Use of Cork as Absorbent Material

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Abstract. Cork is a green and sustainable material. At the end of its useful life, it can be disposed of into the environment without causing any damage. It can be used to improve the acoustics inside environments, as a system for the reduction of reverberation time. Sound absorption systems consist of cork panels mounted at a distance onto a rigid wall. The thickness of the cork panels considered are 1.5 mm and 2.5 mm. While the distances considered from the rigid wall are 3 cm, 5 cm, 10 cm and 15 cm. The absorption coefficient of the samples was measured in the frequency range from 100 Hz to 2,000 Hz with an impedance tube (tube of Kundt). Furthermore, the problems relating to the realization of sound-absorption systems composed of cork panels are also discussed.

INTRODUCTION

Research in the field of applied acoustics and energy conservation is currently focusing on the application of organic materials. Studies are being carried out to replace the materials coming from the oil industry with organic materials or materials which at the end of their useful live do not cause any damage to the environment when disposed of. Absorption systems made from hemp, kenaf, gorse and sheep wool compounds have been studied [1, 2, 3, 4]. The measurements of the absorption coefficient of these materials have provided appreciable values. Cork has not been studied in great detail, even if current literature reports the absorption coefficient values of of semi-rigid cork panels of an appropriate thickness and different grain sizes. In this configuration, the presence of a binder to obtain the semi-rigid panels reduces the sound absorption coefficient value. The sound absorption coefficient values, reported in current literature, are relatively low at low and medium frequencies, while they increases at higher frequencies. This behaviour is due to the size of the cork grains and the binder used that prevent the passing of air, therefore reducing the absorption effect of the sound. Cork is obtained from oak bark, with the tissue being composed of spherical granules containing air, making the panels light and elastic. It is an excellent thermal insulation material. Cork is an organic coating tissue of secondary origin, which covers the stem and roots of woody plants, that, with its compact structure, is waterproof and fire resistant. It can be used for thermal and acoustic insulation. Since cork is an organic material, it is biodegradable, recyclable, renewable, widely available and has relatively low manufacturing costs. It also has the advantage that at the end of its useful life it can be disposed of without any difficulties and without damaging the environment. This material can be used in the field of architectural acoustics as an insulating material. It is a "sustainable material" and used for the construction of buildings components. This paper discusses the application of cork panels as an absorption material. The thickness of the cork panels considered are 1.5 mm and 2.5 mm. When a thin flexible panel is placed at a distance from a rigid wall, it absorbs a part of the incident sound energy. The sound absorption is highly influenced by the distance of the panel from the rigid rear wall, in a way that the maximum absorption results for a cavity equal to $\lambda / 4$ (defined λ the sound wavelength). This means that a greater depth of the cavity moves the absorption towards the low frequencies. The use of thin cork panels, mounted at a distance appropriate to a rear rigid wall can be used for the acoustic correction of closed environments. The cork panels were mounted with a back cavity of 3 cm, 5 cm, 10 cm and 15 cm. This can adequately accommodate the acoustic comfort conditions and make environments aesthetically pleasing, thus expanding the use of cork in interiors.

METHODOLOGY

The sound absorption coefficient at normal incidence was measured according to the procedure described in ISO 10534-2 [5, 6, 7]. This method allows to measure the acoustic parameters by using small samples mounted inside the measurement tube. The measurements were carried out using the impedance tube, with the following features: internal diameter of 10 cm (corresponding to a lower limit of 100 Hz, an upper frequency limit of 2,000 Hz), a length of 56 cm, and two microphones mounted. The distance from the two measurement microphones was 5 cm . Figure 1 shows the impedance tube for the sound absorption coefficient measurement at normal incidence [8, 9, 10, 11]. This system requires progressive plane waves inside the measurement tube. The acoustic measurements of the sound absorption coefficients were taken for cork panels with a thickness of 1.5 mm and 2.5 mm. The cork panels were mounted with a back cavity of 3 cm, 5 cm, 10 cm and 15 cm. Figure 2 shows the cork sample used for the acoustic measurements, the diameter was 10 cm, equal to the inner dimeter of the impedance tube. Figure 3 shows a schematic drawing of the measurement setup performed with the impedance tube creating a back cavity behind the cork panel. While Figure 4 shows the absorption coefficient values for the samples mounted at different distances from the back cavity [12, 13, 14, 15].

