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CONSTITUTING OF COMPOSITE MATERIALS FROM RECYCLED PLASTICS SHOWING NOISE-SUPPRESSING PROPERTIES

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Abstract

The characteristic feature of contemporary civilization is generation of excessive noise level into the environment. To avoid this problem several solutions are proposed and applied, natural and artificial ones. The paper presents the conditions of constituting polymer composites consisting of recycled polymers and rubber (also particle size distribution of the components) for which the best noise suppression may be obtained.

Keywords: *composite materials, acoustic screens, noise suppression*

1. Introduction, objective of the work

Many scientific and research centers and industrial institutes are looking for the convenient constructional and technological solutions which allow to minimize the harmful influence of noise, especially at the source of its arising. Figures 1 and 2 show the example of main sources of noise generation in everyday life.

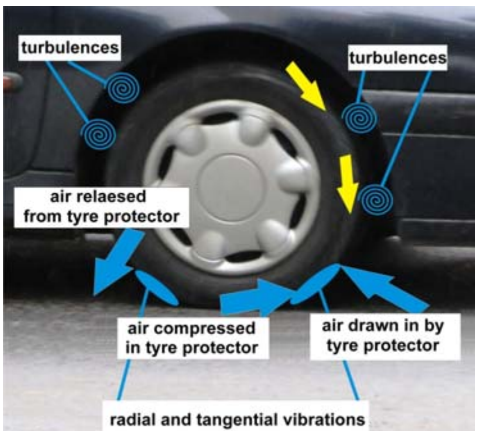

Fig. 1 Noise generation when contacting: tire - road surface [5]

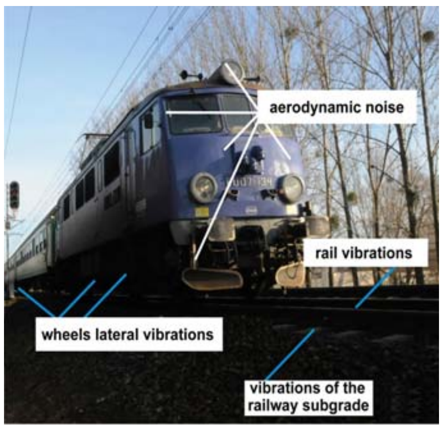

Fig. 2 Noise generation by movement of rail vehicles [5]

To avoid this arduous problem different solutions are applied, i.e. natural (like green areas along the communication routes) as well as artificial ones being an effect of research and experience in this matter thoroughly presented in professional literature [2, 4, 11]. There are also indirect solutions joining both solutions. The great expectations are connected with so called noise-suppressing shields (screens) for highway engineering. Certain materials are usually used for this purpose like aluminum plates/mineral wool, or concrete/wood. More and more often polymer materials are used, especially polymer composites. The properties assigning such composites for this application are, first of all: inflammability and impact resistance [6, 8].

Application of polymer composites for manufacturing of noise-damping elements has another advantage, i.e. pro-ecological activity. At present, when the problem of huge mass of post-consumer plastics wastes is of ever growing importance, the waste management focuses on material recycling. Polymer composites are the best example of materials, which may be produced relatively easy, at low cost, using secondary plastics and elastomers [3, 10, 12, 13] (fig. 3).

More and more RD&A tasks are undertaken in connection with application of acoustic screens made of plastics including composites, the functional properties of which may be constituted in wide range.

From the scientific and useful point of view the most important is searching for the determined constructive-technological conditions connected with constituting polymer materials and composites of special properties as well as determination of processability of those composites for practical application [6, 8, 10, 12]. One has admitted a thesis that there are determined constructive-technological conditions of constituting polymer materials and composites for which the most advantageous properties may exist and that there are the modes of realization of those assumptions (e.g. special conditions of size-reduction, mixing components and pressure compacting), the choice of which will decide about quality of products made themof.

Basing on literature analysis as well as long-lasting cooperation with scientific centers the admitted operations are [3-10]:

- size-reduction of starting materials, especially repeatability of grain fraction, assessment of shape and surface of elementary grains,
- processes of mixing starting materials (in solid state) in grainy form) and assessment of mixing degree of starting materials,
- processing operations used for preparing composites (extrusion, injection moulding, high pressure compacting.

In table 1 (column I) the unit processes have been listed that have significant influence on functional properties of the composites. It turns out from the table 1 that condition of efficient development of wanted solution is closer cognition of listed constituent processes which, in qualitative way, could determine the influence of selected constructional and technological factors (column III) concerning sort, dimensions of the material to be size-reduced and mixed, susceptibility to pressure compacting, and to injection moulding, described by the functions of the tested object and their influence on physical parameters determining effectiveness of a constituent process (shown in column II as a measure).

