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New wood/polymer (WPC) and rubber/polymer (TP-RP) composites for noise-suppressing purposes

Introduction

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. The main sources of noise generation in everyday life are generally connected with development of civilization, i.e. automotive, aircraft and entertainment industries.

To keep the human beings from excessive noise there are many solutions applied along the communication routes, like e.g. green areas. Authorities of railway systems and highway engineering expect more and more advanced noise suppressing systems separating housing estates from communication routes – Fig. 1

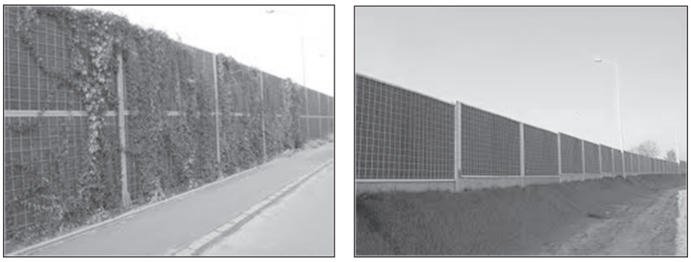

Fig. 1. Examples of constructional solutions of acoustic screens [*Czaja, 2009*]

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 [*Zimniak and Królikowski, 2004; Jurkowski and Jurkowska, 1991*].

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 [*Konieczka, 1996*].

More and more RD&A tasks are undertaken connected 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 [*Królikowski and Zimniak, 2004; Kobus 2012*]. 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 them of.

Acoustic screen is made of constituent elements called acoustic panels which are manufactured by extrusion method using WPC (wood plastic composites). Fig. 2 shows an example of the panel of dimensions: 120 × 600 × 6000 mm. The shape of the panel has been designed to suppress the noise at the widest extent considering the mechanical properties which allow its application in typical constructions of acoustic screening systems.

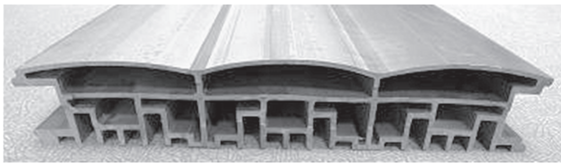

Fig. 2. General view of cross-section of acoustic screen panel [*Czaja, 2009; Śliwa and Zimniak, 2011*].

The objective of this work is comparative research of noise-suppressing ability of traditional composite WPC and TP-RP composites made of recycled thermoplastics and rubber basing on the technology worked out at the *Faculty of Mechanical Engineering of the University for Technology and Life Sciences* in Bydgoszcz, Poland and *Institute for Engineering of Polymer Materials and Dyes* in Toruń, Poland.

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 (Tab. 1).

Tab. 1. List of WPC and TP-RP composites used for testing [*Zimniak, 2009; Kobus 2012*]

No.	Type of composite	Number of layers				
		1	2	3	4	6
1	KTD_1	+	-	-	-	-
2	KTD_2	+	+	-	-	-
3	KTD_3	+	+	+	-	-
4	KTD_4	+	+	+	+	-
5	KTD_5	+	+	+	+	+
6	KTG_1	0.8	-	-	-	-
7	KTG_2	0.8	0.8	-	-	-
8	KTG_3	0.8	0.8	0.8	-	-
9	KTG_4	0.8	0.8	0.8	0.8	-
10	KTG_5	0.8	0.8	0.8	0.8	0.8
11	KTG_6	1.2	-	-	-	-
12	KTG_7	1.2	1.2	-	-	-
13	KTG_8	1.2	1.2	1.2	-	-
14	KTG_9	1.2	1.2	1.2	1.2	-
15	KTG_{10}	1.2	1.2	1.2	1.2	1.2
16	KTG_{11}	1.6	-	-	-	-
17	KTG_{12}	1.6	1.6	-	-	-
18	KTG_{13}	1.6	1.6	1.6	-	-
19	KTG_{14}	1.6	1.6	1.6	1.6	-
20	KTG_{15}	1.6	1.6	1.6	1.6	1.6
21	KTG_{16}	2.0	-	-	-	-
22	KTG_{17}	2.0	2.0	-	-	-
23	KTG_{18}	2.0	2.0	2.0	-	-
24	KTG_{19}	2.0	2.0	2.0	2.0	-
25	KTG_{20}	2.0	2.0	2.0	2.0	2.0

Designations: Samples 1-5 (WPC composite) denoted as KTD,
Samples 6-25 (composite TP-RP) denoted as KTG.

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The share of components, grain size distribution of the SBR rubber powder (KTG composites) and KTD composites have been gathered in:
a) PP (50%) + rubber powder (50%) of grain size 0.8 mm,
b) PP (50%) + rubber powder (50%) of grain size 1.2 mm,
c) PP (50%) + rubber powder (50%) of grain size 1.6 mm,
d) PP (50%) + rubber powder (50%) of grain size 2.0 mm,
e) PVC (50%) + wood flour (50%) of grain size 0.8 mm.