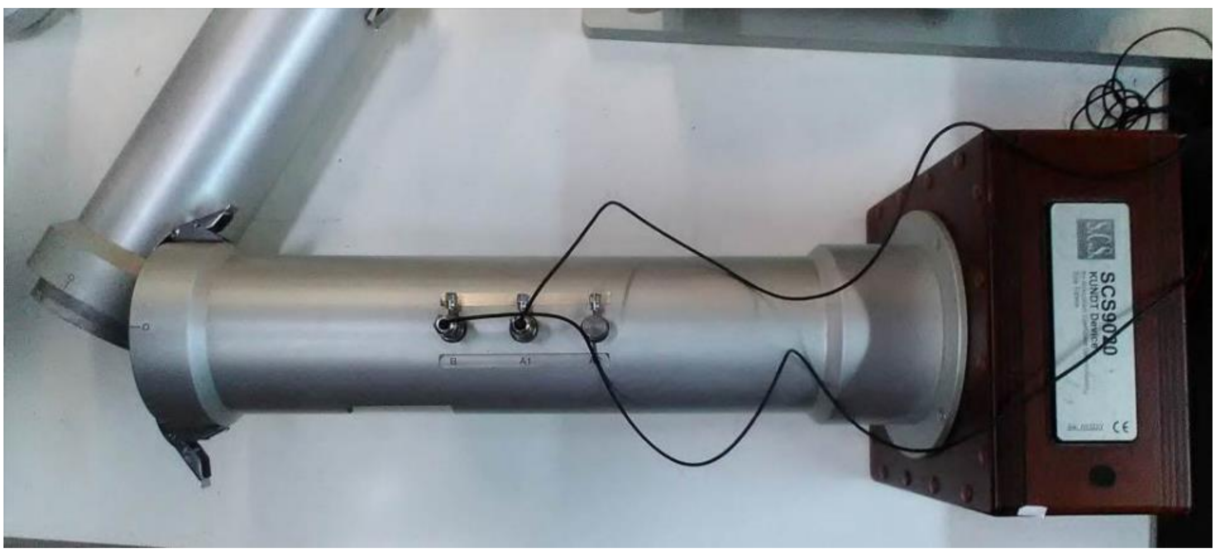

FIGURE 1: Impedance tube for the sound absorbent coefficient measurement

DISCUSSION

Figure 4 shows the results of the acoustic measurements carried out on two different cork panel samples with a thickness of 1.5 mm and 2.5 mm. The measurements of the absorption coefficient were taken with an impedance tube by varying the back cavity compared to the rigid wall thickness of 3 cm, 5 cm, 10 cm and 15 cm. The blue dotted line represents the cork panel with a thickness of 1.5 mm, while the red solid line represents the 2.5 mm. cork panel. The tests were performed on 10 cm diameter samples. For the cork panel of 1.5 mm thickness, as expected, upon increasing the cavity behind the cork sample within the impedance tube, the maximum sound absorption value moved towards the low frequency range. For the cavity with a thickness of 15 cm, the maximum absorption was around the frequency of 300 Hz, for the thickness of 10 cm, the maximum absorption was around the frequency of 400 Hz. While, for the cavity with a thickness of 5 cm, the maximum absorption was around the frequency of 600

Hz. For the cavity of 3 cm, the maximum acoustic absorption was obtained at a frequency of 900 Hz. For all the cavities considered, the value of the absorption coefficient was reduced as it went down towards the low frequency areas. The development of the absorption coefficient around the frequency in which it has the maximum absorption has the form of a very enlarged bell. The material behaves like an extended absorber around the maximum absorption frequency, this behaviour allows for the applications of 1,5 mm thick cork panels at a large enough frequency interval. From the measurements carried out with the impedance tube, the cavity with a thickness of 5 cm is the best suited for the acoustic correction of closed environments, since it provides an absorption coefficient value greater than 0.8 in the frequency range between 500 Hz and 1100 Hz. While from the measurements carried out with the impedance tube, the cavity with a thickness of 3 cm is the best suited for the acoustic correction of closed environments, since it provides an absorption coefficient value greater than 0.8 in the frequency range between 700 Hz and 1200 Hz. For the 2.5 mm cork panel, as expected, upon increasing the cavity behind the cork sample within the impedance tube, the maximum sound absorption value moved towards the low frequency range. However, compared to the previous case, the 2.5 mm thick panel does not behave as an extended absorber. The absorption coefficient value assumes a value that selectively focuses around the maximum value, with a very narrow bell development. The 2.5 mm cork panel does not exhibit a satisfactory value of sound absorption coefficient and therefore cannot be used for the correction of acoustic environments.

