NOISE CONTROL FOR RAILWAY STRUCTURES

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REZUMAT: Reducerea zgomotului este esenţială pentru conversia energiei acustice într-o alta, mai puţin deranjantă din punct de vedere energie-căldură. Controlul zgomotului presupune trei componente: reducerea generării de zgomot de la sursă, reducerea zgomotului din punct in punct, de-a lungul căii de transmitere şi reducerea zgomotului la receptor prin tratament acustic. Toate transmisiile sunetului sunt atât prin aer, cât și suportate de structuri, deoarece, sunetul provoacă structura să vibreze de-a lungul propagării. Incidența energei sonore face ca partiția să vibreze şi să genereze sunet pe de altă parte. Indicele de reducere a sunetului (pierdere de transmisie) este utilizat pentru izolarea calității sunetului a barierei acustice.

Cuvinte cheie: zgomot, incidenţa atenuare, frecvenţă, structuri fonoabsorbante.

ABSTRACT: Noise reduction is essentially of converting acoustical energy into another, less disturbing from energy-heat. Noise control is comprised of the three components: reduction of noise generation at the source, reduction of noise from point to point, along the transmission path and reduction of noise at the receiver through acoustical treatment. All sound transmission is both air-borne and structures-borne since, the sound travel along the structure and causes the structure to vibrate. The incidence of sound energy causes the partition to vibrate and generating sound on the other side. Sound reduction index (transmission loss) use for sound-isolation quality of the acoustic barrier.

Keywords: noise, attenuation, incidence, frequency, phonoabsorbant structures

1. GENERAL CONSIDERATION

The general objective is the assurance the basis and connex infrastructure and the necessary conditions for a lasting development of economy and increase of the life standard qualities. Reaching this objective will directly contribute to the economical growth of Romania by the positive impact of relaunching the short time request and, indirectly, by influencing of the transport offer upon the the payment structure at the economic agents and stimulating the increase of the trans-border of persons and goods [1]. Presently on an European scale a more increased interest for railway transport is manifested for the following reasons:

- energetical efficiency
- circulation safety
- protection of the environment
- efficient use of the ground
- social implication, with transport offering for all social categories

A lasting development imposes the decrease of the transport-environment impact and stabilizing at a low level of the emissions and polluting agents that result from the transport and connex transport activities. The process of a lasting development process aims at a gradual achievement of unpolluting infrastructures "friendly" and efficient, combined with the compatibility with the European and global requests. In conformity with the European legislation ,all transport activities must obey the European legislation concerning the evaluation and controlling the noise in the environment. The strategical cartography of the noise must be imposed in all interest zones, in such a way as a permanent monitorizing of the phonic pollution levels exists, fact that allows adopting tough measures for fighting noise in the future [4].

The limitted values imposed by the countries legislation must have as a basis the prevention principle with the purpose to get rid of the polluting factors which present negative effects upon people and the surrounding environment [3].

2. NOISE CONTROL. PHONIC INSULATION

In the railway vehicles there are two sources of phonic pollution: external and respectively internal sources of noise. The most important external source of noise is given by the vehicle running on the rails. According to the way it is produced the are the following types of noises: rolling on the railway, the circulation in alignment or curves, when breaks is used or of cavity generated by their disturbance of air masses.

The reduction of noise for the railway vehicles must be done beginning with the projection and building phase, so that by using the newest technologies in the domain, a high comfort both inside the vehicle and in the railway adjacent zones.

No matter the type of the source, the aerial noise enters the vehicle or passes from one part of it to another by the help of the structure elements of the gear box. It behaves the acoustic screens which more or less oppose the passing of the acoustic energy.

The simple screen represents a structure which is comprised of one single material, homogeneousness from the mechanical properties point of view. The transmission of the noise from one part to another of the separating screen is explained by, on one hand the direct conduction of the acoustic waves through three media (the external air, the screen material and the inside air) and on the other, by the diaphragm effect through which, under the action of the incidental waves on the screen , it vibrates as a aperture and emits acoustic energy in the interior.

The transmitted acoustic energy is equal to the incident acoustic energy, and the transmission acoustic pressure level is identical with the one of the incident acoustic pressure, fact the proves that at transmission reflectant waves no longer occur. The screen becomes totally transparent form the acoustic point of view.

