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COMPARISON OF SOUND ABSORPTION COEFFICIENTS OF TWO FINE MATERIALS ACCORDING TO ASTM E1050-2012

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Abstract. *Noise is an ordinary problem in daily life of people and can be harmful to human health. Simultaneously, there is currently a need for using materials and developing products that do not harm the environment. Materials from natural origin that are normally discarded or underutilized such as fiber from coconut husk, fiber from sisal and waste from sugar cane. In this work was realized a preliminary study of sound absorption coefficient of samples of fiber from coconut husk (FC) and samples of polyurethane (PU). The experiments comply with ASTM E1050-2012. The results show that sample of polyurethane, despite of having closed pores, have better sound absorption coefficient than sample of fiber from coconut husk in high frequencies.*

Keywords: *noise, sound absorption coefficient, fiber from coconut husk, polyurethane, ASTM E1050-2012.*

1. INTRODUCTION

The sound pollution is an ordinary problem in people's daily lives and can be harmful to human health. An individual, who is exposed for an extended period in a noisy place, may present in addition to problems related to hearing, others diseases such as headache, stress, insomnia, cardiac arrhythmia and arterial hypertension (Griefahn *et al.*, 2006; Canlon *et al.*, 2012; Frei *et al.*, 2014; Babisch *et al.*, 2014).

Noise can be attenuate by fibrous or porous materials, which is called sound absorbing material. Absorbent materials dissipate acoustic energy through the vibration of air within the interstices of fibrous or porous material under the action of sound pressure. This oscillation causes energy loss due to friction within the absorbent material, converting acoustic energy into thermal energy (Beranek and Vér, 1992).

Nowadays, there is a great interest to use raw materials and develop products do not harm environment, in other words, sustainable material. Natural materials can be high potential like environmentally friendly material such as fiber from coconut husk, fiber from sisal and waste from sugar cane.

The automotive industry have concerned both with acoustic comfort and developing products using sustainable raw materials. Natural materials, compared to synthetic materials, decreased the production coast and meet environmental standards.

Automotive vehicles have many non-biodegradable parts, which cannot be directly disposed to environment. One of this part is the roof trim, which is composed by polyurethane. This polymer is synthesized through reaction between a diisocyanate and a diol (Caraculacu and Coseri, 2001). However, isocyanates are notably toxic chemical and synthesized from an even more toxic substance, which causes environmental hazards. Moreover, exposure to isocyanates can cause health effects, such as skin irritation and long-term asthma (David and Staley, 1969).

In this work was realized a preliminary study of sound absorption coefficient of samples of fiber from coconut husk (FC) and samples of polyurethane (PU). The experiments comply with ASTM E1050-2012.

2. EXPERIMENTAL PROCEDURE

The sound absorption coefficient was determined according to ASTM E1050-2012. The equipment used in measurements are shown in Fig. 1: a signal analyzer PULSE from B&K Type 3160-A-042 with four input channels and two output channels, two ¼” microphones B&K Type 4935 with nominal sensibility 5,6 mV/Pa and two impedance tube SCS model 9020B/K. The impedance tube with 100 mm of internal diameter was used for measurement at low frequency and the impedance tube with 28 mm of internal diameter was used for measurement at high frequency.

