Abstract: This paper deals with noise protection and the practical means to achieve this purpose. Individual working places, especially for construction machines with intensive and random dynamical working cycle require proper noise insulation because of the high level of acoustical pollution. The authors propose a feasible acoustic panel solution based on composites core thus that it will be assure proper noise isolation level for large area of applications in respect with the noise emissions characteristics and the spatial distribution and acoustic sensitivity of the receivers. The basic idea of this study combines selective quantitative and qualitative characteristics of a group of materials such as metal sheets, elastomers and textiles to obtain a proper performance of the panel ensemble. Key words: acoustics, panels, insulation, performances.

1. INTRODUCTION

Basic idea of this analysis starts from the practical necessity of noise insulation at working places denoted by intensive acoustical pollution. Taking into account the large and various range of noise characteristics of the usual technological equipments results a strength requirement of proper noise insulation solutions which can provides relative high performances for a large frequency domain. Low frequencies due to the structural vibrations will combines with medium and high frequencies due to the various types of mechanical parts and ensembles having dynamic behaviour. Besides these one can have the hydraulic and/or pneumatic driving systems, the certain types of fans, the electrical or thermal engines, the different types of handlers and hand tools, etc. All of these equipments and systems lead to an apparent random noise which can affect a certain working place.

In such conditions a proper technical solution for noise insulation has to provide a constant value of acoustical absorption coefficient for how many frequency domains. Whereas single materials which supply this requirement is very difficult to obtain, a composite which combines a various frequency characteristics can assure easily such as conditions. The authors proposed and analyzed some composites of metal, rubber and textile sheets with different number of layers and different thicknesses. Optimum ratio between acoustical insulation performances and weight of used material was mainly taken into account.

2. MATERIALS CHARACTERISTICS

Appropriate combinations of insulation materials supposes a mixture of vibration isolation and acoustic absorption thus that low frequencies isolation and medium-high frequencies absorption will provides a large characteristic regardless the pollutant sources type.

Vibration isolation performances were characterized by damping coefficient. Instrumental analysis of vibration isolation composites were performed using Oberst Beam Method (OBM), the well known experimental method for damping loss factor evaluation [1...7].
In respect with the initial hypothesis it was adopted four types of composite plates. Damping materials were rubber sheets with 2, 3 and 4 mm thickness, and synthetic felt ingrained with latex. Basic material for the entire set of combinations was a metal sheet with 1 mm thickness [8]. In Fig.1 were depicted the comparative diagrams of damping loss factor for the proposed composites together with the basic case (e.g. 1 mm thick metal sheet). Basic materials were textile sheet - *intersin* (6 mm thick), synthetic rubber sheet - *intex* (13 mm thick) and wasted textiles composite sheet - *tefo* (6 mm thick). Complex composite material (**netrom**) contains multiple layers of synthetic skin against textile layer ingrained with synthetic rubber. Samples of these materials were tested with the help of Kundt method based on the stationary waves approach. In Fig.2 were depicted the acoustical absorption characteristics for the four combinations of materials previously described.

![Fig. 1. Damping loss factor for vibration isolation composites (reproduced from [8])](image1)

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![Fig. 2. Relative acoustical absorption for different materials](image2)

Fig. 2. Relative acoustical absorption for different materials

Noise insulation supposes an appropriate mixture of materials thus that the relative acoustical absorption coefficient acquires high values for medium and high frequencies. The previous studies [8...10] and the authors analyses developed both on computational models, and on experimental tests reveals that acoustical absorption parameter increase in respect with noise frequency. In the same time, the noise absorption efficiency of the porous materials grows up for the high frequencies. This last conclusion also results from an analytical approach [8]. Practical set of tested materials for noise insulation contains both simple layer, and complex structure with multiple layers from different materials.

Comparative analysis of the diagrams in Fig.2 denotes differences between the four types of composites. Also, it reveals low acoustical absorption efficacy for frequency values between 100 and 1000 Hz, while that for frequency values over than 1000 Hz the acoustical absorption coefficient acquire high values. All the composites have a roughly the same characteristics, but the peaks are different for each type. In respect of the number of identical layers, for the same material or composite the acoustical absorption coefficient acquires high values for high frequencies domain. For frequency values over than 1kHz the acoustical absorption increase up to double
value comparative with single layer case. Low frequencies range (under the 250 Hz) does not acquire influences in respect with the number of layers.

