NOISE ATTENUATION USING PANELS MADE OF POLYMER COMPOSITE MATERIALS

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1. INTRODUCTION

It promotes today in Romania a competitive industrial policy principles in order to increase adaptability of Romanian economy the demands of increasingly high market, in terms of trends of economic globalization where to unreported, but the real market is. (1)

Economy and industry, attracts serious concerns about environmental pollution. This is the environmental contamination with materials harmful to health, quality of life or the natural functioning of ecosystems.

Although some environmental pollution is the result of the action of nature is mostly caused by human activity. (2)We live in a world of sounds without doubt essential in terms of communication and / or transfer information.

Nature provides for us an abundant variety of sound sources, but the usual man-up health problems for the environment. Noise pollution is human or animal exposure to sound levels annoying, stressful or harmful. (3)

Noise pollution generally refers to unwanted sound produced by human activities undesirable in that it interferes with communication, work, rest, recreation, or sleep.

Unlike other types of pollution such as air, water, and hazardous materials, noise is not much time remains in the environment (4)

2. NOISE CONTROL SOLUTIONS

Noise control is a system problem at work; system, in this case is the combination of noise sources, propagation environment (ways) acoustic energy and receptors. Noise control methods have incorporated elements of this system.

Such are: methods to combat noise at source; methods to combat noise propagation paths; methods to combat noise receiver.

The main solutions to combat noise source and propagation paths, consist of installation of noise source (machinery, equipment) the elements vibration isolators, casing or installation of sound absorbing panels. Where it is necessary to reduce noise at a certain point, between these and the noise source is interposed a sound-absorbing screen and soundproofed. By making such a screen to obtain a noise attenuation almost the whole frequency range, recorded higher attenuation at frequencies above 2400 Hz.

Screen locations should be considered that this should not disturb the technological process and allow oversee the running machine and access control elements. To achieve a higher attenuation of noise, where practical conditions permit, the equipment must be provided with a case soundproofed. (5)

3. ABSORBING COMPOSITE MATERIALS

There have been several researches to develop solutions based on technical achievement the structures from materials sound absorption and sound insulation modular conception . The fundamental aim of this research is to establish innovative technical solutions for modular structures of composite materials capable to satisfy simultaneously three functions for noise and structural vibrations: function in the absorption spectrum of high frequency noise; function of noise insulation in low frequency range (below 1000 Hz); structural vibration damping function.

They created products and clean technologies so by using new materials (polystyrene, polyurethane) and by using material from recycling waste (textile, leather, paper, rubber).They have developed products with high added value and greater efficiency in reducing noise and vibration pollution loads below the limit values of safety and health, and the limits set by EU legislation. Creating composite materials is based and recycled materials so as to ensure sound absorbent corresponding.(6)

4. REDUCTION DUE TO ACOUSTIC NOISE BARRIERS

In a sharp contrast with soundproofing materials that are light and porous sound insulation materials are heavy and compact. As such, these insulation materials are effective sound insulation structure by interposing between the noise source and receptors.

It is common practice to specify the characteristics of acoustic insulation in the wall to reduce sound pressure level. Equation which defines the reduction transmission is:

$$\mathrm{TL} = 10 \log \left(\frac{W_\alpha}{W_2} \right) \quad \mathrm{dB} \tag{1}$$

where TL = dB reduction in transmission

W_α = acoustic power incident on the wall

W_2 = radiated acoustic power

Transmission coefficient is defined by:

$$\tau = \frac{p^{2}_{transmisia}}{{}^{2}_{incidenta}} \quad \text{sau} \quad \tau = \frac{W_2}{W_\alpha} \tag{2}$$

where τ = coefficient of transmission.

τ is the ratio of acoustic power going through wall and acoustic power incident on the wall.

Ultimately reduce transmission equation is:

$$\mathrm{TL} = 10 \log \left(\frac{1}{\tau} \right) \quad \mathrm{dB} \tag{3}$$

There is a strong dependence between variation of reducing transmission due to a uniform wall and frequency sound waves. Wall stiffness at low frequencies influence reducing transmission. In practice, noise reduction, which comes from different sources that emit noise levels that disturb the human ear, is accomplished by interposing between the source and receptors of a barrier wall soundproofing.

