THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XIV MECHANICAL ENGINEERING, ISSN 1224 – 5615
2008

ABOUT PHONIC ISOLATION OF THE MOBILE EQUIPMENT CABIN

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ABSTRACT

This work presents vibration absorbing and damping solutions for operator cabin on construction equipment. Hereby, the operator cabin has to be considered accordingly.

Vibration proof and sound proof materials applied on the cabin walls require known attenuation and absorbing coefficients according to frequency. Exceeding the compartment noise level above the established limits involves special noise reducing measures. All the mat surfaces that have horizontal, vertical or diagonal alignment can be insulated according to a certain geometric configuration of an operator cabin.

The work related noise is a major concern in Europe. It affects millions of workers not only in heavy industry but in various fields of activity such as services, education and entertainment. One third of the European employees are exposed to high noise levels during more than one third of their work time. Approximately 40 million workers (the equivalent of population of Spain) have to raise their voices over the normal level in order to communicate properly. That happens during half of the work time, at least.

KEYWORDS: Vibrations, Noise, Attenuation, Absorbing, Dumping.

1. Introduction

There are two situations when it comes to reducing the level of the noise generated by construction equipment operating on the construction sites; reducing the noise from the machine to the environment, on one hand, and the one received by the cabin and the operator, on the other hand.

The main noise sources are parts of the construction equipment (regular and electric engines, hydraulic engines and pumps etc.).

The noise is transmitted through air and machine structure.

Construction equipment classification:

a) for embankment:
- bulldozers
- excavators
- bulldoexcavators
- vibrating compactors

b) auxiliary:
- motocompressors
- electrocompressors

c) for construction materials:
- crushers
- screen oscillating shakers
- vibropresses

The noise is transmitted to cabin through air and metallic structure.

The noise and vibration transmitted to an operator on construction site are considered according to standard requirements for construction equipment and work process which are major psychological and physiological stress sources.

There are two categories of technical solutions in order to reduce noise: noise-

isolating encasement of the main generating sources and cabin noise-insulation as noise and vibration absorbing treatments.

Acoustic absorption level and wave transmission level through the separating surface have to be considered quantitatively in order to analyze the noise absorbing characteristics of the materials.

The acoustic reflection coefficient "r" is given by the relation between the acoustic energy flux of the reflected waves and the acoustic energy flux of the incident waves on the separating surface.

$$r = \left(\frac{z-1}{z+1} \right)^2 \quad (1)$$

$z = \rho_2 c_2 / \rho_1 c_1$ - medium1 and 2 impedance inverse ratio relation:

$$r = R$$

Acoustic transmission coefficient is given by the relation involving acoustic energy flux of the transmitting waves and acoustic energy flux of the incident waves on the separating surface between medium 1 and medium 2:

$$\tau = \frac{2z}{z+1} \quad (2)$$

$$\tau = \overline{T} .$$

The acoustic energy which is not reflected is considered to be absorbed. The acoustic absorption phenomenon on separation surface is characterized by the acoustic absorption coefficient

The acoustic absorption coefficient is defined below[1], [2]:

$$\alpha = 1 - \frac{\Phi_r}{\Phi_i}, \quad (3)$$

Φ_i - incident acoustic energy flux;

Φ_r - reflected acoustic energy flux.

2. Phonic isolation of the mobile equipment cabin

The noise inside mobile equipment cabin is generated by outer sources (engines, pumps, muffler etc.).

The phonic insulation inside the cabin leads to noise level reducing, calculated as it is shown below:

$$\Delta L = 10 \lg \frac{A}{A_0} \ [dB], \quad (4)$$

A_0 - equivalent acoustic absorbing surface of the cabin before insulating treatment (m2AU);

A - equivalent acoustic absorbing surface of the cabin after insulating treatment (m2AU).

The following relation is considered for the equivalent absorbing surface:

$$A = \sum_{i=1}^{n} \alpha_i S_i \quad (5)$$

S_i - the surface corresponding to "i" partial cabin area m^2;

α_i - acoustic absorbing coefficient corresponding to "i"area.