Polymer composites are prepared by mixing polymer matrix with minor phase. The matrix usually is thermoplastic polymer as a single or mixture of polymers. Minor phase usually is, except of size-reduced rubber, other material like glass fiber, fillers a.s.o. To get the composite the components must be subjected to operations, the basic of which are size-reduction, mixing and processing. The size-reduction is a constituent process which enables the proper grain size distribution of the components, mixing is responsible for preparing the composite as a polymer mixture of proper component proportions.

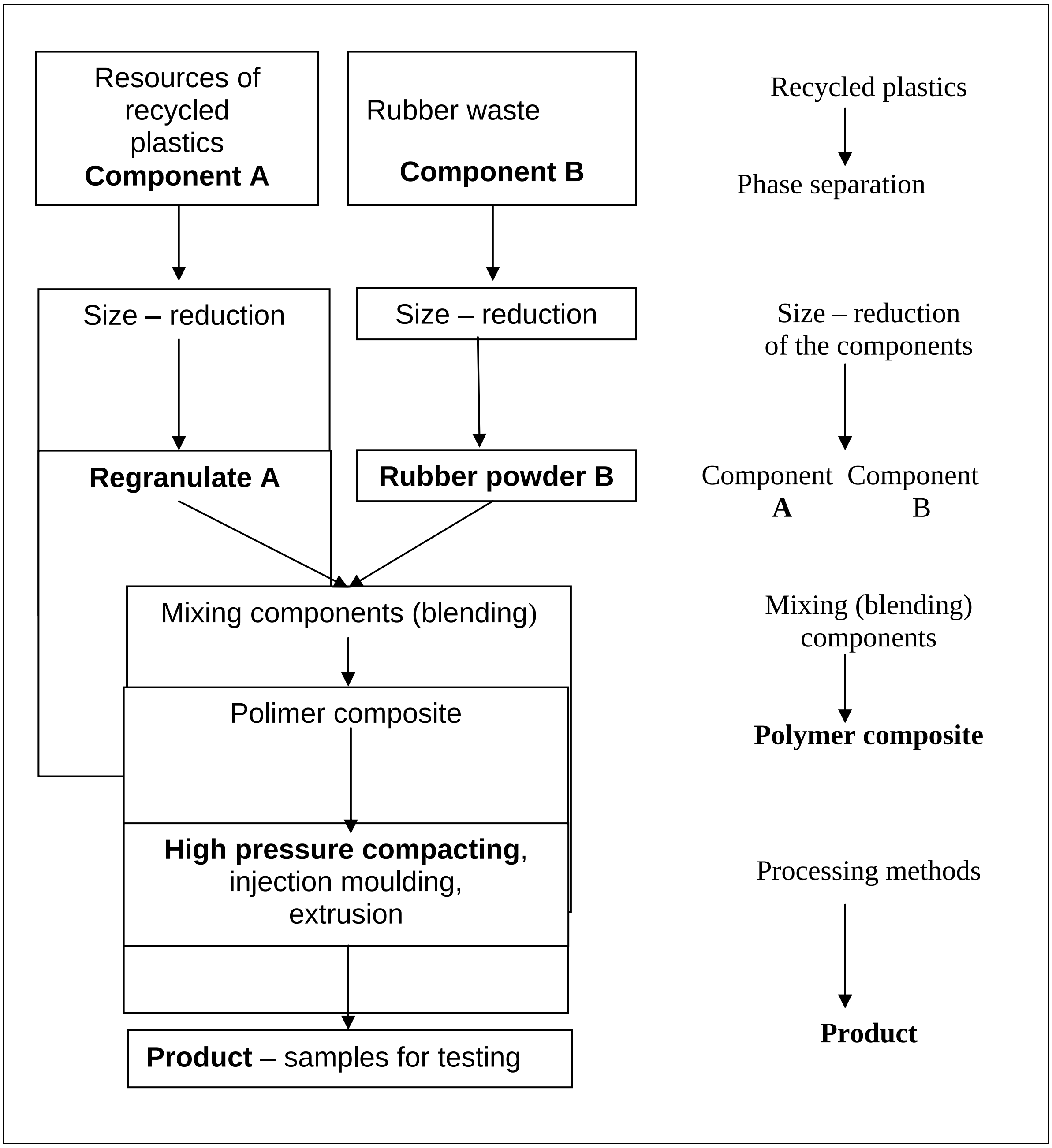

Fig.3. Block scheme of constituting composite materials made of recycled plastics [14]