Sound waves coming from the issuing source propagated by receptors support a process of diffraction which depends on the distance between the barrier, the source and receptors. (7)

Diffraction problem which depends on the edges of the barrier has been treated by Sommerfeld, McDonald, Redfearn, and others. (8-10)

Diffraction refers to various phenomena associated with bypass by sound waves obstacles appearing in their path.

Diffraction occurs for any type of wave, including sound waves, water surface waves, and electromagnetic waves such as visible light. (11)

In general, diffraction waves is considered theoretically as a case of multiple wave interference secondary from a large number of sources second point, which replaced wave-front (Huygens principle).

Fresnel showed that the secondary waves that propagate to environment from which they came to interfere destructively, while the secondary waves which spreads beyond the barrier produce fringes of maximum and minimum, known as diffraction fringes. (12)

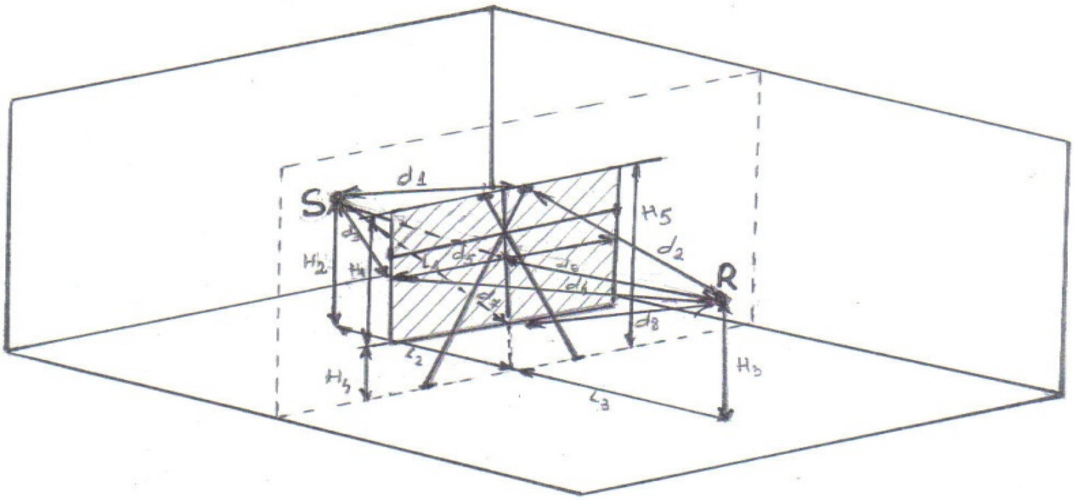
Maekawa suggested that good results are obtained by summing all areas difractrate of each edge. (13)

Moreland and Musa continued to develop well-defined expression, experimentally justified, on the diffraction of sound waves that depend on the barrier edge of rectangular shape for industrial use. (14)

Researchers have developed an expression of sound pressure level and made a series of noise measurements by placing a rectangular barrier between source and receiver.

5. REDUCTION OF SOUND PRESSURE LEVEL BY ATTENUATION WITH A INSULATING BARRIER PRODUCT OF COMPOSITE MATERIAL

Tests were made using a barrier / wall soundproof product of composite material made of epoxy resin reinforced with rubber powder. The test was done Absorber lined room (deaf) a sample with these dimensions: L_1 - wall length = 1.32 m; L_2 - length source - wall = 1.62 m; L_3 - wall length - receiver = 1m; H_1 - wall height = 1.07 m; H_2 - which is the source height = 0.75m; H_3 - which is the receiver height = 1 m; H_4 - which is wall height = 0.5 m, $H_5 – H_1 + H_4 = 1.57$ m. S = source ; R = receptor.



Measurements were made of noise on frequencies between 250 - 8000 Hz at the initial moment without barrier, then interposed between source and receiver sample consisting of sound insulation barrier that is made of composite material. In table 1 are given values sound pressure level values measured at each frequency initially when no barrier soundproofing.

Table 1.

Frequency (Hz)	Sound pressure level (dB)
250	82
500	88.5
1000	82
2000	86.5
4000	97
8000	85.6

Next diagram represents the sound pressure level variation in frequency at the initial moment without the interposition of acoustic barrier between source and receiver.