Test stand

For comparing purposes of noise suppressing properties for WPC (denoted as KTD) and TP-RP (denoted as KTG) the samples of dimensions 77 × 77 × 6 mm were used. The KDT samples denoted as 1-5 (Tab. 1) were cut out from the acoustic panel (Fig. 2), and KTG samples denoted as 6-25 (Tab. 1) were manufactured in a special compression mould [*Zimniak, 2009*]. The testing of noise-suppressing ability was realized experimental in a special test stand [*Zimniak, 2009; Kobus, 2012*].

For testing purposes following composite KTD and KTG samples were used as: from single – to six – fold layered piles subjected to tests using frequency bands ranging from 63 Hz to 4 kHz to get the acoustic spectra for resonance frequency 63, 125, 500, 1000, 2000, 4000 Hz [*Zimniak and Królikowski, 2011; Kobus 2012*]. 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 [*Zimniak, 2009; Kobus, 2012*].

Test results

The results of comparison of noise – suppressing ability of traditional KTD composite used for panel extrusion (Fig. 2) and KTG composite made of PP and wastes of rubber powder were showed in Figs 3–7.

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 KTG_{16} and KTG_{21} after Tab. 1, i.e. for grain size 2.0 mm.

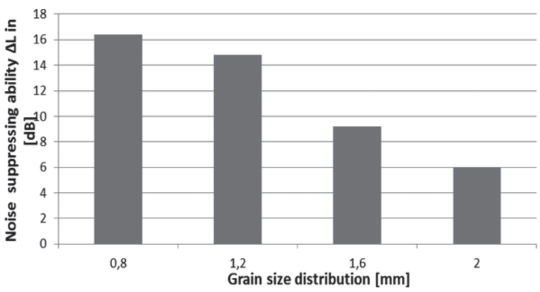

Fig. 3. Influence of rubber grain size on noise suppressing ability of KTG composite

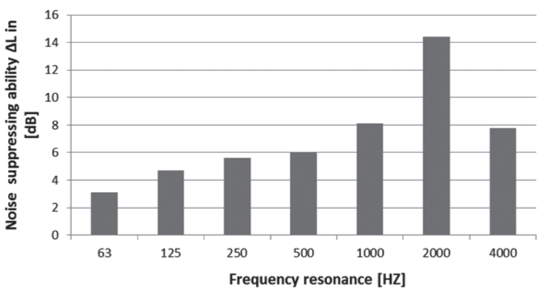

Fig. 4. Influence of resonance frequency on noise suppressing ability of KTD composite

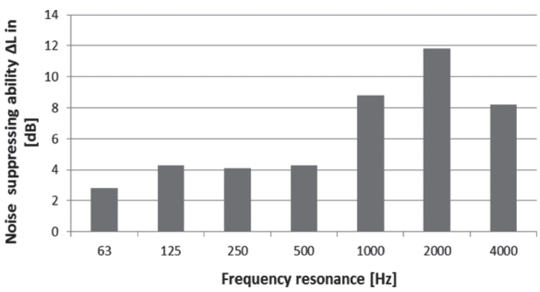

Fig. 5. Influence of resonance frequency on noise suppressing ability of KTG composite

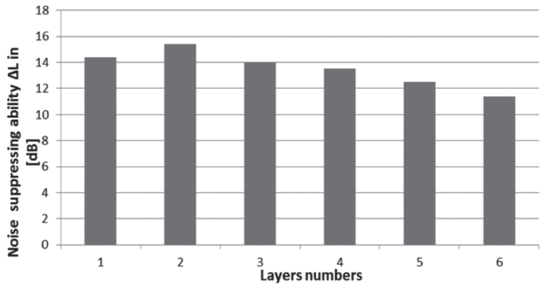

Fig. 6. Influence of number of KTD composite-layers on noise suppressing ability (for 2000 Hz)

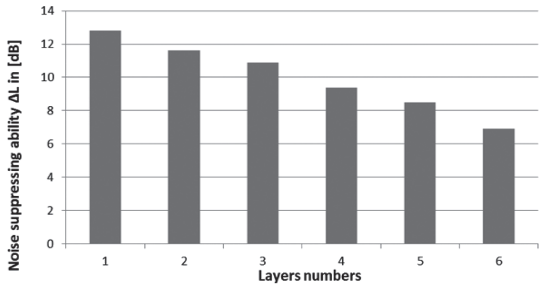

Fig. 7. Influence of number of KTG composite layers on noise suppressing ability (for 2000 Hz)

Summary and conclusions

Analyzing results shown in Fig. 5 one can see that rubber powder size ranging from 0.8 to 2.0 mm has considerable influence on noise suppressing ability.

The most advantageous results were obtained for KTG composite with rubber grain size of 2.0 mm what confirms preliminary results presented at TECHNOMER'11 [*Zimniak and Królikowski, 2011*].

Comparing noise suppressing ability of ΔL for composite KTG and KTD one can admit that in all investigated frequency range, i.e. (63÷4000) Hz the composite KTG shows better suppressing properties (values of noise suppressing ability ΔL are smaller -), more advantageous than WPC independently from layers' number to be investigated.

From the ecological point of view it makes good prospects for recycled materials to be applied in acoustic panels. However, it needs further detailed investigation.

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