

Low tuning antivibrating systems

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The technical solutions for two vibration insulation systems consisting of rubber elements and metallic rigid bars designated to perform a static deflection high enough as compared with classical solutions are presented. The systems constructed in Romania have been tested and they are used for the vibration insulation in case of equipment mounted inside buildings (such as air conditioning systems, ventilating systems, heating/cooling systems etc).

This work contains for each insulating system the curves illustrating the rigidity variation depending on the rubber elements distribution as well as the vibration insulation degree related to the rubber composition, the type of damping elements and the system geometrical configuration.

Finally, the paper includes the significant values obtained by calculus and experimentally for the two new systems constructed in ICECON Bucharest, as compared with the classical insulation system consisting on rubber damping elements only.

1 Introduction

The requirements imposed to the degree of comfort, hygiene and health inside housing, social, cultural and hospital buildings can be met only in case the vibrations transmitted are reduced in the limits of acceptable levels basing on reference regulations. This is the reason why in the present the vibration isolation concept represents a fundamental matter in designing the elastic supporting systems intended to attain an appropriate isolating degree, at least $I \geq 0,90$.

This paper comparatively treats three elastic systems, namely: the first represents the classic solution for a directly supporting elastic system – SED, the second is the simple elastic system SES – having a single lever to multiply the deflection under loading and the third is the composed elastic system SEC having two levers to multiply the deflection under loading. The conception of the last two systems is original and belongs to ICECON Bucharest, Romania, being studied in the frame of research programs coordinated by the Ministry of Education and Research.

Basing on the analysis of these three types of elastic systems their performances are presented in a comparatively manner having in regard the possibility to modify the fundamental eigen frequency as a function of the system characteristics. A dynamic equipment having the mass equal to 1000 kg and the operating excitation

frequency $f = 12,5$ Hz (750 rot/min) and consisting of a variable number of rubber elastic elements has been considered.

2 Technical solutions

Figure 1 illustrates the three elasting supporting solutions, respectively the directly supporting elastic system SED (figure 1a), the simple elastic system SES, having one lever to multiply the static deflection (figure 1b) and the composed elastic system SEC having two levers to multiply the static deflection (figure 1c).

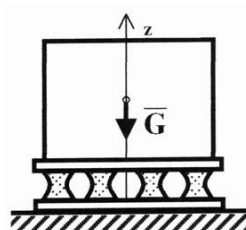


Figure 1.a
Directly elastic system

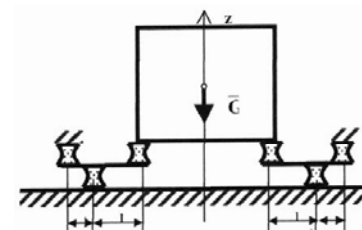


Figure 1.b
Simple elastic system

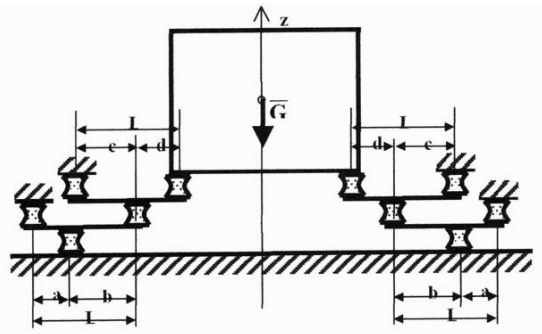


Figure 1.c: Composed elastic system

The elastic systems consist of rubber antivibrating elements having round section, subjected to compression. All the elements are considered to be identical and their total number is different according to the elastic system configuration. Thus, for SED $N_1 = 8$ pieces, for SES $N_2 = 12$ pieces and for SEC $N_3 = 20$ pieces are necessary.

