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CONSIDERATIONS ON THE NON-LINEAR MODELLING OF THE DYNAMICS OF THE VIBRATION AND SHOCK ISOLATORS MADE FROM COMPOSITE NEOPRENE

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ABSTRACT

This study presents the results of theoretical and experimental researches and numerical modeling for some composite material structures of neoprene used to manufacture the viscous-elastic supports of the technological equipment with dynamic loads. This kind of equipment, which has a high level of vibration and mechanical shocks, can transmit great dynamic forces and mechanical moments to the environment trough the bearings. The analyzed theoretical models are characterized by the rigidity coefficient and by the dissipation coefficient, making obvious the advantages of some types of composite structures. The article presents the amplitude and the power diagrams function of non-linear damping coefficients for some technological equipments.

KEYWORDS: vibration and shock isolator, non-linear modelling, composite neoprene

1. INTRODUCTION

In order to damp dynamic action through shocks and vibrations, the bearings of the technological equipment have to comply with the following conditions: a good bearing capacity by appropriate values of the mechanical resistance, a good rigidity in order to attain static deflections under loading conducting to avoid the significant and possible destroying resonance and an optimum relative to low rigidity and high internal dissipation.

Construction of passive insulation elements in neoprene single microstructure mixture has demonstrated that the isolators can have the necessary elastic characteristics but low internal damping.

2. THE STRUCTURAL ANALYSIS OF THE DAMPERS MADE FROM COMPOSITE NEOPRENE

The most frequent passive isolation systems are realized based on neoprene elements in a sandwich construction having intermediary steel shims and the same neoprene mixture for each layer. To fulfill the above desiderates, it has to take into consideration a new approach regarding realization and modelling of the isolators from composite neoprene. The structure is made from micro structural composite rubber by using some appropriate grading of the powder materials – smoke black and air introduction in nanometer spaces by cork poudrette or chemical foam compound.

The macrostructure composite isolator consists of identical neoprene layers separated by steel shims, each layer consisting of macrostructure distinct units having various physic-mechanical characteristics.

The rheological modelling for the neoprene isolator behavior shows the increase of the internal energy dissipation by increasing of the hysteretic factor (damping structure coefficient).

According to [1], the rheological modeling for the neoprene isolators with composite structures puts into evidence the possibility to realize these type of dampers based on microstructure composite mixture consisting of neoprene smoke black and chemical foam compound or solids with entrapped air (cork poudrette).

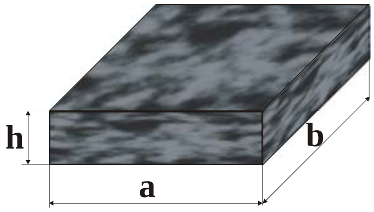

Figure 1 Neoprene type SAB 31

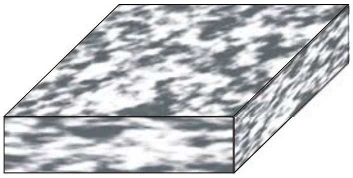

Figure 2 Neoprene type SAB 4a

Figure 1 and fig. 2 show the microstructures of two types of rubber used for macrostructure composite; the physico-mechanical characteristics of these rubber types are shown in Table 1.

The mechanical characteristics of the units made from these rubber types are shown in Table 2. Figure 3 shows the macrostructure of one layer of composite neoprene made from two units of SAB 31 and two units of SAB 4a. The sizes A×B×h of each unit are 0.5×0.5×0.25 [m].

The bearing with sandwich composite structure shown in fig. 4 is made from four identical layers (as in fig. 3) with the sizes a×b×h 1×1×1 [m]. Table 3 shows the mechanical characteristics of the sandwiches.