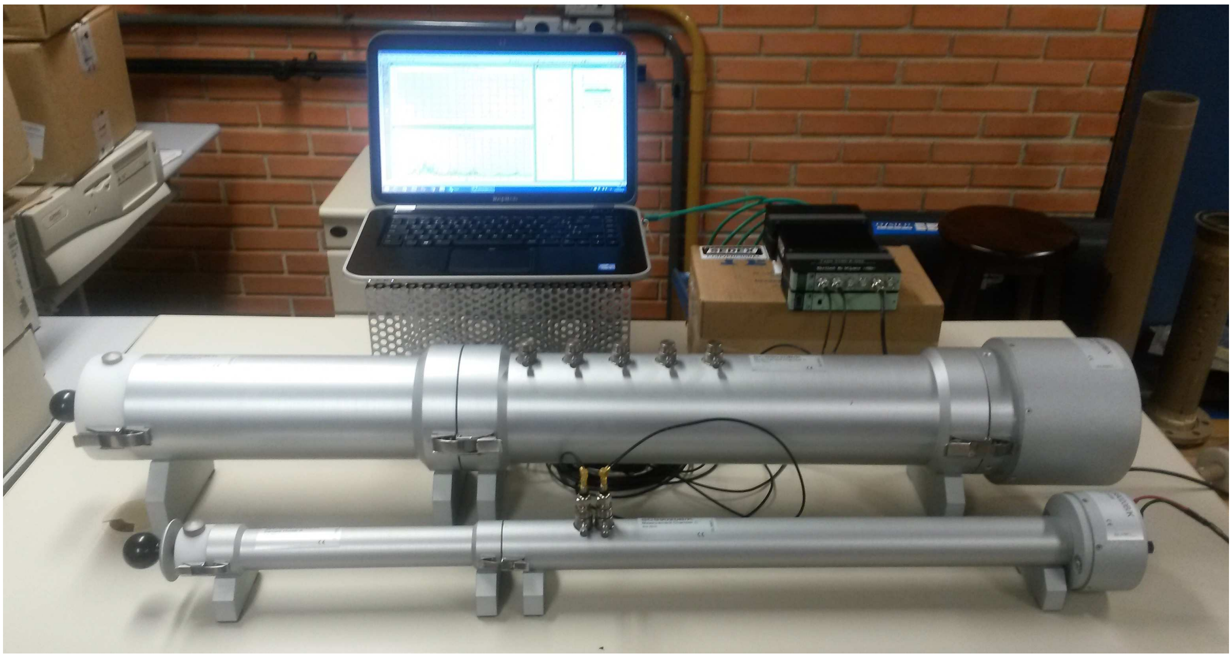

Figure 1. ASTM E1050-2012 equipment.

In Figure 2 is shown the schematic of impedance tube. At one end of the impedance tube is mounted the loudspeaker and at another end is located the sample backed by a rigid termination.

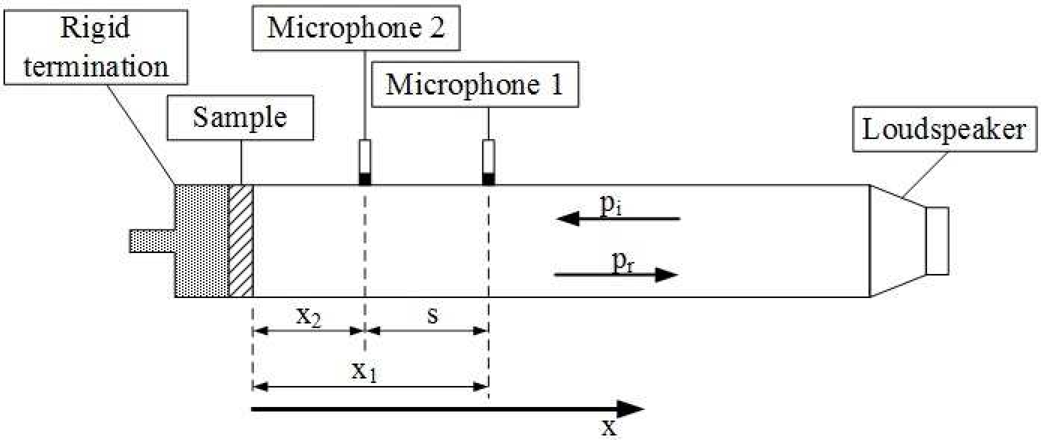

Figure 2. Setup of impedance tube.

The data of microphone spacing s, distance between sample and the nearest microphone x_2, distance between sample and the farthest microphone x_1, frequency range and cutoff frequency of each impedance tube are shown in Tab. 1. The frequency range (Bodén and Abom, 1986) and the cutoff frequency (Eriksson, 1980) can be calculated, respectively, by:

$$f_l \rangle \frac{0.1c}{2s} \tag{1}$$

$$f_u \rangle \frac{0.8c}{2s} \tag{2}$$

$$f_c \rangle \frac{1.84c}{\pi D} \tag{3}$$

where,

f_l	is lower working frequency of the tube;
f_u	is upper working frequency of the tube;
f_c	is cutoff frequency;
c	is speed of sound in the air;
D	is internal diameter of the tube.

