Assessment of Sound Absorbing Properties of Composite Made of Recycling Materials

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Abstract

In modern world we are searching methods to reuse most of industrial disposals produced during manufacturing. Some kinds of materials, like scraps from acoustic foam, however are not so easily utilized using recycling methods for its primary usage. Disposals produced during the manufacturing process can be compressed and reused as sound absorbing material.

The purpose of this article is to examine sound absorbing properties of material made of acoustic foam disposals and compare it with sound protection materials, which are commonly used. Sound absorbing damping were tested using Kundt's tube and reverberation room examination method. Tests were carried out according to standard PN-EN ISO 354:2005, for reverberation room examination, and according to Bruel&Kjaer electronic instruments technical manual for Kundt's tube examination.

Keywords: sound absorbing materials, recycling, sound absorption coefficient, composite materials

1. Introduction

Everlasting increase of consumptions of goods by the humans leads to production rise, however it is also connected to escalation of waste production leading to growing industrial pollution.

In XXI century we can observer growing trend to utilize as much waste as possible by recycling. However even if some materials are widely reused, others, like acoustic foam, are omitted in recycling utilization process.

Moreover because of everlasting technological improvements in various areas of services people are surrounded by noise generation. Cars, industrial machinery, communal transport etc. generates high amount of infrasound, which even if not perceived by our ears, has negative impact on our health conditions [1]. Our internal organs have specific density, which results in certain frequencies have impact on them. People, which are exposed on constant low frequency noise are reporting more often problems with headaches, fatigue, ringing in the ears and heart problems. It was reported that low-frequency sound of value equal to 75 dB is assumed as critical for human health, omitting specific personal sound vulnerability [2].

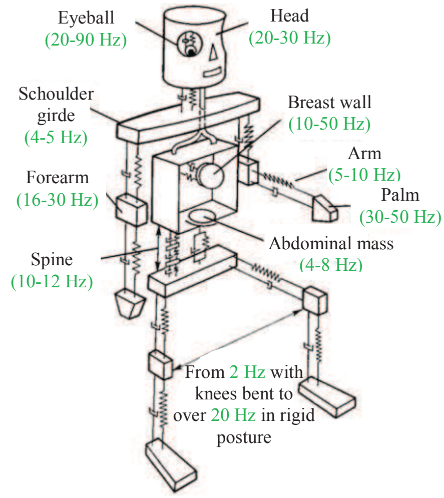

Figure 1. Characteristic frequencies of human organs vibrations [3]

What is more, infrasound, due to its long wave nature, they propagates well and are not dampened in the air. For example wave of frequency equal to 10 Hz decays 0.1 dB per kilometer. Because of wavelength of infrasound typical acoustic isolation are not so effective and other damping materials has to be used [4, 5].

2. Methodology research

The research was carried out in Institute of Power, Thermal Technology Branch "ITC" laboratory. Two examination methods were used. Test were performed using four types of material: three commonly used and recycling composite made of mix of scraps from polyurethane and polyethylene foams. Components ratio of scraps is classified by the producer. Materials were prepared for the tests accordingly. Thickness of tested materials are presented in Table 1.

Table 1. Thickness of examined materials

Material Type	Thickness [mm]	Density [kg/m^3]
Acoustic Foam (Plain)	56	35
Acoustic Foam (Pyramids)	55	28
Glasswool	49	35
Recycling Composite	53	40

First phase was checking physical absorption coefficient with impedance tube method (Figure 1). SVAN 912 analyzer was used to record test results. Circular samples with 100 mm diameter were prepared for examination.

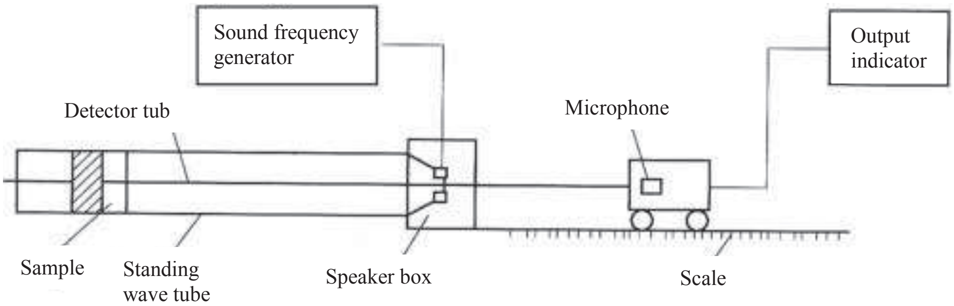

Figure 2. Impedance tube scheme [6]

Measuring equipment consists of tube with 100 mm diameter, which is connected to the speaker box. Microphone probe is inserted via the hole in the speaker and connected to the trolley, which is moving on track with scale.

