Using Particles of Recycled Rubber when Making Some Soundproofing Materials

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Waste rubber cause both health and environmental problems and this has forced governments to develop laws for recycling. Using particles of recycled rubber in the domain of soundproofing materials is of major importance from a technical, economical and ecological point of view. In this paper we determine the ability of sound absorption of each obtained material by measuring the sound absorption coefficient depending on frequency, using the impedance tubes. Materials, as composite materials prototype, were made from particles of recycled rubber and a polyurethane binder, in combination with other materials existent on the market (cork of fabric).

Keywords: recycled rubber particles, acoustical materials, sound absorption coefficient.

The use of recycled rubber in the production of sound absorber will help combat the existing problems of both waste disposal and noise pollution. Zhou et al. [1] found that recycled rubber particles had some excellent sound energy absorbency property and the composite panel made with the recycled rubber crumbs created some good sound attenuation.

The reduction of energy consumption in construction, the production of thermally insulating materials and the solution of environmental problems by recycling of industrial and domestic waste are becoming a relevant problem [2].

Traditionally, noise is controlled by using expensive and non-biodegradable sound absorbing materials such as glass wool, polymer foams, fabric filler and polymer fibres, posing an additional harm to the environment [3].

To protect environment by reducing 'black pollution' and save resources have become an important issue for every country. Effectively recycling waste tires such as manufacturing wood–rubber based composites could be one of the solutions [4].

Yang et al. [5] studied the straw–waste tire composites and their test results showed that straw/recycled waste tire rubber composites had similar mechanical properties compared to wood/recycled tire rubber composites. Meanwhile, the straw/waste tire composites also possessed better sound insulation.

The thermal and sound properties of crumb rubber concrete panel were investigated. The crumb rubber from used tires, produced in a local recycling plant, was used to replace fine aggregate at ratios of 10%, 20% and 30%. Properties such as thermal conductivity, thermal resistivity, heat transfer, conductance value, sound absorption at different frequency and noise reduction were investigated. Results indicated that crumb rubber concrete panel was not only lighter but had higher sound absorption and lower heat transfer properties than the conventional concrete panel [6].

Usually, wasted rubber particles demonstrate lower sound absorption at higher frequencies. This is altered by matching with polypropylene particles and polystyrene particles, resulting a novel composite material with higher sound absorption for a wider frequency range [7]. Although these materials possess good heat and acoustical insulating properties, they cause environmental pollution and pose danger to human health.

Taking into account various results from similar researches [8-11] is needed a prototype with optimized acoustics caracteristics and also to better study and understand the influence of the constructive parameters on the final acoustic performance.

This study investigated the possibility of using of crumb rubber as composite materials, and the potential applications for which these materials could be used after recycling.

Materials made of rubber crumbs usually have high porosity and consequently good sound absorbtion properties. However the grains alone show no mechanical strenght, so it necessary to mix them with an adequate binder and to consolidate the compound in order to create a solid structure.

Experimental part

Materials and Method

Six samples were used to perform the experimental part. They are presented in figure 1. These samples have polyurethane binder as a matrix and particles of recycled rubber from used tires were used as reinforcing material.

The particles of recycled rubber have a size of 1 ÷ 3 mm and a density of 0.620 g/cm^3.

Samples 1 made of recycled rubber particles and 15% polyurethane binder with a thickness of 15 mm compared to sample 1, sample 2 also has a layer of cork with a thickness of 3 mm, and sample 3 also has a layer of material made from fabric wastes with a thickness of 3 mm.

Sample 4 has a thickness of 40 mm and it was made of particles of recycled rubber and 15% polyurethane binder.

Sample 5 is made from three layers: a layer of particles of recycled rubber and 15% polyurethane binder, a second layer made from fabric wastes and third layer made from particles of recycled rubber and 15% polyurethane binder.

Sample 6 is made from four layers: a layer of particles of recycled rubber and 15% polyurethane binder, second layer made from fabric wastes, third layer is made from