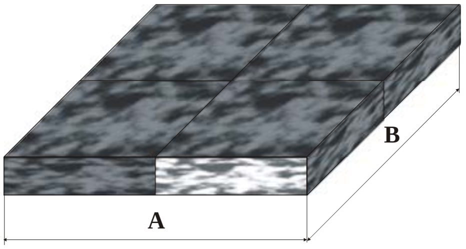

Figure 3 One layer of composite neoprene

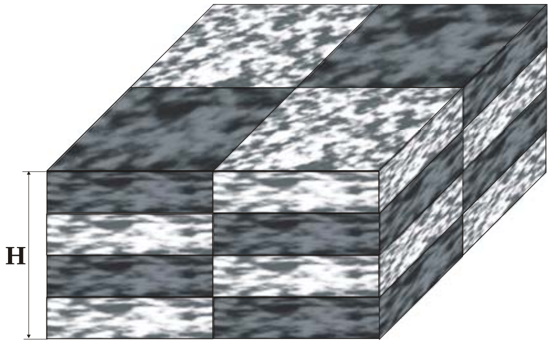

Figure 4 Sandwich composite (4 layers)

Table 1. The characteristics of different neoprene types used for composites

Characteristic	Unit	Rubber type	
		SAB 31	**SAB 4a**
Longitudinally modulus **E**	MN/m^2	4.30	7.00
Shear modulus **G**	MN/m^2	0.80	1.16
Hardness grade	^{0}ShA	55	65
Hysteretic factor **Δ**	-	0.170	0.250
Hysteretic dissipation ratio ζ	-	0.085	0.125

Table 2. The characteristics of one layer of composite macrostructure neoprene

Characteristic		Unit	Model		
			V-K$^{1)}$	**H-M$^{2)}$**	**V-K + H-M$^{3)}$**
Rigidity coefficient	for compression $\mathbf{k_z}$	MN/m	30.40	33.52	28.36
	for shearing $\mathbf{k_x}$	MN/m	3.92	4.60	3.90
Hysteretic dissipation factor **Δ**		-	0.218	0.500	0.380
Critical damping fraction ζ		-	0.109	0.250	0.190

Table 3. The characteristics of composite macrostructure neoprene sandwich (4 layers)

Characteristic		Unit rate	Model		
			V-K$^{1)}$	**H-M$^{2)}$**	**V-K + H-M$^{3)}$**
Rigidity coefficient	for compression $\mathbf{k_z}$	MN/m	7.60	8.38	7.90
	for shearing $\mathbf{k_x}$	MN/m	0.98	1.15	0.975
Hysteretic dissipation factor **Δ**		-	0.218	0.500	0.380
Critical damping fraction ζ		-	0.109	0.250	0.190