Table 1. Setup of impedance tube .

	Low frequency impedance tube	**High frequency impedance tube**
s [mm]	100	60
x_1 [mm]	250	80
x_2 [mm]	150	20
Frequency range [Hz]	173 ~ 1384	865 ~ 6920
Cut-off frequency [Hz]	2027	7238

The sound reflection coefficient R(f) can be obtained by:

$$R(f) = \frac{H_{12}(f) - e^{-iks}}{e^{iks} - H_{12}(f)} e^{2ikx_1} \tag{4}$$

where,

k	is the wave number of air;
$H_{12}(f)$	is the transfer function of microphone 2 to microphone 1.

The sound absorption coefficient α(f) can be obtained by:

$$\alpha(f) = 1 - |R|^2 \tag{5}$$

In Figure 3 are shown samples of FC and PU. Five samples of FC with 28 mm diameter, five samples of FC with 100 mm diameter, five samples of PU with 28 mm diameter and five samples of PU with 100 mm diameter were evaluated.

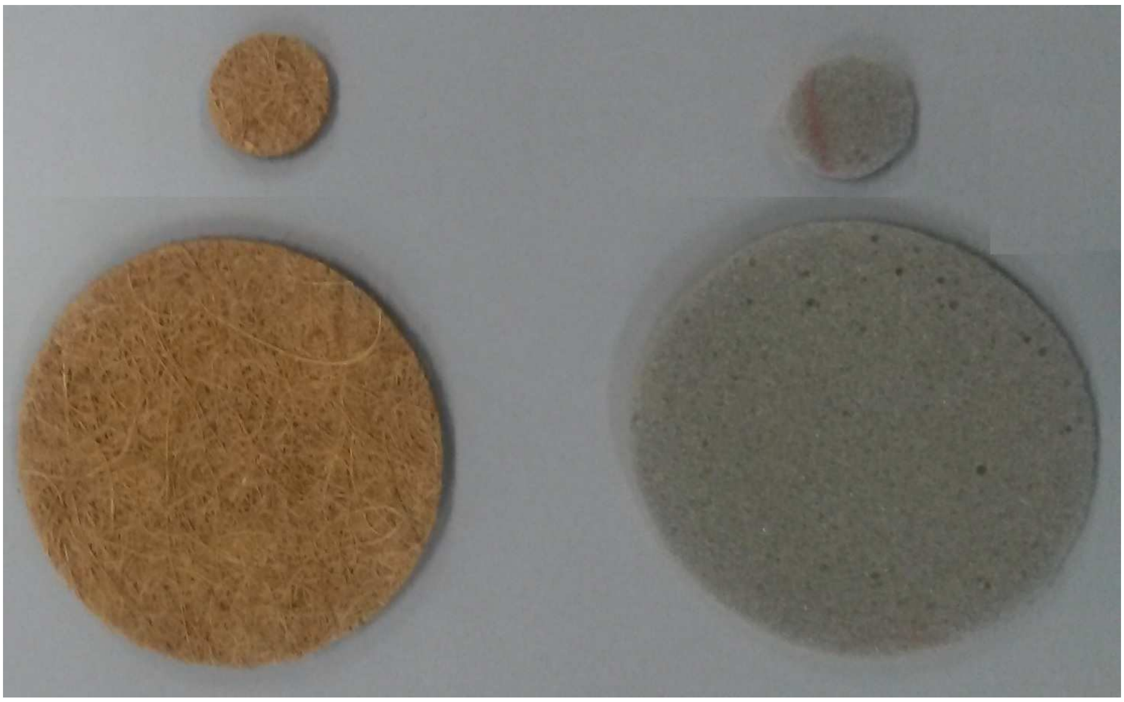

Figure 3. Samples of FC and PU.

Table 2 presents the mass, the thickness and the density of samples of FC. Table 3 presents the mass, the thickness and the density of samples of PU.

Table 2. Data for FC.