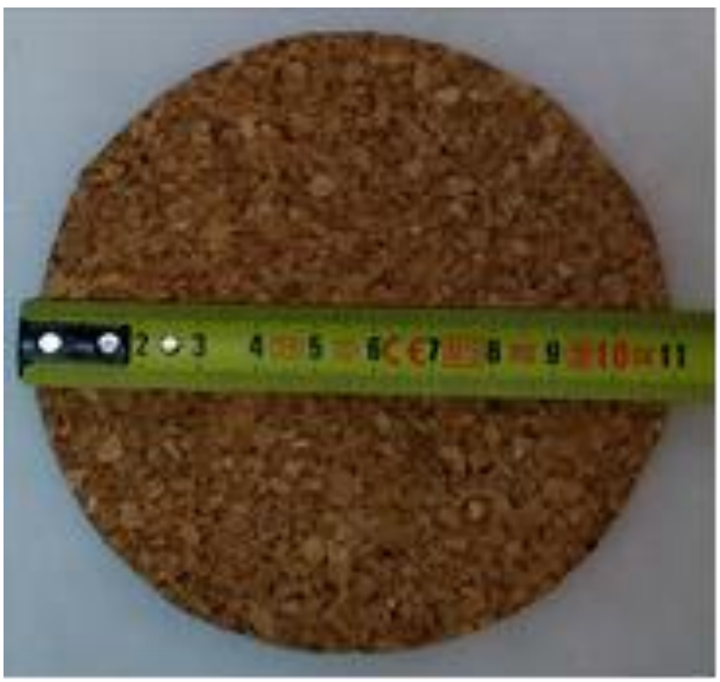

FIGURE 2. Sample used for acoustic measurements

CONCLUSIONS

This paper presents the acoustic properties of cork panels measured using an impedance tube. The cork panels considered in this study had a thickness of 1.5 mm and 2.5 mm respectively, the diameter of the specimens was 10 cm, equal to the internal diameter of the impedance tube. The cork panels were mounted at a distance of 3 cm, 5 cm, 10 cm and 15 cm from a rigid rear wall. The cork panels with a thickness 1.5 mm have good absorption coefficients at low and medium frequencies. These panels act as extended absorbers, but the decrease of thickness of the cavity behind the value of the absorption coefficient moves toward the high frequencies. The cork 2.5 mm thick panels have good absorption coefficients in a narrow range of frequencies, around the maximum value. In this case, when decreasing the rear cavity thickness, the value of the absorption coefficient moves toward the high frequencies.

The results show how cork panels have good sound absorption values and can therefore be considered as a valid alternative to traditional sound absorbing materials. As expected, increasing the thickness of the cavity gives an absorption coefficient value in the low frequency components. The high absorption obtained in some frequency bands, depending on the back cavity depth, confirmed the possibility of using cork panels for the acoustic correction of different type of rooms, churches or classrooms. The thicknesses of the cork panels that have a good absorption coefficient value are those of 1.5 mm. Thicker panels do not present a good sound absorption value. Further studies on cork panels of different thickness should be carried out, with it is also being necessary to realize real scale cork panel absorption systems, to be used for the acoustic correction of environments in order to evaluate the feasibility of the system and assess any possible problems [16, 17, 18, 19, 20].

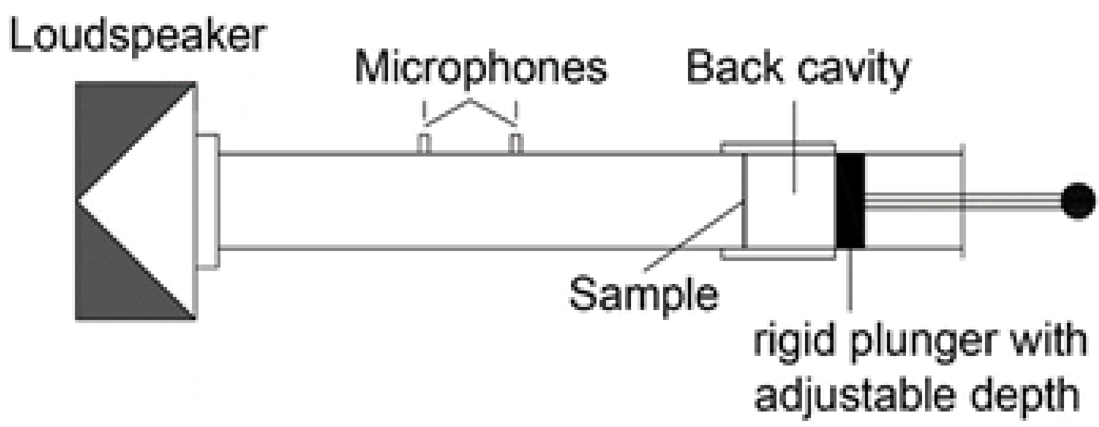

FIGURE 3. Scheme of the impedance tube using a sample with a back cavity.