Table 1. List of constituent processes influencing functional properties of composite [4, 13, 14]

Name of the constituent processes		Parameter determining the effectiveness of the constituent process	Constructional and technological factors significant for constituent process
I		**II**	**III**
A Size – reduction process	OBI	Torque: M_o Cutting force: F_c	M_o, F_c = f(a_1, a_2 …..a_n)
B Mixing process	OBII	Power N, time t_m, stopień zmieszania M_m	N, t_m, M_m = f(b_1, b_2,.....b_n)
C Processing: (injection moulding, high pressure compacting operations and others)	OBIII	Temperature, pressure p_p, time t_p of pressing, injection moulding	p_p, t_p = f(c_1, c_2............c_n)
D Verification of the research tasks	OBIV	Strength parameters e.g. tensile strength R_m, degree of mixing M_m , acoustic screens ΔL	R_m, M_m ΔL = f(V_1, $\varphi_1 V_n$,φ_n)
N Others	OBN	....	Ψ, Φ = f (x_1, x_2 …….x_n)

The general objective of the work is presentation of the concept enabling determining the conditions of constituting composites in technological process to obtain products made of them of required acoustic properties. The detailed research objectives are:

- influence of mass fraction of rubber powder in polymer matrix,
- influence of grain size of the rubber powder in composite,
- number of effective layers in the sample on noise-suppressing properties of selected composites.

2. Research program – realization of the tests

To determine the grain size and mass fraction of the filler on noise-suppressing acoustic vibrations the samples have been prepared using recycled PP and rubber powder type SBR. The mixtures have been prepared in the framework of the other research task [7,12]. The share of components, grain size distribution of the SBR rubber powder and components, have been gathered in table 2.

3. Test stand

The experimental was realized in two phases:

A. pressure compacting plates made of composite using special compacting mould (fig. 4) for basic tests (table 2),
B. testing of noise-suppressing ability – scheme of the test stand shown on fig. 5.

Tab.2. List of composites used for testing [7,14]

Denotation of the composite	Grain size distribution of the rubber powder type SBR, mm	Content of the rubber powder SBR in composite, wt.%
K_0	-	-
K_1	0,8	30
K_2	0,8	40
K_3	0,8	50
K_4	1,2	30
K_5	1,2	40
K_6	1,2	50
K_7	1,6	30
K_8	1,6	40
K_9	1,6	50
K_{10}	2,0	30
K_{11}	2,0	40
K_{12}	2,0	50

The composites K_1 to K_{12} listed in table 2 have been presented after growing grain size in the composite. K_0 sample is a reference sample made of pure recycled PP for further tests and comparisons.

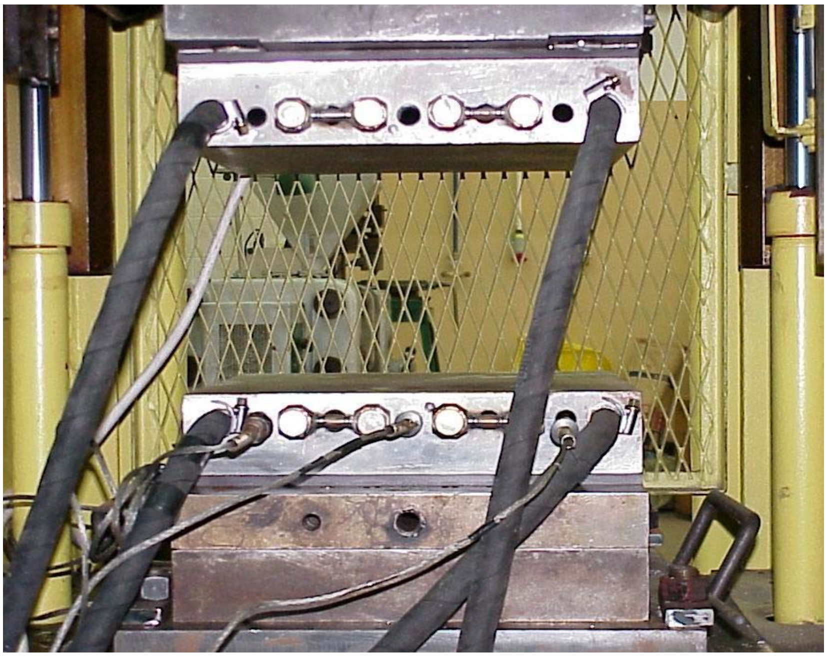

Fig. 4. The view of the compacting mould for composite plates [15]

The plates of dimension 210x180x6 mm from which test samples of dimension 75x75 mm for further testing are made.

