

# THE INFLUENCE OF NONLINEAR BEHAVIOR OF VISCOUS-ELASTIC ELEMENT ON EQUIPMENT FOUNDATION WITH DYNAMICAL APPLY STRESSES

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## ABSTRACT

This paper presents a dynamical analyze on the foundation of machine when are apply stresses such the beat (percussion) in nonlinear behavior of the viscous-elastic elements hypothesis. In this way can be evaluate (more realistic) the influence of this particularities on the dynamical behavior of the technological equipment foundation.

### 1. The physical and mathematical model

For the present study is considered a forging hammer with foundation placed on four viscous-elastic trirectangular identical support (fig. 1). Foundation has a plan of symmetry which fact leads to the auto trip movement feasibly when how follows: movement Y, Z and  $\varphi_x$  and movement Y,  $\varphi_y$  and  $\varphi_z$ .

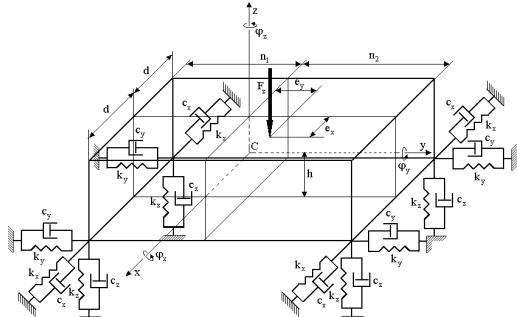


Fig. 1

This model presents a general character, the possible rigid's movement is:

- X – forcing lateral vibration;
- Y - forcing longitudinal vibration;
- Z - forcing vertical vibration
- $\varphi_x$  - forcing pitching vibration;
- $\varphi_y$  - forcing rolling vibration;
- $\varphi_z$  - forcing turning vibration;

For analyse dynamically response of systems are considered the way declutches characterizes through movements: Y, Z and  $\varphi_x$ , because the movement on direction OZ is most illustrative from the viewpoint of effects vibrations about environment

The mathematical model who characterizes this system from dynamic viewpoint is:

$$\begin{aligned} \ddot{m}\ddot{X} + 4c_x\dot{X} - 4hc_x\dot{\varphi}_y - 2c_x(n_2 - n_1)\dot{\varphi}_z + 4k_xX - 4hk_x\dot{\varphi}_y - 2k_x(n_2 - n_1)\dot{\varphi}_z &= 0 \\ \ddot{J}_y\dot{\varphi}_y - 4hc_x\dot{X} + 4(c_xd^2 + c_xh^2)\dot{\varphi}_y + 2c_xh(n_2 - n_1)\dot{\varphi}_z - \\ - 4hk_xX + 4(k_xd^2 + k_xh^2)\dot{\varphi}_y + 2k_xh(n_2 - n_1)\dot{\varphi}_z &= 0 \quad (1) \\ \ddot{d}\dot{\varphi}_z - 2c_x(n_2 - n_1)\dot{X} + 2hc_x(n_2 - n_1)\dot{\varphi}_y + 2[c_x(n_2^2 + n_1^2) + 2c_yd^2]\dot{\varphi}_z - \\ - 2k_x(n_2 - n_1)X + 2hk_x(n_2 - n_1)\dot{\varphi}_y + 2[k_x(n_2^2 + n_1^2) + 2k_yd^2]\dot{\varphi}_z &= 0 \end{aligned}$$

where:

- m – foundation mass;
- k – rigidity of the viscous-elastic element;
- c – damping of the viscous-elastic elements;
- J – inertia moments of the foundation block

Excitation of systems is done through half sine shock pulse (fig. 2), who characterize best the real solicitation of shock.

The rigidity on OZ direction of the viscous-elastic element onis placed foundationof the technological equipments, have the nonlinear expression how follows:

$$k_z = k_0(1 + \beta \cdot x^2)_{OZ} \quad (2)$$

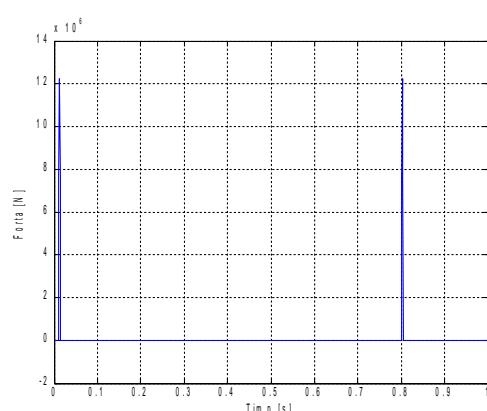


Fig. 2

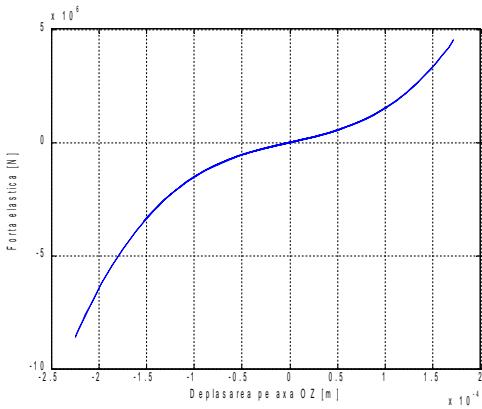


Fig. 3

The solving system has made in hypothesis of the next's numerical value:

$$\begin{aligned} P &= 1288 \cdot 10^4 \text{ N}; \\ k_0 &= 2 \cdot 10^9 \text{ N/m}; \\ c_y &= 2.5 \cdot 10^6 \text{ Ns/m}; m = 100 \cdot 10^3 \text{ kg}; \\ k_z &= 9505 \cdot 10^7 \text{ N/m}; \beta = 6 \cdot 10^7 \text{ 1/m}^2; \\ c_z &= 2.1 \cdot 10^6 \text{ Ns/m}; \\ J &= 77 \cdot 10^4 \text{ kgm}^2; \\ e &= 0.05 \text{ m}; \\ n_1 &= 3 \text{ m}; n_2 = 3 \text{ m}; h = 1.5 \text{ m}, \end{aligned}$$

rate of curve of rigidity is presented in fig. 3.