A rubber antivibrating element is characterized by the following parameters: the diameter $d = 5\text{cm}$, the height $h = 5\text{cm}$, the shape factor $\Phi = 0,25$, the rubber hardness 65°ShA , the elastic modulus $E_{st} = 54\text{daN/cm}^2$, the capable force $P_{cap}^{st} = 125\text{daN}$, the axial rigidity coefficient $k_o = 170\text{daN/cm}$, the permissible maximum normal tension $\sigma = 6,15\text{daN/cm}^2$, the permissible maximum unit deformation $\epsilon_a = 0,15$, the permissible maximum axial deformation $\Delta h = 0,75\text{cm}$

3 The elastic system performances

a) The directly supporting elastic system – SED

The equipment static deflection under the dead weight $G = 10^4\text{N}$ is:

$$\Delta_{st} = \frac{G}{k_o N_1} \tag{1}$$

and the fundamental eigen frequency can be written as:

$$f_o = \frac{1}{2\pi} \sqrt{\frac{k_o N_1}{m}} \tag{2}$$

or

$$f_o = \frac{1}{2\pi} \sqrt{\frac{g}{\Delta_{st}}} \tag{3}$$

where replacing the primary data it results in $\Delta_{st} = 7,3 \cdot 10^{-3}\text{m}$ and $f_o = 5,81\text{Hz}$.

Taking into account the working frequency of the equipment $f = 12,5\text{ Hz}$, the antivibrating isolating degree is given by relation :

$$I = 1 - \left| \frac{1}{1 - \Omega^2} \right| \tag{4}$$

with $\Omega = \frac{f}{f_o}$ the relative pulsation. Thus, for the SED,

the isolation degree does not comply under the imposed condition.

b) The simple elastic system – SES

The equivalent vertical rigidity is :

$$k_{ech}^{SES} = \frac{k_o N_2}{2(\lambda^2 + \lambda + 1)} \tag{5}$$

where $\lambda = \frac{a}{b}$ is the coefficient controlling the deformation multiplying effect for the first elastic stage.

The fundamental eigen frequency is calculated as:

$$f_o^{SES} = \frac{1}{2\pi} \sqrt{\frac{k_o N_2}{2(\lambda^2 + \lambda + 1)}} \tag{6}$$

and the frequency ratio $\nu = \frac{f^{SES}}{f_o}$, results under the form:

$$\nu = \frac{f^{SES}}{f_o} \sqrt{\frac{N_2}{2N_1} \frac{1}{\lambda^2 + \lambda + 1}} \tag{7}$$

Replacing the data $N_1 = 8$ and $N_2 = 12$, we have:

$$\nu = 0,866 \frac{1}{\lambda^2 + \lambda + 1} \tag{8}$$

The vibration isolation degree due to SES is :

$$I^{SES} = 1 - \left| \frac{1}{1 - \Omega_{SES}^2} \right|$$

where $\Omega_{SES} = \frac{f}{f_{SES}} = \frac{f}{f_o \nu}$ and $\Omega_{SES}^2 = \frac{4,62}{\nu^2}$.

Thus, we have :

$$I^{SES} = 1 - \left| \frac{1}{1 - \frac{4,62}{\nu^2}} \right| \quad (9)$$

The graphic for the eigen frequency ratio ν and the isolation degree I^{SES} depending of λ is illustrated in figure 2.

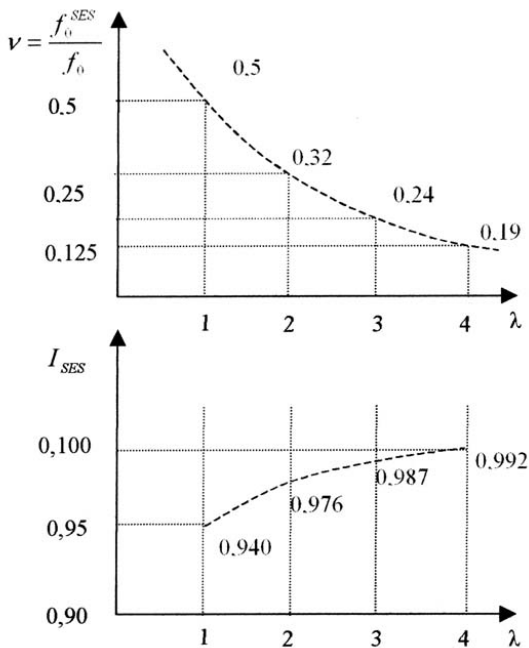


Figure 2: Eigen frequency ratio and isolation degree as functions of λ

c) The composed elastic system – SEC

The equivalent vertical rigidity coefficient is :

$$k_{ech}^{SES} = \frac{k_o N_3}{2(\lambda^2 + \lambda + 1)(\mu^2 + 2\mu + 1) + \mu^2 + 1} \quad (10)$$

where $\mu = \frac{d}{c}$ is the coefficient controlling the deformation multiplying effect for the second stage.