In railway exploitation all vehicles structures there is largely used, with very good results the phonic insulation with double screens. These screens have a unitary mass summing with the simple screen which they replace. The mass law shows that a screen with the unitary mass half of the considered screen will have at the same frequency, an attenuation index 6 dB reduced. Using two light screens with a total unitary mass equal with that of the initial screen, but placed at such a distance as to function independently, a double attenuation index is obtained compared to the case of using a single screen.

Generally all the important structures of the railway vehicles are constructively made under the form of double screens, thus achieving a corresponding phonic insulation

As the resonance phenomenon cannot be eliminated, it is necessary to find constructive solutions in such a way that the frequency at which the resonance occurs be outside the phonic insulation field.

At any frequency of the incidental waves, the absorbent of a phonoabsorbant stratum increases as the thickness of the stratum is greater. There is a limitation as the acoustic impedance, as well as the transmitting constant depend on the frequency.

Another important parameter which influences the insulation degree is represented by the incidence angle of the sound wave on the screen surface. In the real cases of exploitation, the elastic waves field are spread with a certain incidence. The wavelength of the incidence angle no longer simultaneously reach the surface of the screen as in the case of normal incidence, but at different moments in different points.

When the train rolls on the railway multiple reflections occur which produce a diffuse field at the transmitting the acoustic waves so that the average attenuation index must be calculated for incidence angles between 0^0 and 90^0. Along with the incidence angle influence the effect of overlaying of the incidence and reflected waves occur.

From equation (1) results the value of the attenuation index for different incidence angles:

$$D_{s1_i} := 10 \cdot \log\left[1 + \left(\frac{m_s \cdot \omega_i \cdot \cos\left(\frac{\theta_1 \cdot \pi}{180}\right)}{2 \cdot \rho_0 \cdot c_0}\right)^2\right] \quad [dB] \qquad (1)$$

where :D - attenuation index [dB];

m - unitary mass of the screen [kg/m^2];

ω - own pulsation [s^{-1}];

ρ - material density [kg/m^3];

c - speed of sound transmission [m/s].

In figure 1 the influence of the incidence angle and the frequency upon the attenuation incidence is shown for a glass screen, screen that can be assimilated to the wagons windows.

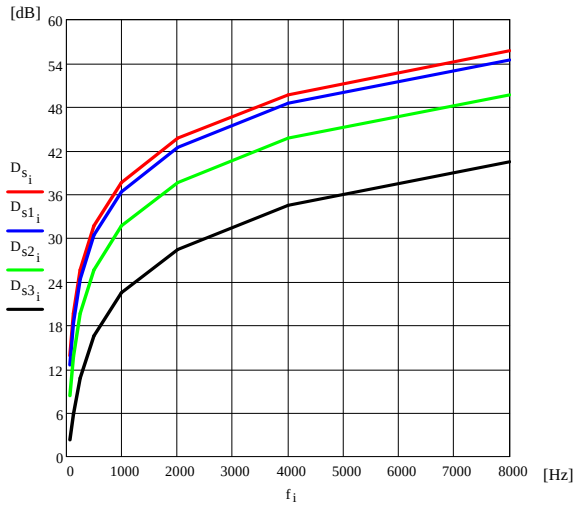

Fig. 1 *Influence of the incidence angle and of frequency upon the attenuation index for glass 4 mm*

For double screens the attenuation index may be defined by the relation:

$$D = 20\lg\frac{\omega(m_1 + m_2)}{2\rho_0 c}[dB] \qquad (2)$$

where: D - attenuation index for double screens[dB];
m1 - the external unitary mass of the screen [kg/m2];
m2 - the inner unitary mass of the screen [kg/m2].

In the case of double windows, the obligatory structure for all up to date railway vehicles the attenuation index is presented in figure 2.