3. EXPERIMENTAL TESTS RESULTS

The practical utilization of the composite panels for reducing the technological noise at working area imposes a lot of instrumental tests and analysis thus that the Regulations requirements for each application type can be accomplish. If the vibration isolation also benefits from an additional technical means such as the passive or active dampers embedded on the pollutant sources, the noise insulation have to be taken into account for each case. Following this idea, it was supposed three types of technological equipments from different category to verify the efficacy of the proposed noise insulation solutions. Hereby it were considered two types of equipments which are affected by different dynamic loads during the working cycle (MMT45 low capacity wheel loader and S1201 excavator) and one equipment which uses vibrations into its working cycle (CVA10 vibratory compactor).

It was evaluated the average acoustical absorption coefficient in respect with frequency for each equipment using the expression

$$\alpha_{av} = \frac{\sum \alpha_i S_i}{S}$$

where $\alpha_i$ denotes the acoustical absorption coefficient for each surface $S_i$ with total surface of the protection area denoted by $S$. For basic unprotected surface (thin metallic sheet) and for glass area (windows) was adopted the acoustical absorption coefficients as follows: $\alpha_{base} = 0.08$, respectively $\alpha_{glass} = 0.33$.

Global evaluation of noise insulation performances contains also the other two parameters. The first is noise total level reduction $\Delta L$ evaluated with the expression

$$\Delta L = 10 \log \frac{A}{A_0}, \text{[dB]}$$

where $A$ and $A_0$ denote equivalent areas of acoustical absorption after, respectively before the noise insulation treatment application.

![Graphs showing average acoustical absorption coefficient in respect with frequency and number of layers for MMT45, S1201, and CVA10.](image)

Fig. 3. Parametrical diagrams of average acoustical absorption coefficient in respect with frequency and number of layers
The second is the absorption constant $R$ evaluated based on the average acoustical absorption coefficient $\alpha_{av}$ with expression

$$R = \frac{\alpha_{av}S}{1 - \alpha_{av}}$$  \hspace{1cm} (3)

Diagrams depicted in Fig.3 present the characteristics of the average acoustical absorption coefficient $\alpha_{av}$ in respect with frequency. The analysis was made with variable number of identical protective layers from single to fourfold. Analysis of these parametrical graphs reveals a relative similar shape but quantitative differences. The acoustical absorption performances widely increase between single and double layers cases, but roughly maintain at the same values for elder layers number. In Fig.4 it was presented a comparative analysis between protected and different types of unprotected areas of working domain. First and second situations suppose relative close values for total protection area; last situation have a quarter less value than other two. The glass area of the second situation is half of its corresponding total surface; this case supposes a less noise protected surface (38%). In the same time the noise protected surface of the last situation exceeds half of its total surface. But it provides a relative high unprotected area (24%). First situation corresponds to a balanced case, with relative close values of protected and glass surfaces, with low value of unprotected area (17%). It had to be mentioned that full noise protected surfaces provide between double and three times value of acoustical absorption coefficient than the glass area.

Taking into account the percentage values in Fig.4 and the previous suppositions, a global comparative quantitative analysis between diagrams in Fig.3 reveals the major influences both of the unprotected surface percentage, and of the glass surface percentage, in respect with the total protection area. Balanced solutions can assure better protection than an extremely closed approach of the working area, especially when it is required windows.

**4. CONCLUSION**

The complexity of vibration and noise insulation at the working places comes from the strength necessity of human operator protection assurance. European and National Regulations stipulations contain acceptable limit values both for vibration and noise exposure. In order to frame into the normal state of noise exposure it is imperative to use acoustic barriers and vibration isolation systems. Frequency range of technological equipments includes medium and high values. In the same time, structural vibration leads to a background noise with low and very low frequencies. This structural noise can affect both inside and outside the noisy structure.

The analyses briefly presented into this paper show the suiting capability of the some regular materials, for simple or complex composite utilization, to assure high performance regarding noise absorption.

Future studies follow the requirement of quantitative reducing of basic materials both through the layers thickness decreasing, and through an appropriate combination into the final composites.
5. REFERENCES


6. ADDITIONAL DATA

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