The average acoustic absorbing coefficient is calculated as shown below:

$$\alpha_m = \frac{\sum \alpha_i S_i}{S} \quad (6)$$

S - total surface of the cabin

Acoustic absorbing inside the cabin is also characterized by the absorption constant R [3]:

$$R = \frac{\alpha_m S}{1 - \alpha_m} \quad (7)$$

3. Vibration reducing materials

Acoustic insulation encaging of the outer sources and vibration and acoustic isolation of the cabin involves the knowledge concerning characteristics of the insulating materials in order to choose the optimal insulating solution.

The most efficient noise and vibration reducing materials are shown in the table below:

Table no. 1
Sound absorbing materials

No.	Notation	Thickness, mm	Density, g/cm^2
1.	Impregnated textile support type "Super-heavy double Neterom"	3	0,412
2.	Non-impregnated textile support " Intersin F "	3	0,135
3.	Artificial leather " Sinapa heavy type"	1	0,392
4.	Rubber plate type CD x 60	4	1,194
5.	Textile waste plate type "TEFO"	13	0,168
6.	Polyurethane plate "Spurnorin"	4,5	0,029
7.	Latex plate	13	0,13

The vibration absorption effect is different from a material to another. The artificial textile support, impregnated with latex "Super-heavy double Neterom" has the most powerful effect in vibrations absorption [5].

4. Noise levels measured on open construction sites

4.1. Technological construction equipment for embankment and foundation:

- technological noise generating procedures
- concrete + brick leftovers demolish
- foundation soil improvement drilling
- simultaneous equipment functioning (80% approximately)
- noise level

$$L_{eq} = 83 - 92\ dB(A).$$

4.2. Road repair:

- asphalt milling, concrete leftovers removal, etc
- asphalt milling machine, hummers, loading-excavators
- asphalt mixing, leveling and compacting machines
- 78% simultaneity
- noise level [10, [11] [12]:

$$L_{eq} = 85 - 90 dB(A).$$

5. Conclusions

Different noise reducing systems based on certain materials with specific characteristics are considered in order to isolate the cabin and the noise generating sources of the construction equipment.

Acoustic reflection coefficient "r" and acoustic transmitting coefficient t are to be considered in analyzing acoustic absorbing and insulating materials.

The noise is transmitted through the metallic parts of the machine and thru air to the cabin.

Construction equipment operating on open construction sites or in urban areas generates noise transmitted to the environment and to the operator cabin. These are the major issues in finding a noise reduction solution[6], [7].

At the construction equipments working on the construction sites turn up two important problems, namely:

- the fight against the noise transmited to the external environment;
- the fight against the noise transmited to the operator in the equipment cabin.

The noise production must be eliminated anywhere it is possible. This requirement can be realised by changing the construction method or changing the working method.

The fight against the noise can be realised by noise elimination measures at the source and collective measures, which include working set up, too.

Exceeding the compartment noise level above the established limits involves special noise reducing measures. All the mat surfaces that have horizontal, vertical or diagonal alignment can be insulated according to a certain geometric configuration of an operator cabin [8].

An efficient acoustic insulation can be achieved only by considering the characteristic of the selected materials.

The mat surfaces of the cabin have to be isolated considering all geometric directions.

The best results are achieved using impregnated textile support type "Super-heavy double Neterom".

Other noise reducing measures:

Contractors on the same construction site have to communicate and to act conjointly as it follows:

-to isolate noisy work processes and to create restrictive areas;

-to reduce air transmitting noise by utilizing noise reducing screens and premises ;

-to use acoustic absorbing materials in order to reduce reflected noise;

-reducing soil transmitted noise and vibration by utilizing dumping treatments;

-managing noise generating tasks to decrease the number of exposed workers;

- to reduce working time in noise exposed areas;

- to organize work schedule considering the stress generated by noise and vibrations [9], [13], [14].

According to EU legislation concerning exposure to noise, the daily limit is 87 dB(A).

The risk of noise exposure has to be reduced to minimum. The noise sources have to be treated accordingly for a safer work environment [15], [16].

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