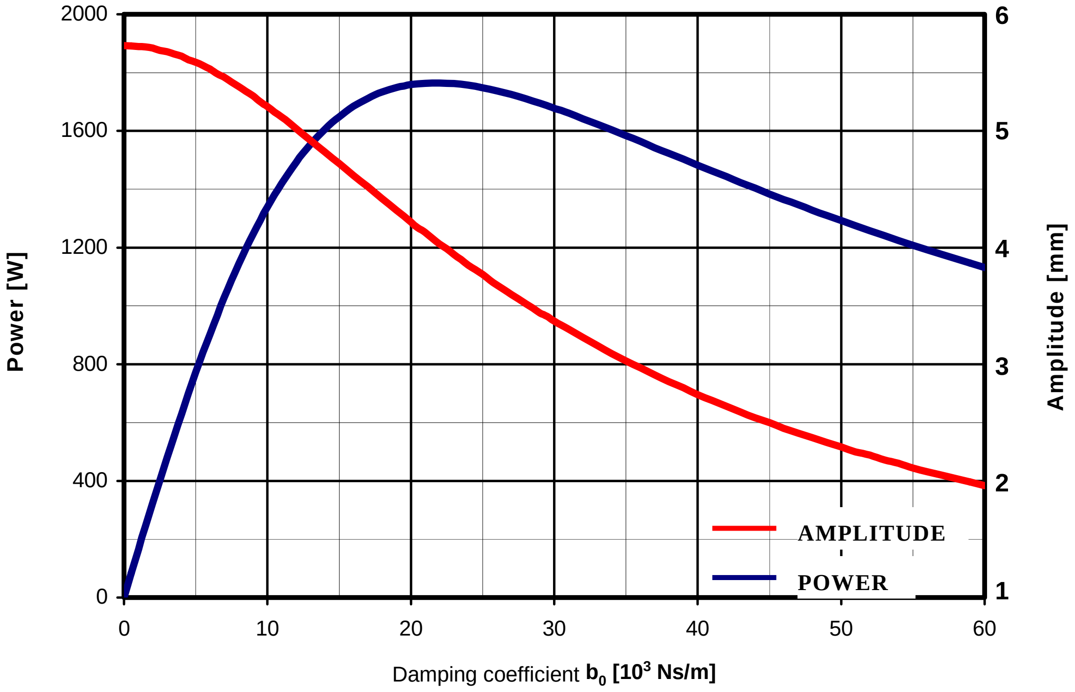

Figure 5 The amplitude and power characteristics of the linear model

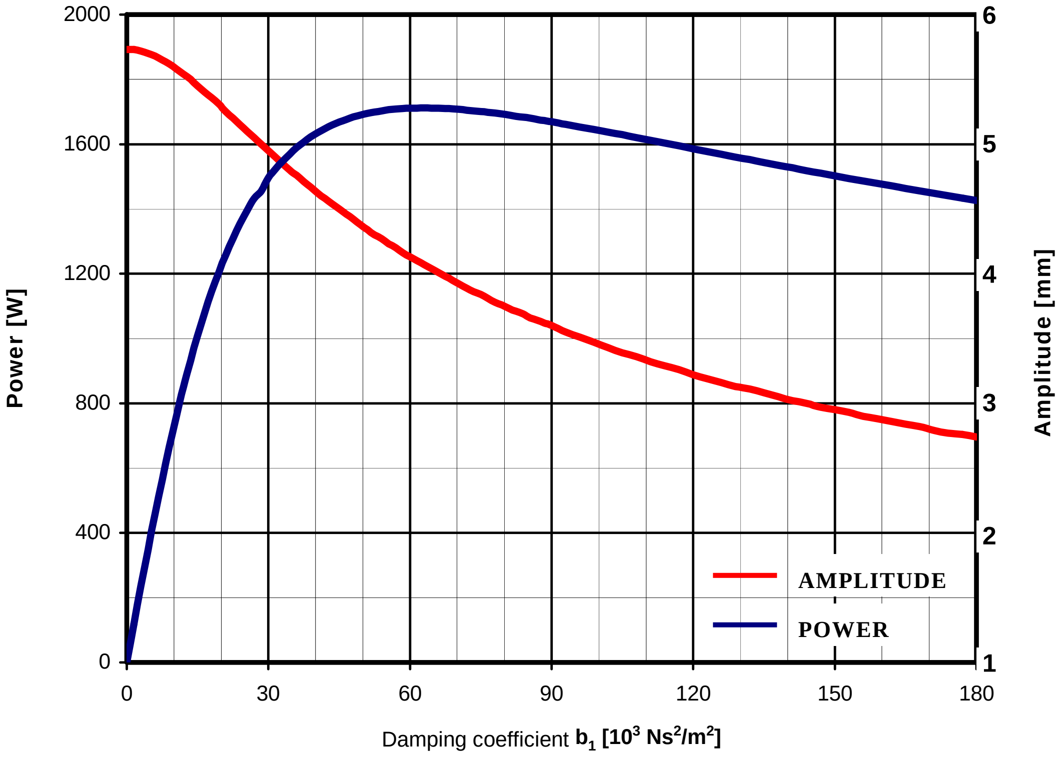

Figure 6 The amplitude and power characteristics function of the damping coefficient b_1

