

Figure 3. Measurements of sound absorption coefficient in reverberant chamber according to Standard UNE-EN ISO 354:2004

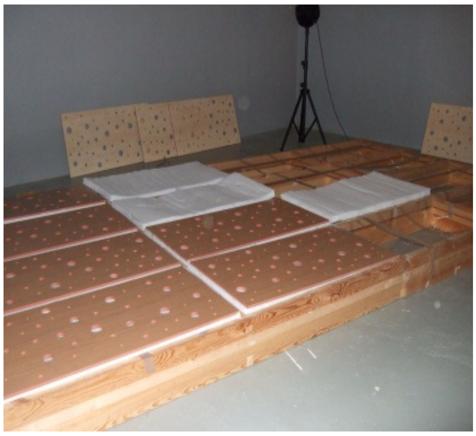

Figure 4. Measurements of sound absorption coefficient in reverberant chamber according to Standard UNE-EN ISO 354:2004

3 RESULTS

We have tested, from the acoustic point of view, samples of polyester wools with 4cm of width and combinations of these polyester wools and nanofibers veils with 0.2mm of width. The composition and development process of the textile veil are detailed in [9].

The airflow resistivity of polyester wools and polyester wools combined with nanofibers veils, is 9 $k{\cdot}Pa{\cdot}s/m^2$. According to the CTE (technical edification code) [1], the value of airflow resistivity should be above 5 $k{\cdot}Pa{\cdot}s/m^2$ to be able to use the material for acoustic insulation applications. Figure 5 shows the results for the sound absorption coefficient of normal incidence that we obtained for polyester wools and for polyester wools combined with a nanofibers veil. These results have been obtained according to Standard UNE-EN ISO 10534-2:2002 [5].

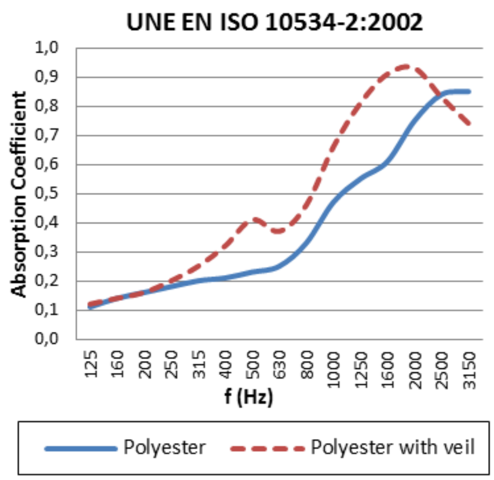

Figure 5. Sound absorption coefficient of normal incidence for polyester wools and polyester wools combined with nanofibers veils.

Figure 6 shows the results for the sound absorption coefficient that we obtained for several combinations of absorbent materials and drilled panels as a whole. These results have been obtained according to Standard UNE-EN ISO 354:2004 [4].

Next, the description of each of the studied combinations listed below.

- Drilled panel without absorbent material in the plenum (D.P).
- Drilled panel with absorbent material (polyester wool) in the plenum (D.P.P)
- Drilled panel with absorbent material (polyester wool combined with nanofibers veil) (D.P.P.V).
- Drilled panel with mineral wool in the plenum (D.P.M.W).

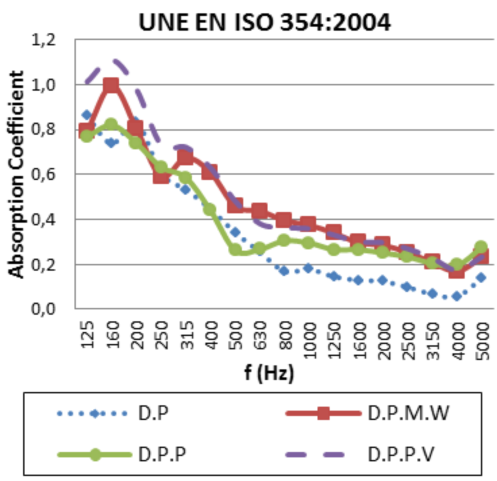

Figure 6. Sound absorption coefficient of each of the studied combinations obtained according to Standard ISO 354:2003 [4].

4 CONCLUSION

In this work, we have studied the feasibility of using textile materials combined with nanofibers veils to improve the acoustic features of drilled panels. Figure 3 shows how the sound absorption coefficient of normal incidence for polyester wool increases when we use a nanofiber veil as covering of this polyester material. We can see this improvement in practically all range of frequency. We want to emphasize that we obtained a 30% increase on the sound absorption coefficient in some frequencies with a width increase of only around 0.5%.

From the results obtained in the first part of the work, results of sound absorption coefficient of normal incidence, arises the possibility of introducing combinations of textile and nanofibers with drilled panels to improve the acoustic features of the last ones.

Drilled panels used to be combined with mineral wools like rock wools or glass fibers. Figure 6 shows the results of the sound absorption coefficient that we obtained from several combinations of absorbent materials and drilled panels as a whole. We can see that the sound absorption coefficient increases at mid and low frequencies when we use a nanofibers veil between polyester wool and drilled panel.

Moreover, we can see that the results obtained with the configuration composed by polyester wool, nanofiber veil and drilled panel, are better than the results we would have obtained if we had used a traditional mineral wool as absorbent material.

Acknowledgments

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