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ACOUSTIC ATTENUATION IMPROVEMENT OF DOUBLE SEPARATING SCREENS

Adrian Chiriac, Ramona Nagy, Alexandru Boltosi, Liviu Bereteu, Voichiţa Hule

Department of Mechanics and Vibrations , "Politehnica" University of Timişoara
Bd. Mihai Viteazu, nr.1, 300222 Timişoara, Romania

Abstract. The acoustic attenuation of a double screen is negatively influenced by the vibrations of the constitutive screens, vibrations due to the action of the acoustic waves. A way to improve the acoustic attenuation [1], [2], is the reduction of vibration amplitude of the auxiliary screen, situated behind the screen on which directly act the sonorous waves, be applying a force to the screen. In the paper, the possibility of vibration attenuation of the auxiliary screen is studied.
Keywords: acoustic attenuation, double separating screen, industrial noise.

1. Physical Model

In fig. 1, the disposition of the two screens is presented. On the primary screen 1, the frame 3 is rigidly fixed, and on it, the auxiliary screen 2 is mounted; between the screens, the rubber band 4 is glued. The force generator 5 is an electro-dynamic vibrator, whose body is fixed on the primary screen, and the mobile part, on the auxiliary screen.

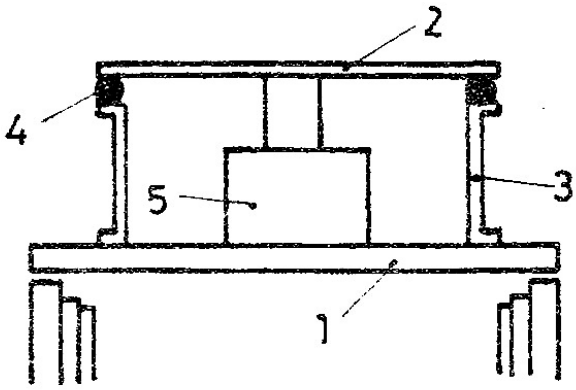

FIGURE 1. Physical Model

2. Dynamic Model and Dynamic Study

In order to determine the force F which must be applied to the auxiliary screen, the dynamic model in figure 2 was adopted [3]: m_e - mass of primary screen; m_v - mass of vibrator; k_1 - elasticity constant of vibrator membrane; c_1 - damping coefficient of vibrator membrane; k_2 - elasticity constant of rubber band; c_2 - damping coefficient of rubber band; m_1 - cumulated mass of vibrator coil and auxiliary screen; F – electromagnetic force, generated by the vibrator; x_1, x_2 - absolute displacements of screens.

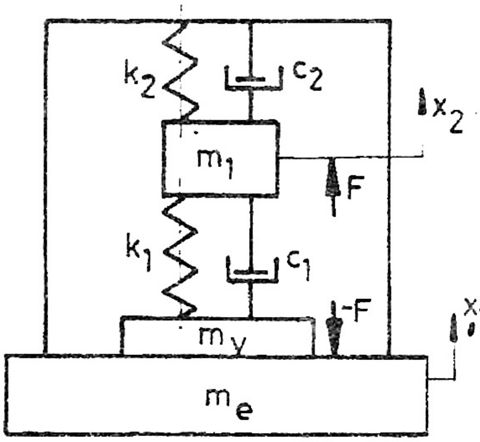

FIGURE 2. Dynamic Model

If $k = \frac{z_0 cA}{d}$ (d – distance between screens, A – area of auxiliary screen, c – sound velocity in air; z_0 - air specific impedance) is the elasticity constant of the air wedge between screens, then the differential equation of auxiliary screen motion, in the absence of force, is

$$m_1\ddot{x}_2 + (c_1 + c_2)(\dot{x}_2 - \dot{x}_1) + (k + k_1 + k_2)(x_2 - x_1) = 0, \tag{1}$$

respectively, in the presence of force,

$$m_1\ddot{x}_F + (c_1 + c_2)(\dot{x}_F - \dot{x}_1) + (k + k_1 + k_2)(x_F - x_1) = F, \tag{2}$$

where $x_F(t)$ is the law of motion of the auxiliary screen, under the action of the active force F.