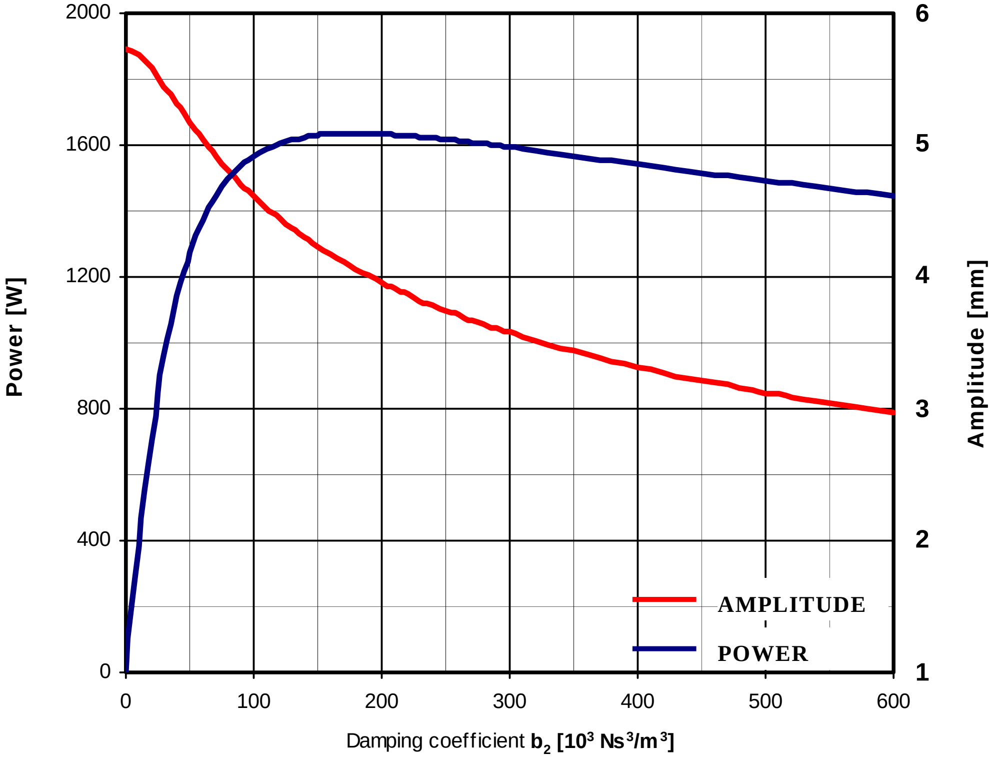

Figure 7 The amplitude and power characteristics function of the damping coefficient b_2