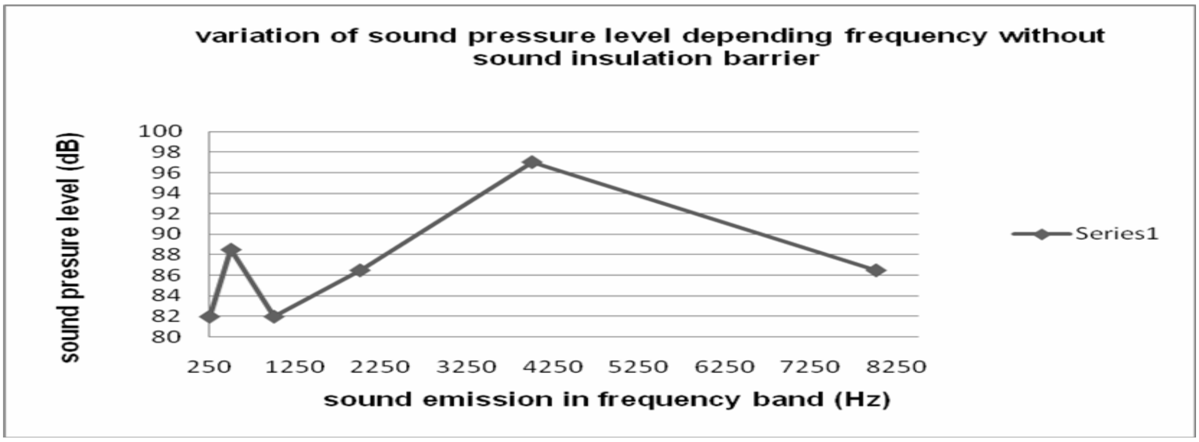


Diagram 1.

After obtaining the values above to put a wall between source and receiver. The following table shows the values of sound pressure levels depending on the frequency at the next moment, when interposed between source and receiver to a sound insulation barrier.

Table 2.

Frequency (Hz)	Sound pressure level (dB)
250	85
500	84
1000	71
2000	69
4000	72
8000	68

Graphic interpretation of the table above result to obtain the following chart which represents variation frequency with sound pressure level at the next moment, when interposed between source and receiver to a sound insulation barrier.

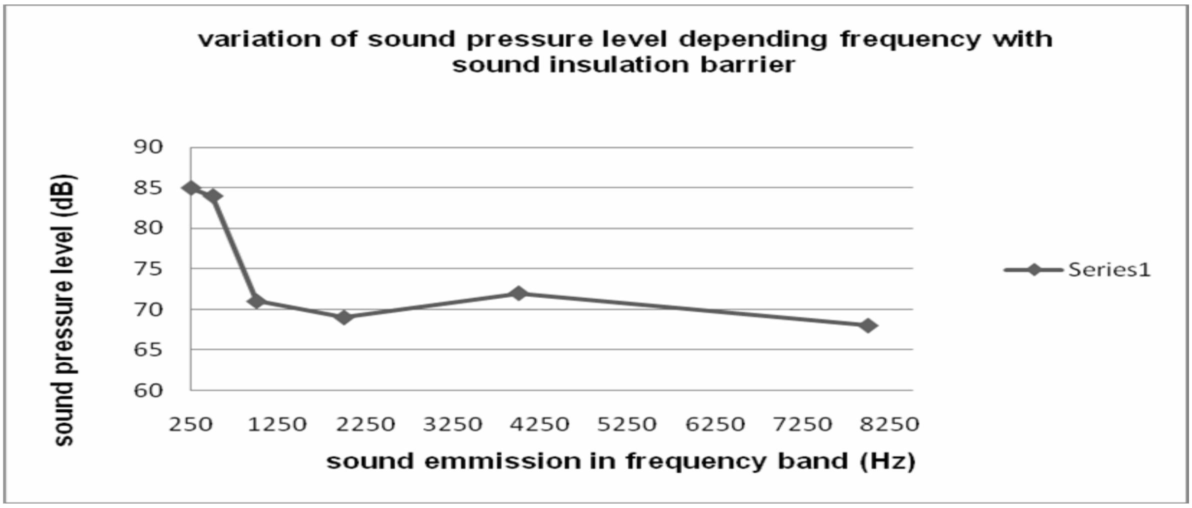


Diagram 2.

Comparing the two situations result in the following table where the first column is the working frequency and the second column is the sound pressure level when no sound insulation barrier while the third column are the values of sound pressure level when it was interposed between source and receiver that barrier sound insulation.

Table 3.