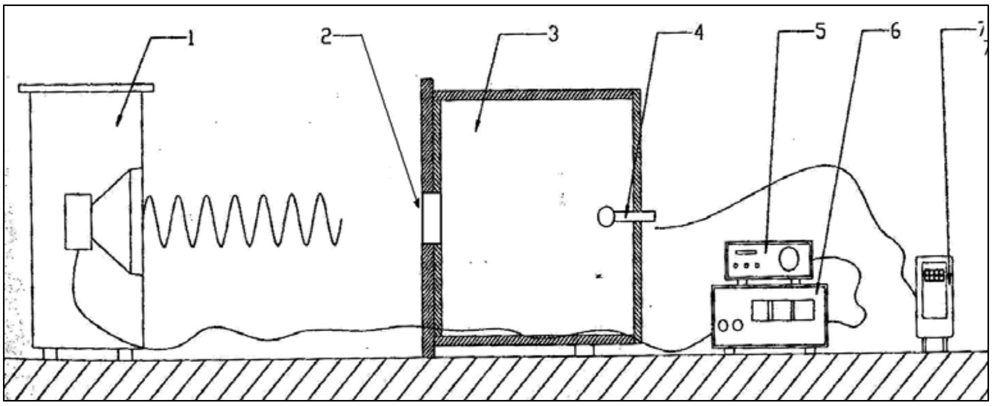

Fig. 5. Scheme of the test stand for determining the noise-suppressing ability of acoustic vibrations: 1 – loud speaker, 2 – sample of the composite, 3 – measuring chamber, 4 – microphone, 5 – frequency generator, 6 – amplifier, 7 – vibration damping meter [15]

For testing purposes following composite samples were used as: single-, double-, triple-, and quadruple – layered piles subjected to tests using frequency bands ranging from 63Hz to 4kHz to get the acoustic spectra for dominating frequencies 63, 125, 250, 500, 1000, 2000, 4000Hz [7,14, 15]. In the first stage the referencing spectrum for test equipment has been determined. It has been denoted as Leg_w and next the spectra for samples have been determined and denoted as Leg_z. The result of damping ability (denoted as ΔL), i.e. difference concerning two values: $Leg_w - Leg_z$. The smaller ΔL value, the better damping capacity of acoustic vibrations [10, 15].

4. Test results

The results of testing influence of layers' multiplicity of samples, grain size distribution and rubber powder content in the composite on damping ability has been gathered in figs. 6 – 8.

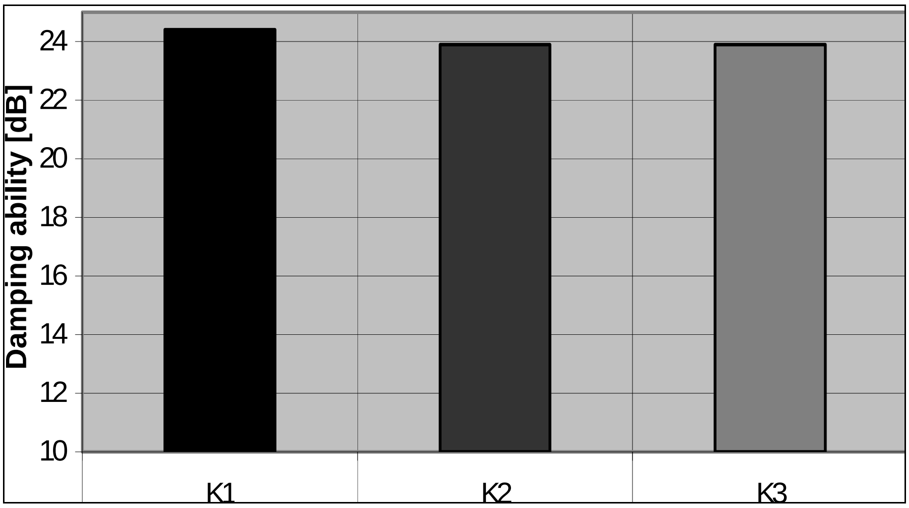

Fig. 6: Influence of layers' multiplicity of samples on damping capacity of acoustic vibrations (X axis – number of layers, Y axis – damping ability ΔL in dB)

The results show that comparing ΔL values there is no considerable influence of rubber powder content in the composite and layers' multiplicity of samples on damping ability. However, grain size distribution ranging from 0,8 to 2,0 mm have considerable influence on damping ability. The most advantageous may be observed for composite denoted as K_{12} after table 2, i.e. for grain size 2,0 mm.