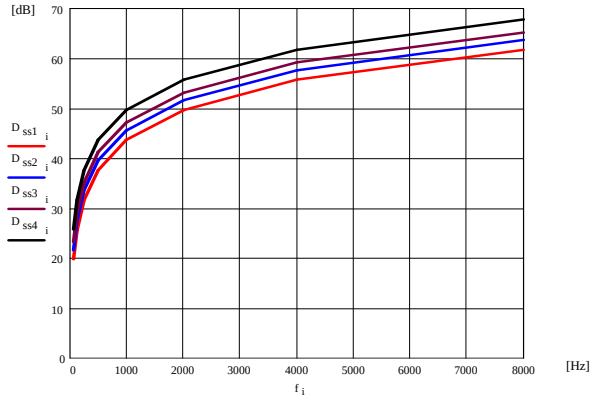

Fig. 2 *The influence of frequency upon the attenuation index at a double glass screen with distanced at 10 mm*

The acoustic most simple absorbents which have as a basis the principle of Helmholtz resonator are built under the form of a perforated screen behind which there is a space of air to the wall or a rigid bridging on which it is set up. The screen perforations allow the entrance of the wavelength inside where through multiple reflexions a attenuation of the transmitted acoustic energy will result. Double screens are presented which in the inner space may have an air pillow or another phono-absorbent material. In both cases an attenuation of the transmitted noise index which will be at least double compared to the case of using only one simple structure.

Experimentally through measurement, analysis and noise evaluation important data for esteeming the potential effects of the noise upon the confort, health, security and work efficiency. Standard SR EN ISO 3095 from 2007 show the conditions under which the measurements concerning the noise produced by the railway vehicles. [7]. For the measurements done a sonometre of integrator type class I was used in conformity with the norms established by CEI 60651 and the prescriptions CEI 60804.

In the cabin of the LDH 1250 HP locomotive a level of phonic pollution was displayed, more over the admitted limit on the entire measurement interval. This fact is due to the position of the cabin above the hydraulic transmission and to a lean acoustic insulation. In figure 3 present the exceeding noise over the medium recorded level is presented. In the updated Diesel hydraulic locomotive case a decrease of the noise level in the cabin was noticed due to a better insulation compared to the prior locomotives series.

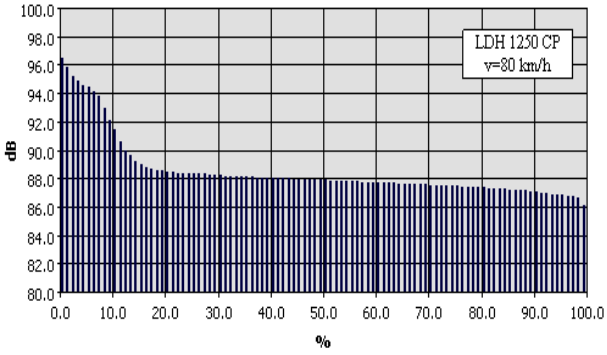

Figure 3 *Exceeding level of noise at locomotive LDH 1250 HP*

New systems for flexible connection of the Diesel motor and of the electrical generator but also setting double windows for all vibrant surfaces were adopted. At a speed up to 80 km/h it became clear the fact that the admitted level was overtaken with 3 -7 dB, situation which does not impose the reduction of the period of exposure to the noises (figure 4).

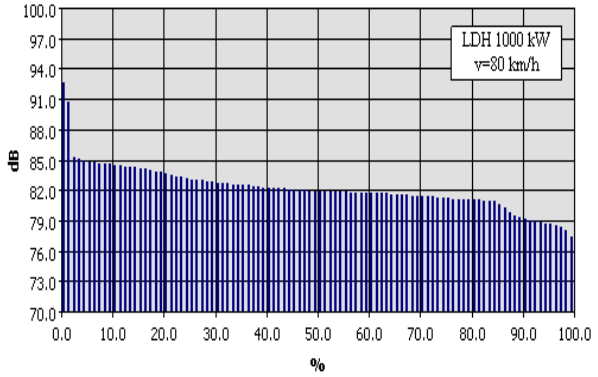

Figure 4 *Exceeding noise level at locomotive LDH 1000 kW*

3. CONCLUSIONS

The phonic insulation with screens made of materials with great rate of absorption at the place in which there is noise emission presents the best technical solution of restricting the phonic pollution.

The increased efficiency of the systems composed of double screens was proved at which the attenuation indexes have the higher values. Thus using two, screens with a unitary mass equally summed up with the mass of the simple screen, a significant reduction of the elastic waves transmission is obtained. The influence variation of the attenuation index was underlined, as well as the variation of the transmission index connected to the

incidence angles of the fronts of waves at the screen surface.

The experiments on the rolling material done revealed the influence of the disturbing factors upon the noise level. The predominant noise sources are represented by the force installations placed on the railway vehicles which must be the first to insulate.

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