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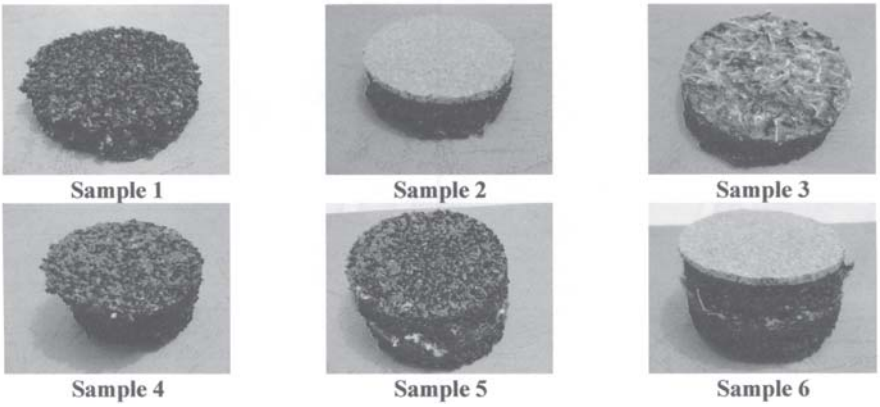

Fig. 1. Samples used in the research

particles of recycled rubber and 15% polyurethane binder and the fourth layer is cork.

Nine tests were conducted: Test 1 – sample 1 measured on the rubber side; Test 2 – sample 2 measured on the rubber side; Test 3 – sample 2 measured on the cork side; Test 4 – sample 3 measured on the rubber side; Test 5 – sample 3 measured on the fabric material side; Test 6 – sample 4; Test 7 – sample 5; Test 8– sample 6 measured on the rubber side; Test 9 – sample 6 measured on the cork side.

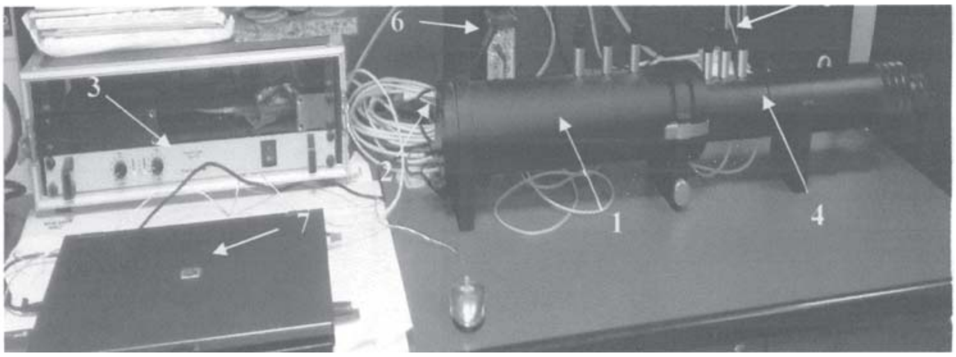

Fig. 2. Measurement system used for samples analysis: 1 – Impedance tube, 2 –Sound source, 3 –Signal amplifier, 4 – Sample position, 5 – Microphones position, 6 – Pulse Analyser, 7 – Laptop PC.

To determine the acoustical property of the composites for use as insulating material, the sound absorption coefficients were determined by the impedance tube method. The material measurements were based on a two-microphone transfer-function method according to ISO 10534-2 [12], which are for horizontally mounted orientation-sensitive samples. The measurement system was part of a complete acoustic material testing system (fig. 2), featuring Brüel & Kjaer PULSE interface. A sound source (loudspeaker) is mounted at one end of the impedance tube, and a sample of the material is placed at the other end (fig. 2). The loudspeaker generates broadband, stationary random sound waves, which propagate as plane waves in the tube, hit the sample and reflect. The propagation, contact and reflection result in a standing-wave interference pattern due to the superposition of forward- and backward - traveling waves inside the tube. By measuring the sound pressure at two fixed locations (two microphones 4187 B&K) and calculating the complex transfer function using a two-channel digital frequency analyzer, it is possible to determine the sound absorption and complex reflection coefficients and the normal acoustic impedance of the material. The usable frequency range depends on the diameter of the tube and the spacing between the microphone positions.

In this study a medium tube kit from Brüel&Kjaer Type 4206 A was used to measure different acoustical parameters for the frequency range 100 ÷ 3200 Hz. Medium impedance tube kit, was consisted of a 63.5 mm diameter tube and therefore tests were performed on circular samples with a diameter of 63.5 mm. Acoustic signal generated by PULSE Analyzer 3560-B-030 is amplified by Power amplifier 2716 B&K and then the results were recorded and processed on a PC.

Results and discussions

A material has a good sound absorption when its absorption coefficient is close to 1 – the maximum values and with an absorption plane at this value on a large frequency level. Data obtained upon measurements were elaborated and the charts of absorption coefficient variation depending on frequency were drawn.

The variation of the absorption coefficient depending on frequency for the 6 samples is presented in figures 3 ÷ 9.