	Mass (g)	**Thickness (mm)**	**Density (kg/m³)**
FC 1 ∅28	0.80	4.56	284.76
FC 2 ∅28	0.66	3.89	275.72
FC 3 ∅28	0.60	4.76	204.60
FC 4 ∅28	0.58	4.18	225.61
FC 5 ∅28	0.67	4.53	240.46
FC 1 ∅100	8.85	5.14	219.33
FC 2 ∅100	9.67	4.89	251.91
FC 3 ∅100	8.24	5.25	199.84
FC 4 ∅100	9.04	4.70	244.90
FC 5 ∅100	9.35	5.78	206.14

Table 3. Data for PU.

	Mass (g)	**Thickness (mm)**	**Density (kg/m³)**
PU 1 ∅28	0.07	5.50	20.67
PU 2 ∅28	0.07	5.50	20.67
PU 3 ∅28	0.07	5.60	20.30
PU 4 ∅28	0.07	5.50	20.67
PU 5 ∅28	0.07	5.65	20.67
PU 1 ∅100	0.92	5.60	20.92
PU 2 ∅100	0.91	5.54	20.91
PU 3 ∅100	0.94	5.61	21.33
PU 4 ∅100	0.91	5.39	21.50
PU 5 ∅100	0.89	5.18	21.88

3. RESULTS AND DISCUSSION

Figures 4 and 5 show the sound absorption coefficient obtained in low frequency impedance tube and high frequency impedance tube, respectively. The continuous red line presents the attenuation caused from viscous and thermal losses at the walls of impedance tube (Han *et al.*, 2007). The continuous line blue and green are the sound absorption coefficient without correction for tube attenuation and the dashed line blue and green are the sound absorption coefficient with correction for tube attenuation.

Tube attenuation effects when sound absorption coefficient is quite small, as seen in Fig. 4. However, there is no effects when sound absorption coefficient is relatively high, as shown in Fig. 5.

The results of sound absorption of FC and PU were approximately the same in frequency span from 200 Hz to 800 Hz. In frequencies above than 800 Hz, the absorption of samples of PU is better than samples of FC.

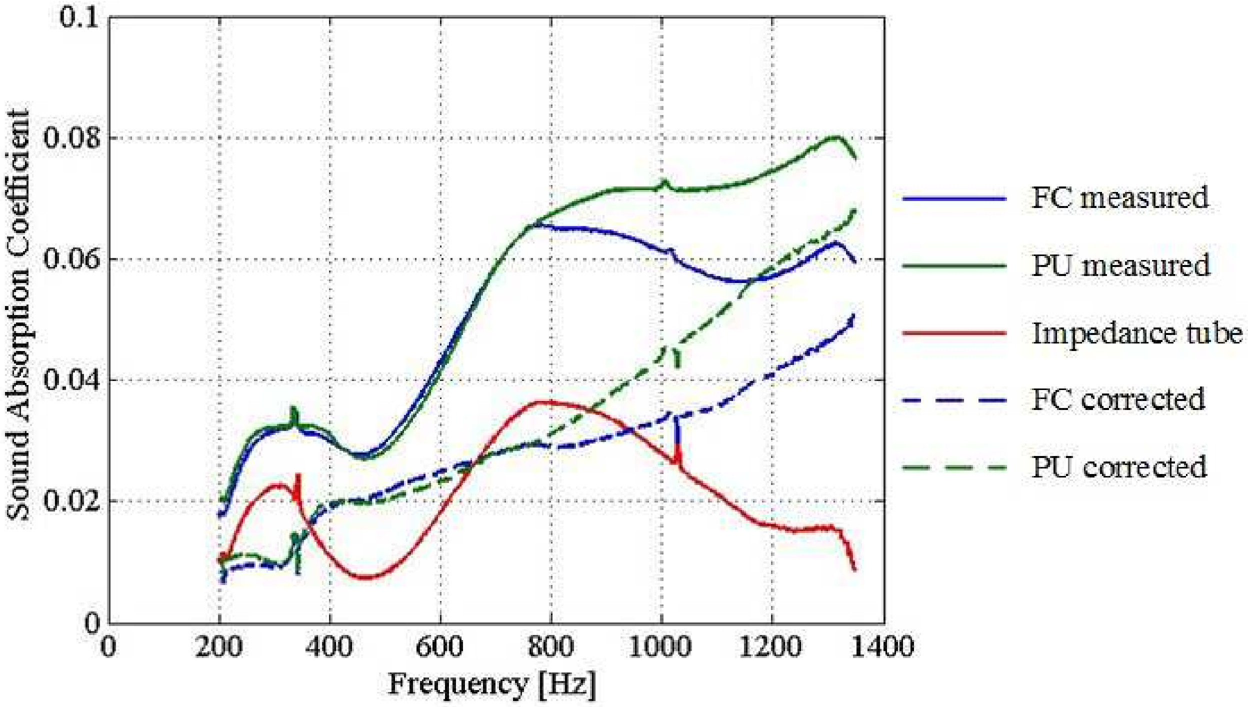

Figure 4. Sound absorption coefficient of FC and PU samples for low frequency impedance tube.