Physical sound absorption coefficient α_f is calculated using following formula (1).

$$\alpha_f = 1 - \left(\frac{n-1}{n+1} \right)^2 \tag{1}$$

Where:

α_f – physical sound absorption coefficient,

p_{max}/ p_{min} – maximal/minimal value of acoustic pressure,

n – value of maximal acoustic pressure divided by minimal acoustic pressure.

To obtain meaningful results examinations were carried out for three samples of every kind of material

Second phase of test was examination of materials using reverberation room method. At start samples were inserted into reverberation room for 24 hours to acclimatize to the atmospheric conditions in chamber.

In order to measure reverberation sound absorption coefficient for every sample two measurements were conducted: first for reverberation of chamber and second – reverberation of chamber with sample placed on the floor of the chamber.

For every test 10 m^2 of material was placed on the floor of the reverberation chamber according to standard PN-EN ISO 354:2005 [7]. For examination nor140 acoustic analyzer connected to the rotating boom has been used.

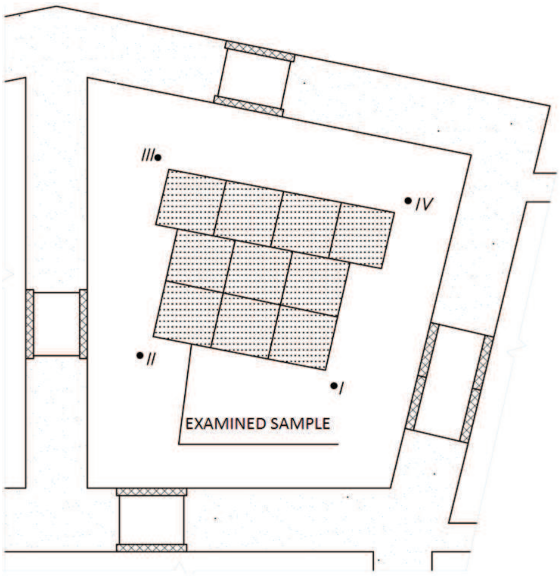

Figure 3. Setup of sample in reverberation room

To calculate reverberation sound absorption coefficient of material, firstly equivalent area of sound absorbing area within reverberation room, without tested material must be calculated (formula 2):

$$A_1 = \frac{55.3 \times V}{c \times T_1} - 4 \times V \times m_1 \tag{2}$$

where:

V – volume of the reverberation room [m^3],

c – speed of sound in specific temperature [m/s^2],

T_1 – reverberation time of the empty reverberation room [s],

m_1 – acoustic power damping coefficient [1/m].

After that, equivalent area of sound absorbing area within reverberation room, with tested material must be calculated (formula 3):

$$A_2 = \frac{55.3 \times V}{c \times T_2} - 4 \times V \times m_2 \tag{3}$$

Which leads to calculating equivalent area of sound absorbing area of the tested material (formula 4):

$$A_T = A_2 - A_1 \tag{4}$$

Reverberation absorption coefficient is calculated according to formula 5:

$$\alpha_s = \frac{A_T}{S} \tag{5}$$

where:

S – area of examined material

What is important to remember that unlike to physical sound absorption coefficient, reverberation sound absorption coefficient can be greater than one due to e.g. diffraction effects on the edges of examined material and additional sound absorbing surface of sidewalls. This is why it can't be presented as percentage value [8].

3. Research results

On the chart (Figure 4) are presented results of sound absorption examination conducted via Kundt's tube method. As it is presented it can noticed that all of tested materials doesn't show sound absorbing properties in range up to 200 Hz ($\alpha < 0{,}3$). However, after that range, we can notice increase of absorbing properties. The best overall results are presented by sample made of recycling acoustic materials. Only glasswool was more effective than composite in range of 400-500 Hz.

It is worth to acknowledge, that results for sample made of acoustic foam with pyramids were non-uniform and were highly dependent on from which part of sheet sample was cut off. Placement of pyramids within examined sample had high influence on value of absorption coefficient.