Frequency (Hz)	Sound pressure level (dB)	Sound pressure level (dB)
250	82	85
500	88,5	84
1000	82	71
2000	86,5	69
4000	97	72
8000	86,5	68

Following figure represents graphical interpretation of the above table, namely the variation of sound pressure level according to frequency in the two cases without barrier and with sound insulation barrier.

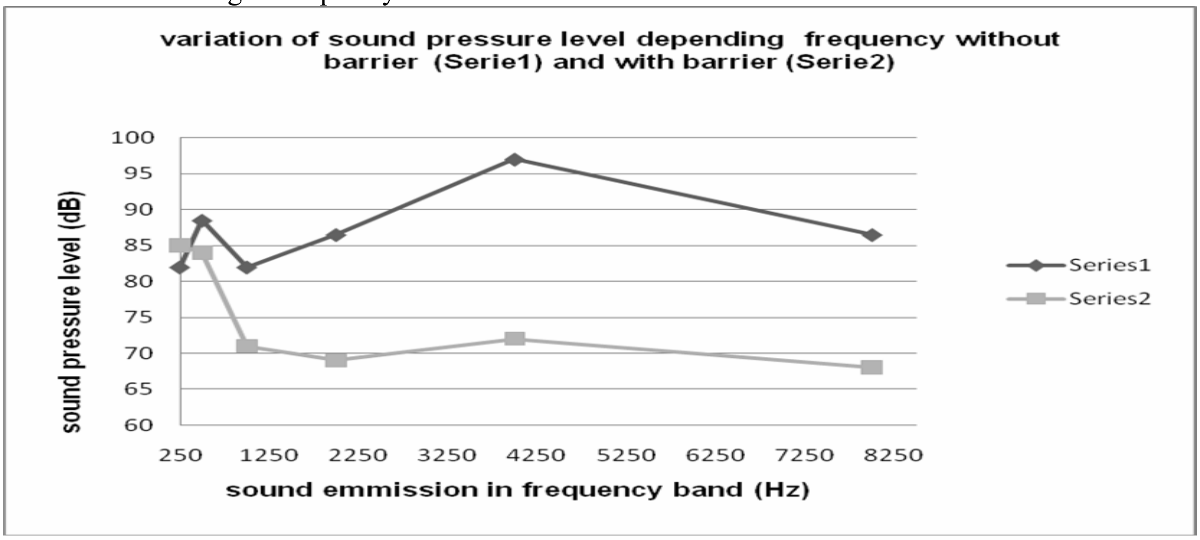


Diagram 3.

To calculate the coefficient of diffraction is taken into account relation on Moreland and Musa

$$p_{b2}^2 = p_{d2}^2 \sum_{i=1}^{n} \frac{1}{3+10N_i}$$

Thus calculating the distances d_1 to d_8 these values resulting in meters: d_1=1.82, d_2=1.15, d_3=1.75, d_4=1.2, d_5=1.62, d_6=1, d_7=1.64, d_8=1.12 .

Continue to calculate the Fresnel number of N, $N_i \equiv \frac{2\delta_i}{\lambda}$ are using values for distances calculated and written above to determine δ = according J.D. IRWIN page 118, is difference between the direct part and the diffracted part between source and receiver.

$$\delta_1 = [(d_1 + d_2) - (d_5 + d_6)] \; , \; \delta_2 = [(d_3 + d_4) - (d_5 + d_6)] \; , \; \delta_3 = [(d_7 + d_8) - (d_5 + d_6)]$$

Result next value: δ_1 = 0,35 m ; δ_2 = 0,33 m; δ_3 = 0,14 m ; Wavelength λ is the speed of sound waves propagated in air c = 343 m / s on the frequency f. $\lambda = \frac{c}{f}$ (m)

In the following table are present values to wavelength for each frequency.

Table 4.

Frequency (Hz)	λ = 343/f (m)
250	1,372
500	0,686
1000	0,343
2000	0,1715
4000	0,0857
8000	0,0428

So, it calculate the number of Fresnel taking into account the wavelength value at each frequency:

- for 250 Hz : $N_1 = 0,51$; $N_2 = 0,48$; $N_3 = 0,2$;
- for 500 Hz : $N_1 = 1,02$; $N_2 = 0,96$; $N_3 = 0,4$;
- for 1000 Hz : $N_1 = 2$; $N_2 = 1,92$; $N_3 = 0,81$;
- for 2000 Hz : $N_1 = 4,08$; $N_2 = 3,84$; $N_3 = 1,63$;
- for 4000 Hz : $N_1 = 8,16$; $N_2 = 7,7$; $N_3 = 3,26$;
- for 8000 Hz : $N_1 = 16,35$; $N_2 = 15,42$; $N_3 = 6,54$;

Thus the number of Fresnel N calculated according to Moreland and Musa diffraction coefficient can be calculated, which represents the physical phenomenon which sound waves encounter an obstacle.