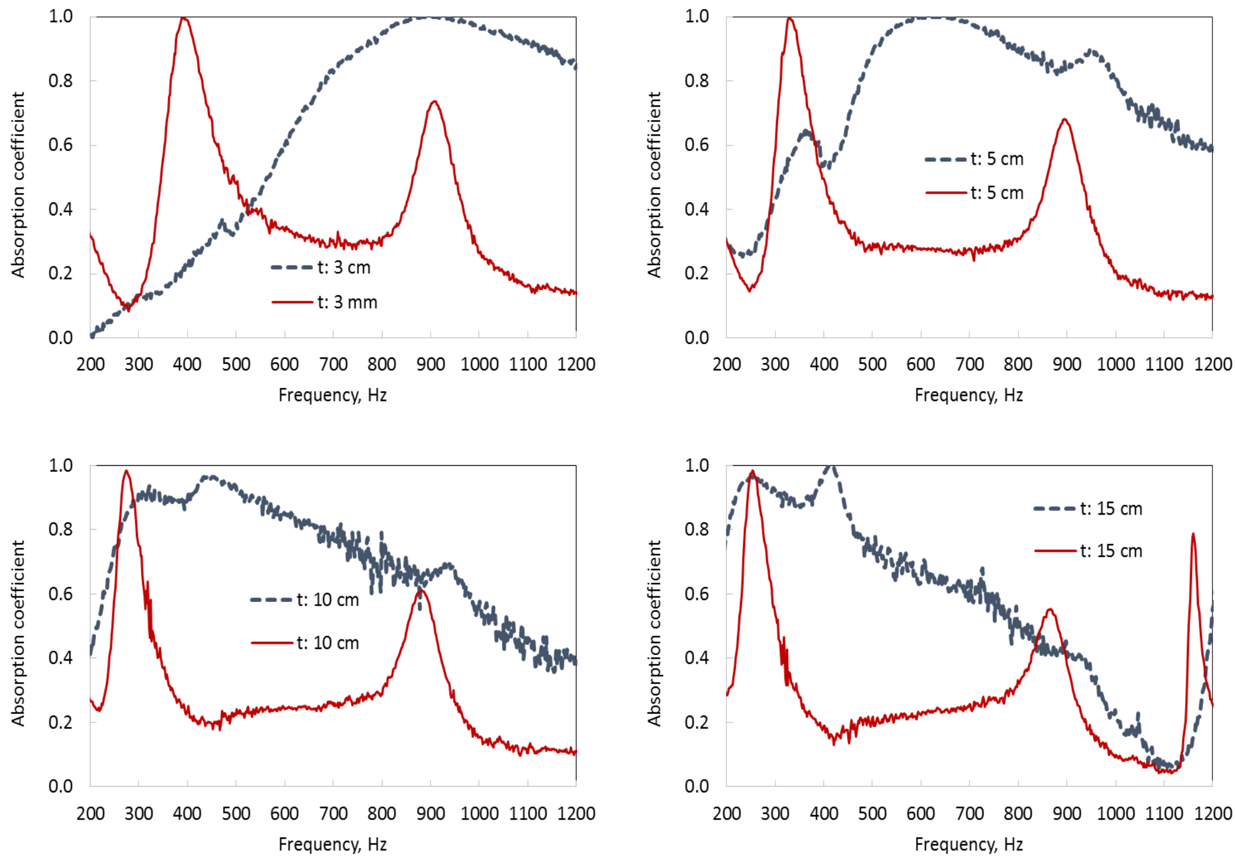

Figure 4. Absorbent coefficient values for sample mounted ad different distances from the back cavity (t = 3 cm, 5 cm, 10 cm, 15 cm). Dashed blue line cork sheet thickness 1.5 mm – Continuous red line cork sheet thickness 2.5 mm.

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