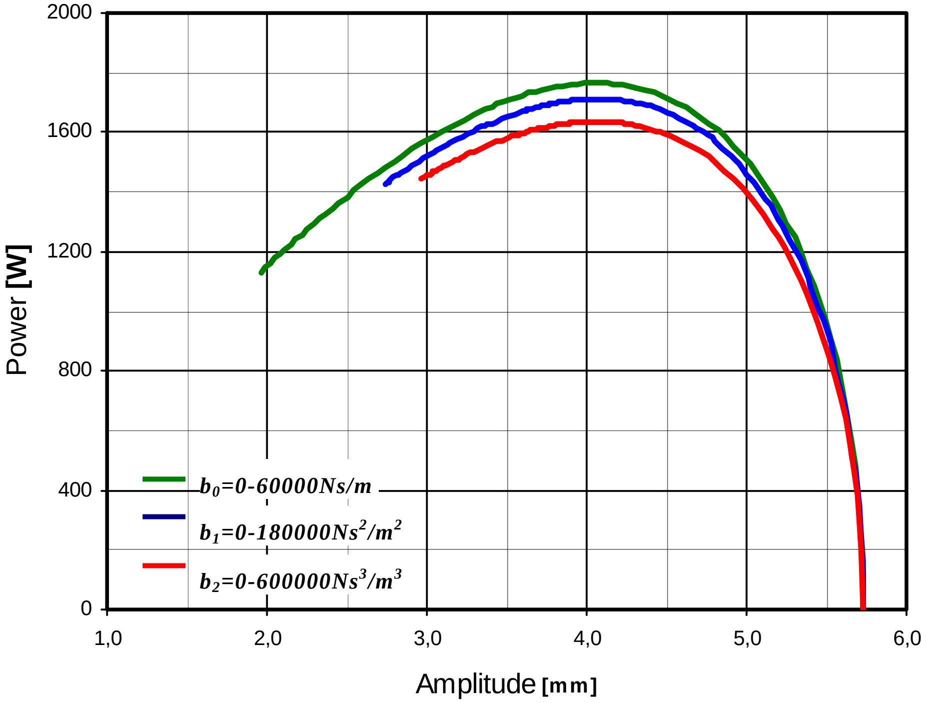

Figure 8 The power characteristics function of the amplitude of the vibration

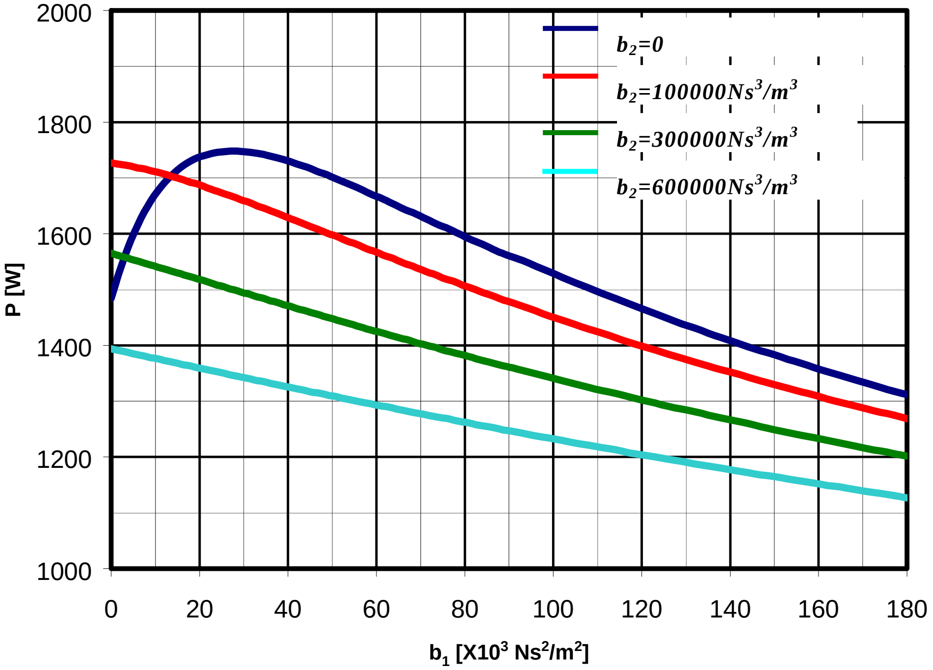

Figure 9 The power characteristics function of the non-linear damping coefficient b_1
(with $b_0=12kNs/m$ and b_2-parameter)