In figure 3 is represented the variation of the sound absorption coefficient depending on frequency for sample 2. We can observe that the absorption coefficient has different values depending on the side on which the measurement was taken. At frequencies smaller than 2500 Hz the cork side has a much better absorption than the rubber side.

When using the material made from fabric wastes over the rubber layer, sample 3, we can see that the absorption is not moved in the low frequency range (fig. 4), but on the contrary we can see an improvement of the absorption in the frequency range between 1600 ÷ 2800 Hz.

Figure 5 shows the difference between the absorption properties of samples 1, 2 and 3 (measured on the rubber side). We can observe an increase of the sound absorption coefficient for sample 3, for which there was used an additional fabric layer, while on sample 2 where cork was used, we can observe a decrease of the absorption properties.

Using a fabric layer between two layers of material made from particles of recycled rubber and binder leads to a widening of the frequency range at which the sound absorption is good and it slightly reduces the absroption at frequencies smaller than 1300 Hz. This can be observed in figure 6.

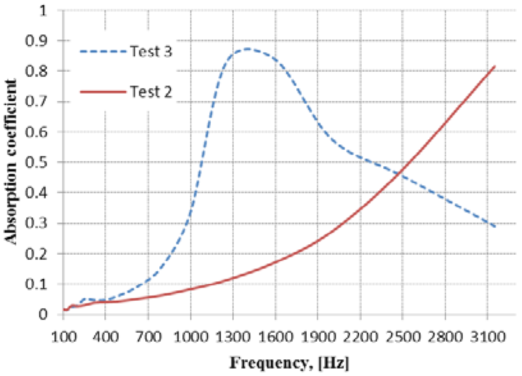

Fig. 3 . Sound absorption coefficient variation depending on frequency for sample 2

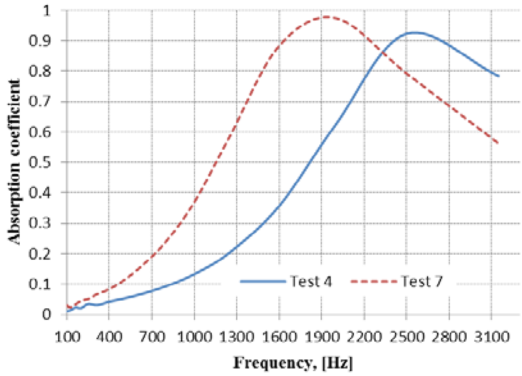

Fig. 7. Sound absorption coefficient variation depending on frequency for samples 3 and 5.

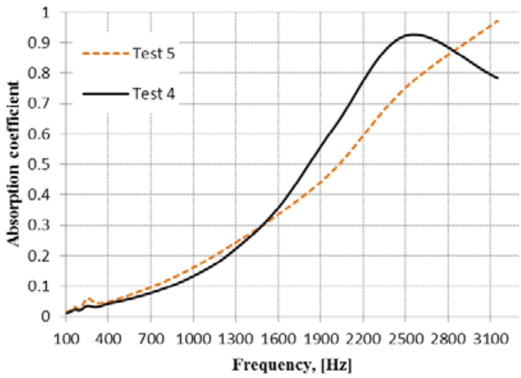

Fig. 4. Sound absorption coefficient variation depending on frequency for sample 3

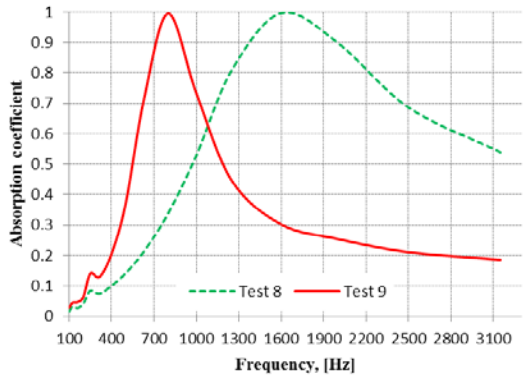

Fig. 8. Sound absorption coefficient variation depending on frequency for sample 6.