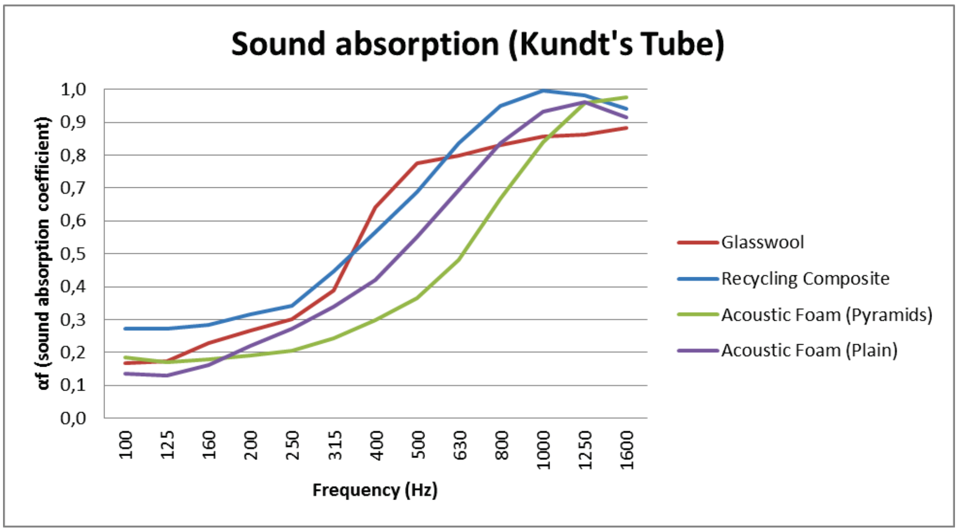

Figure 4. Physical sound absorption coefficient of examined materials

On another chart (figure 5) are presented results of sound absorption examination conducted by reverberation room method. As it is presended it can be noticed that all of examined materials doesn't show sound absorbing properties up to 125 Hz. After this frequency we can observe increasing sound absorbing properties of materials, mainly for recycle composite, glasswool and plain acoustic foam. Recycling composite presents the best overall absorbing properties. Again only glasswool presented better results than composite in limited frequency range (200-315 Hz).

Tests of acoustic foam with pyramids exposed lower than other materials ability to absorb sounds.

It is worth to remember that results of this examination cannot be presented in percentage form, because coefficient α is greater than 1 and it is used mostly to check trend of sound absorbing properties of the materials, where bigger samples could be used.

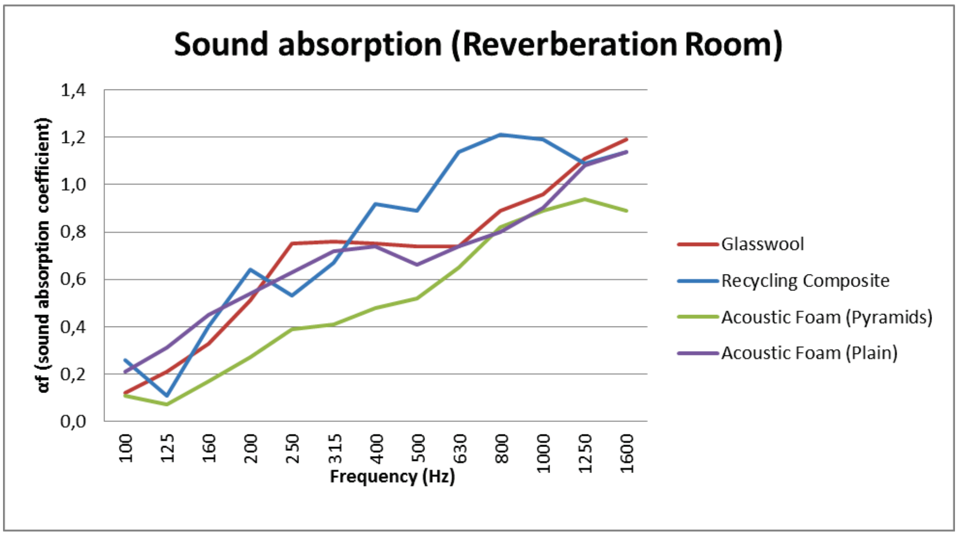

Figure 5. Reverberation sound absorption coefficient of examined materials

4. Conclusions

Conducted examinations has shown that recycling acoustic material composite has comparable, or even superior sound absorbing properties than more commonly used materials in tested frequency range.

However it is worth remembering, that this kind of material has to be used in conditions with no high temperature and humidity, because this parameters could damage this kind of material.

What is more, production process of recycling composite is based on using scraps of previously used in company preparing acoustic materials, so acoustic properties of this type of composite can vastly differ according to materials used in manufacturing process of composite and its ration.

Tests also exposed lower absorbing properties, in comparison to the other materials, of acoustic foam with pyramids, which is one of the most well –known and widely used type of sound absorbing material in music industry and soundproofing the flats.

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