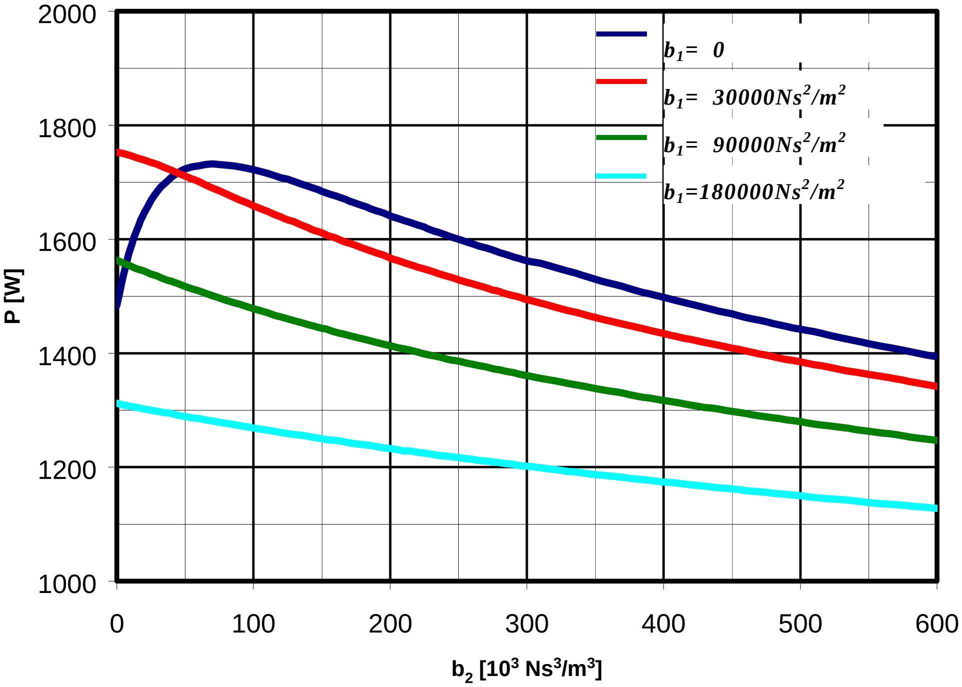

Figure 10 The power characteristics function of the non-linear damping coefficient b_2
(with $b_0=12kNs/m$ and b_1-parameter)

3. NUMERICAL NONLINEAR MODELLING OF 1DOF VIBRATING MECHANICAL SYSTEMS

The goal of the numerical simulation was to calculate the amplitude of the vibrations and the loss of power function of the damping parameters, for the neoprene composite isolators used to support the technological equipment.

Considering 1DOF vibrating mechanical system perturbed by a harmonic force, the mathematic model for it is [1], [2]

$$m\ddot{x} = F_d + F_{el} + F_0 \sin 2\pi f t \ , \qquad (1)$$

where: $\ddot{x}$ is the generalized acceleration

m - mass of the system

F_d - dissipation force

F_{el} - elastic force

F_0 - amplitude of disturbing force

f - frequency of disturbing force

The calculations were made for an inertial vibrator conveyor modeled as 1DOF with the next parameters:

-suspended mass: $m = 250kg$

-rigidity: $k = 300kN/m$

-damping coefficients:

- for the linear model:

$$b_0 = 0 \div 60000 Ns/m$$

- for the model with non-linear damping:

$$b_1 = 0 \div 180000 Ns^2/m^2$$

$$b_2 = 0 \div 600000 Ns^3/m^3$$

-amplitude of harmonic disturbing force:

$$F_0 = 12400N$$

-frequency of harmonic disturbing force:

$$f = 15.8Hz$$

According to [2], the expression for damping force taking into consideration that the numerical modeling was a polynomial one, like the next

$$F_d = b_0\dot{x} + b_1\dot{x}^2 sgn(\dot{x}) + b_2\dot{x}^3 \ , \qquad (2)$$

where: $\dot{x}$ is the generalized velocity

b_0 - the viscous damping coefficient

b_1 - the coefficient for the damping force proportional to the square of the velocity

b_2 - the coefficient for the damping force proportional to the 3rd power the velocity

4. CONCLUSIONS

Figures from 5 to 10 show the power and amplitude characteristics function of the damping coefficient for the system from §3 modelled as an 1DOF mechanical system with non-linear dissipation (2). The non-linear damping force was done by four bearing structures made from neoprene composite sandwiches (rubber type SAB 31 and SAB 4a) with the dimensions a×b×h 200×200×200 [mm].

5. ACKNOWLEDGEMENT

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