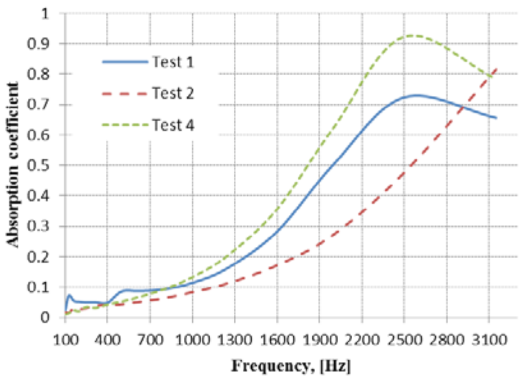

Fig. 5. Sound absorption coefficient variation depending on frequency for samples 1, 2 and 3

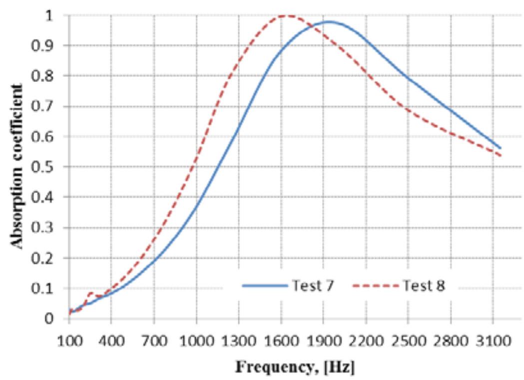

Fig. 9. Sound absorption coefficient variation depending on frequency for samples 5 and 6.

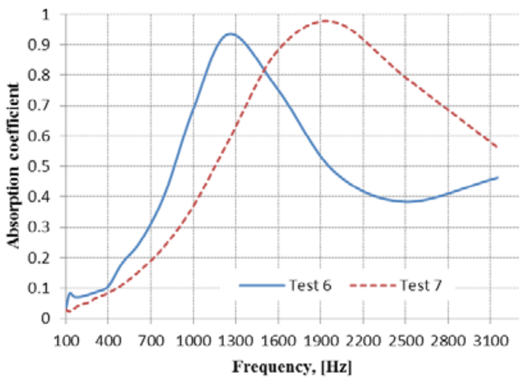

Fig. 6. Sound absorption coefficient variation depending on frequency for samples 4 and 5

In figure 7 we can observe the improvement of the absorption properties at frequencies smaller than 2200 Hz, if we add a layer of material made from particles of recycled rubber and binder to sample 3. However, at higher frequencies the sound absorption coefficient decreases. Thus we can say that if the thickness of the material increases at low frequencies the sound absorption properties also increase.

Figure 8 shows the variation of the sound absorption coefficient depending on frequency for sample 6. We can see that the phonoabsorbant properties of the sample are better when the measurement was made on the rubber side at frequencies higher than 1000 Hz. At frequencies lower than 1000 Hz the absorption is more efficient on the cork side.

Figure 9 graphically represents the sound absorption coefficient for samples 5 and 6 (measured on the rubber side). We can observe a more efficient absorption at frequencies lower than 1900 Hz for sample 6 (which in addition to sample 5 has a cork layer), while sample 5 is more efficient at higher frequencies, in terms of acoustic absorbtion.

Conclusions

Various measurements were executed on several prototypes of sound absorbers made of rubber as composite materials, using the impedance tube technique, in order to highlight the relationships between the sound absorbtion coefficient and the constructive characteristics.

Composite materials produced in this study have good sound absorption properties on a large frequency range, which would provide advantages when it comes to reducing the noise of as many types of noise sources as possible.

Using cork as a surface layer improves sound absorption in the frequency range 100 ÷ 1300 Hz and decreases it at larger frequencies, while the fabric material doesn't significantly change the sound absorption properties.

The materials produced could be used for impact noise reduction and for obtaining decorative panels with sound-absorbing role, improved acoustics, diminution and removal of reverberation phenomena in universal production halls, sports halls, bowling saloons, amphitheaters, indoor pools, show-rooms, shops, etc. These results obtained from the experimental samples encouraging the development of a full scale element prototype and testing of the absorption coefficient in diffuse sound field – reverberating chamber and for measurements of sound insulation in buildings for building elements.

Making a material with multiple layers of the same type or of different types leads to obtaining an effective absorption on a wider range of frequencies.

The research will therefore continue with the production and testing of larger samples, together with the evaluation of further non-acoustical parameters such as inflammability and durability.

Acknowledgement: The authors acknowledge the support of the Managing Authority for Sectorial Operational Programme for Human Resources Development, for the Project "Doctoral studies in engineering science to develop knowledge-based society - SIDOC" Contract POSDRU /88 /1.5 /S /60078 and POSDRU /89/1.5/S/62557.

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12.*** Standard SR EN ISO 10534-2, Determination of sound absorption coefficient and acoustic impedance with the interferometer. Part 2. Transfer function method, 200

Manuscript received: 14.08.2012