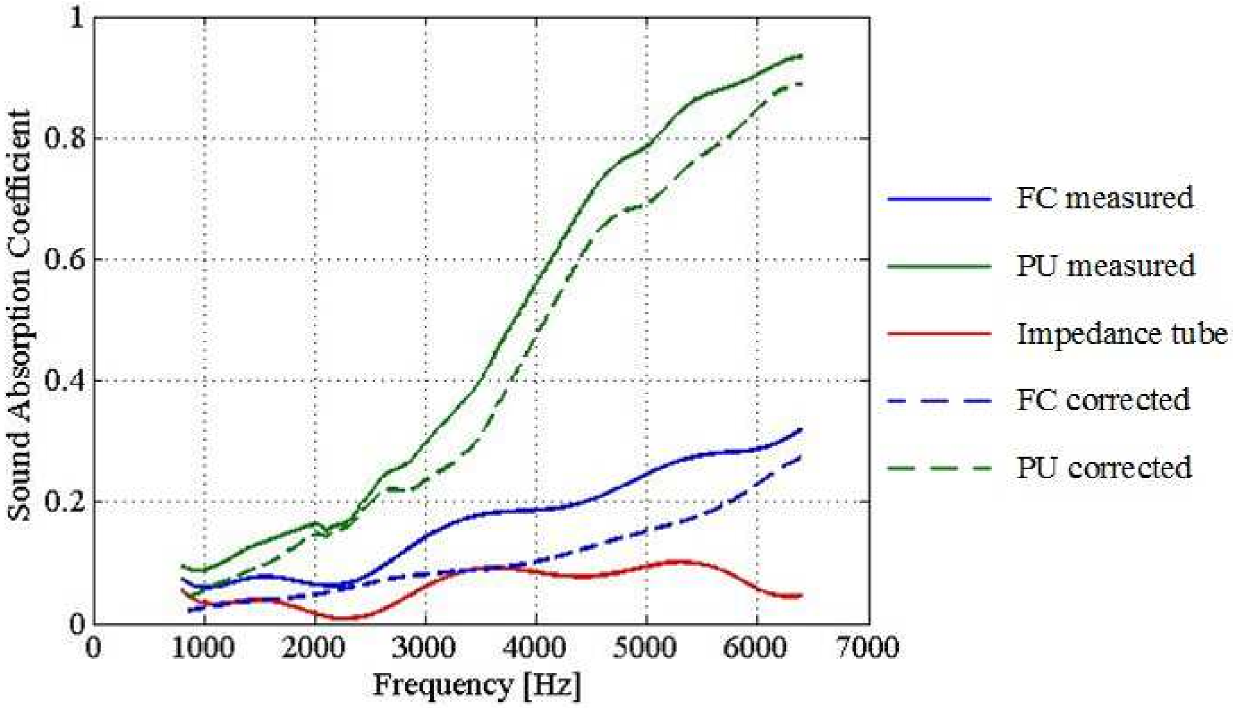

Figure 5. Sound absorption coefficient of FC and PU samples for high frequency impedance tube.

4. CONCLUSIONS

In this work were evaluated the sound absorption coefficient of samples of FC and PU according to standard ASTM E1050-2012. Tube attenuation effects when sound absorption coefficient is quite small, however, there is no effects when sound absorption coefficient is relatively high. The acoustic energy dissipated by the FC and PU were approximately the same in frequency span from 200 Hz to 800 Hz. Although, in frequencies above than 800 Hz, the absorption of synthetic material is more efficient than vegetal fiber.

5. ACKNOWLEDGEMENTS

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7. RESPONSIBILITY NOTICE

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