For harmonic motions of screens, in complex form, $z_1 = x_{10}\, exp(j\omega t)$, $z_2 = x_{20}\, exp[(j\omega t - \varphi)]$, from the Eq. 1, the law of motion of auxiliary screen is deduced:

$$z_2 = \frac{z_1[j\omega(c_1 + c_2) + (k + k_1 + k_2)]}{-m_1\omega^2 + j\omega(c_1 + c_2) + (k + k_1 + k_2)}. \tag{3}$$

In the ideal case, the force F must completely attenuate the screen vibrations, i.e. to realize $x_F = 0$. From the Eq. 2, it results the corresponding complex value,

$$F' = -z_1[j\omega(c_1 + c_2) + (k + k_1 + k_2)], \tag{4}$$

and from the Eq. 3 and 4, its complex value, as a function of the law of motion z_2 of the auxiliary screen:

$$F' = -z_2 [-m_1\omega^2 + j\omega(c_1 + c_2) + (k + k_1 + k_2)] . \qquad (5)$$

By noting $A = -m_1\omega^2 + (k + k_1 + k_2)$, $B = \omega(c_1 + c_2)$, the force F' becomes

$$F' = z_2(-A - jB) . \qquad (6)$$

From the Eq. 6, there are deduced the force amplitude and its phase difference, in relation to the law of motion $z_2(t)$ of the auxiliary screen, of x_{20} amplitude, supposed as known:

$$F_0 = x_{20}\sqrt{A^2 + B^2} \text{ , } tg\varphi_{(x_2 ,F')} = \frac{B}{A} . \qquad (7)$$

The F' force, expressed as a function of the vibration velocity of the auxiliary screen, $\dot{z}_2(t)$, has the expression

$$F' = \frac{\dot{z}_2(-B + jA)}{\omega} . \qquad (8)$$

The force amplitude and its phase difference, in relation to the $\dot{x}_2$ vibration velocity, are

$$F_0 = \frac{\dot{x}_{20}\sqrt{A^2 + B^2}}{\omega} \text{, } tg\varphi_{(\dot{x}_2 ,F')} = \frac{-A}{B} . \qquad (9)$$

By expressing the force F' as a function of the vibration acceleration of the auxiliary screen, $\ddot{z}_2(t)$, it is obtained

$$F' = \frac{\ddot{z}_2(A + jB)}{\omega^2} . \qquad (10)$$

The force amplitude and its phase difference, in relation to the vibration acceleration $\ddot{x}_2$ are

$$F_0 = \frac{\ddot{x}_{20}\sqrt{A^2 + B^2}}{\omega^2} \text{, } tg\varphi_{(\ddot{x}_2 ,F')} = \frac{B}{A} . \qquad (11)$$

By $\dot{x}_{20}$ and $\ddot{x}_{20}$, the amplitudes of vibration velocity and acceleration are noted.

As a function of the cinematic element, adopted as control quantity for the auxiliary screen motion, the force F which must be applied to the auxiliary screen, in order to attenuate its vibrations, is deduced, as amplitude and phase difference, in relation to the law of motion, velocity or acceleration of the auxiliary screen, from the Eq. 7, 9 or 11.

3. Conclusions

From the study concerning the improvement of acoustic attenuation of a double separating screen, by controlling the motion of the auxiliary screen, the following conclusions result:

- it is possible to attenuate the vibrations of the auxiliary screen by applying to it a force, having previously determined characteristics;
- the motion control of auxiliary screen excludes the influence that the motion of the primary screen has on the motion of the auxiliary screen;
- if the motion control of auxiliary screen is correct, realizing the attenuation of screen vibrations, it is obtaining a double separating screen which well attenuates the low frequencies, too;
- the motion control of auxiliary screen is applicable to a frequency domain which is superiorly limited by the first resonance frequency of the bending wave of the auxiliary screen;
- the passing through the screen noise is modified by decreasing of sonorous level of frequencies for which the screen vibration amplitude is attenuated.

References

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