Diffraction coefficient is calculated by following equation : $D = \sum_{i=1}^{n} \frac{1}{3+10N_i}$

The following table shows values of the coefficient of diffraction calculated with the equation above for each frequency:

Table 5.

Frequency (Hz)	Diffraction coefficient (D)
250	0,45
500	0,3
1000	0,2
2000	0,1
4000	0,05
8000	0,03

Next graph is diffraction coefficient variation depending on the frequency :

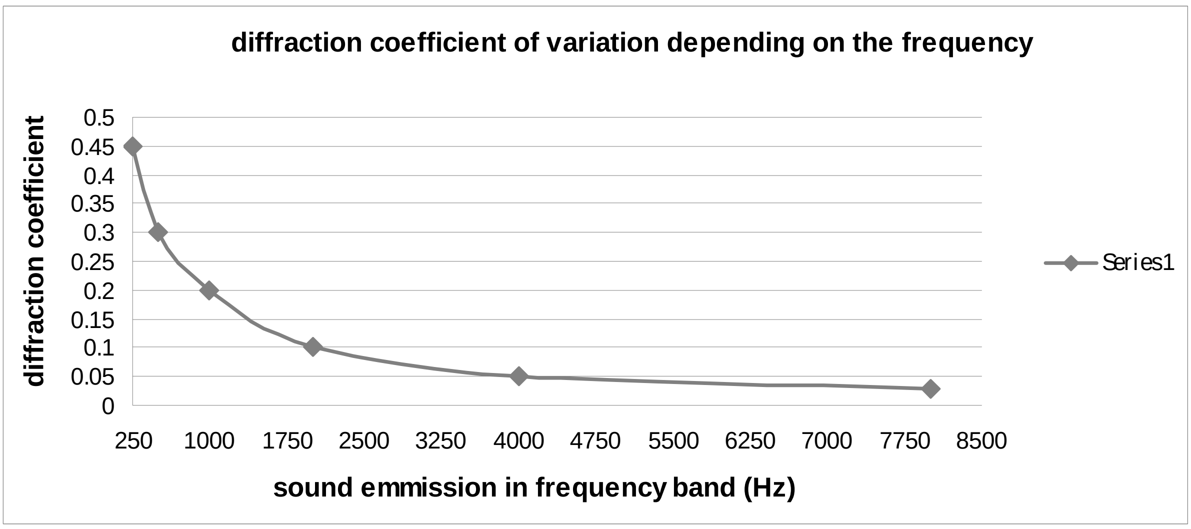


Diagram 4.

6. CONCLUSIONS

Noise pollution is a subject discussed for a log time of modern times being achieved some research to reduce sound pressure level.

There are three solutions to combat noise, namely:

- methods to combat noise at source;
- methods to combat noise propagation paths;
- methods to combat noise receiver.

Reduction of sound pressure level by placing sound absorbing panels or barriers is a common practice.

Thus the walls are very much used both in industry and in road transport, rail or air by placing them between sources and receptors. There have been some research on the types of panels with sound absorbing properties.

Composite materials are important part of the study to reduce noise by using acoustic barriers. In this paper presents research on noise produced by a source that emits sounds in the frequency band between 250 Hz and 8000 Hz. Sound control barrier is used as a composite sample made of epoxy resin reinforced with rubber powder.

According to the charts, there was a significant reduction of noise so that this type of composite material is a good silencer. At low frequencies wall stiffness affect reducing transmission such as at 250 Hz result a slight increase of sound pressure level. In case barriers acoustic waves sound coming from the issuing source and wich propagated by receptor going a diffraction process that depends on the distance between the source and receptors.

Such following the relations calculation after Moraland and Musa to determine the diffraction coefficient values for each frequency. The conclusion is the increasing frequency resulting a decrease in the coefficient of diffraction.

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