The fundamental eigen frequency can be expressed as:

$$f_o^{SES} = \frac{1}{2\pi} \sqrt{m \left[2(\lambda^2 + \lambda + 1)(\mu^2 + 2\mu + 1) + \mu^2 + 1 \right]} \quad (11)$$

and the frequency ratio is defined by relation:

$$\varphi = \frac{f_o^{SEC}}{f_o} = \sqrt{\frac{N_3}{N_1} \frac{1}{2(\lambda^2 + \lambda + 1)(\mu^2 + 2\mu + 1) + \mu^2 + 1}} \quad (12)$$

Replacing $N_1 = 18$ and $N_3 = 20$, we have :

$$\varphi = 1,58 \frac{1}{\sqrt{8(\lambda^2 + \lambda + 1)(\mu^2 + 2\mu + 1) + \mu^2 + 1}} \quad (13)$$

The curve family $\varphi = f(\lambda, \mu)$ having as parameter $\mu = 1, 2, 3, 4$ is represented in figure 3.

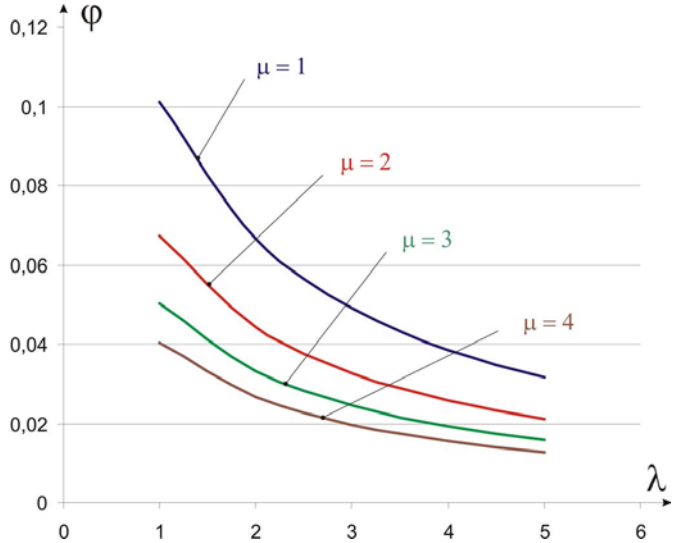


Figure 3: Frequency ratio as a function of λ

Figure 4 presents the curve family for the isolation degree I^{SEC} depending on $\lambda = 1, 2, 3, 4$ for $\mu = 1, 2, 3, 4$.

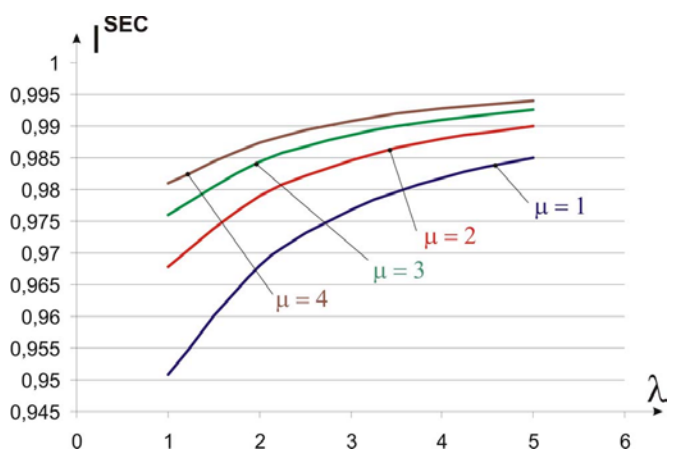


Figure 4: Isolation degree as a function of λ

4 Conclusions

Introducing of some elastic stages intended to multiply the static deflection under loading conduces the eigen frequency attaining very low values, offering the possibility to obtain an efficient antivibrating isolation $I > 0,94$,

The system designing has to be precautionally performed so that all the resistance and stability requirements should be met for both the elastic elements and the entire system.

References

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