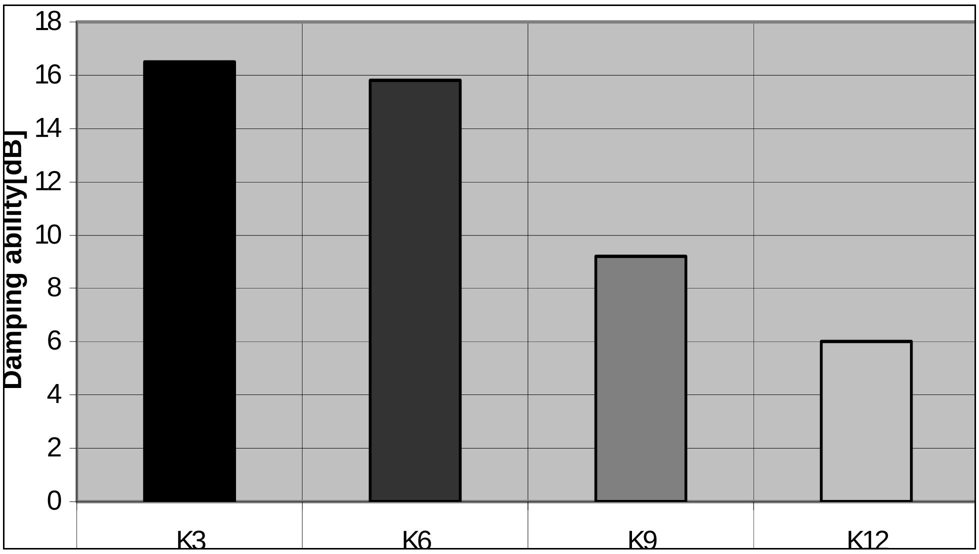

Fig. 7: Influence of rubber powder content in the composite on damping capacity of acoustic vibrations (X axis – rubber powder content in wt.%, Y axis – damping ability ΔL in dB)

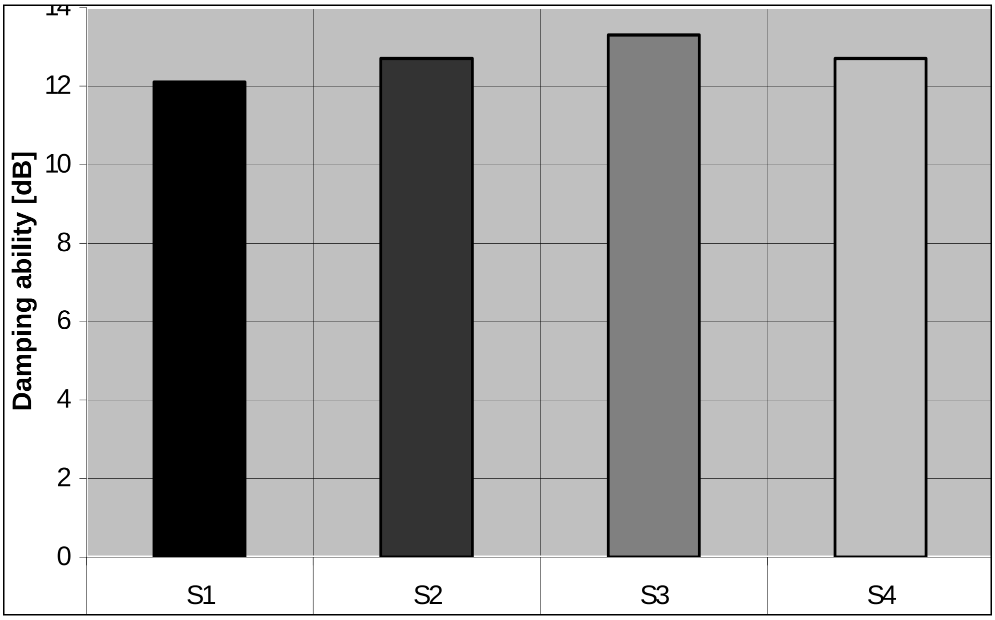

Fig. 8: Influence of grain size distribution of rubber powder on damping capacity of acoustic vibrations (X axis – grain size distribution, Y axis – damping ability ΔL in dB)

5. Summary

Within the framework of the article an attempt of verification of thesis has been undertaken that there exist a determined grain size distribution of components and their mass shares for which the product of most advantageous damping noise capacity may be obtained. From the results of the tests it can be seen that the range of constituting acoustic properties of the composites is relatively wide. Preliminary lab tests showed that the most important factor is grainy component as a minor phase, especially its grain size (grain size distribution). The results may be helpful in constructing the acoustic shields. Program of further research should concern application of other materials for minor phase of different grain size distribution compared to those applied in this work.

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