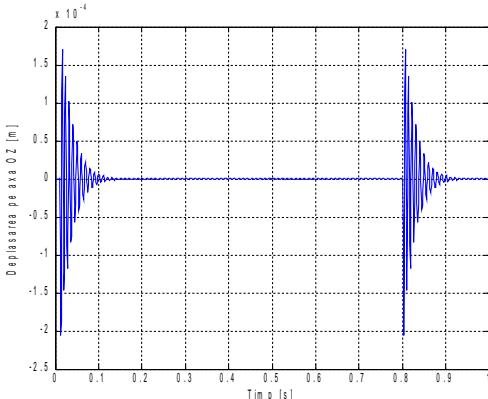


Fig. 4

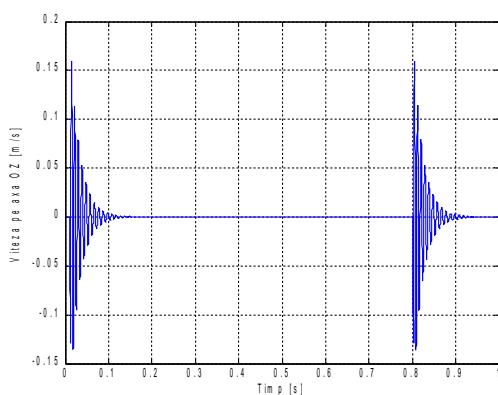


Fig. 5

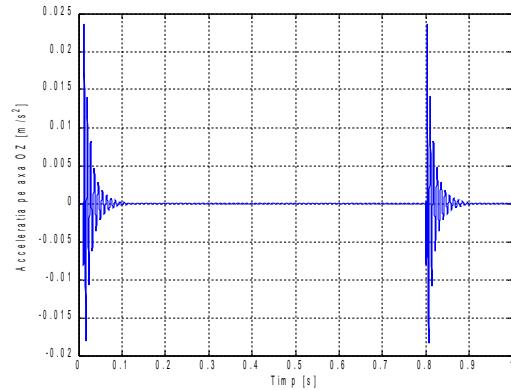


Fig. 6

In hypothesys of the same digital values the solution of the system (1) leads to the determination evolution in time for three kinematic parameters: acceleration, velocity and movement - on OZ direction (fig. 4, 5 and 6). This vibration in time of kinematic parameters, enable characterization effects of transmited vibration the environment comparativ with established limit of standard in vigor.

Elimination times between velocity and the movement permits than obtain - movement trajectory (fig. 7), who show that movement is damped and stable.

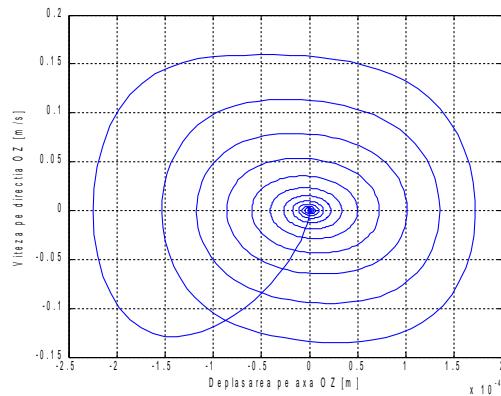


Fig. 7

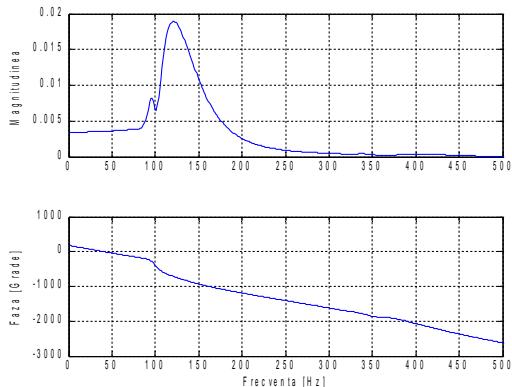


Fig. 8

So frequency response are spectral components around of 97 Hz value (as in the case of linear rigidity), but appear dominant spectral components around of 120Hz value. Distribution of the energy of the shock on spectral components are noticed through plotting the power spectral density (fig. 9). The energy dissipation is done through viscous amortization, what thing is emphasize by plotting the total forces viscous-elastic function by movement (fig. 10).

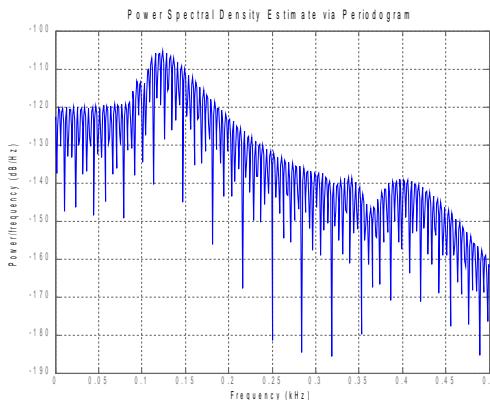


Fig. 9

The value of dissipate energies on a loop of movement is of  $W = 422.33J$ . Towards the case of linear rigidity observe a diminution of dissipate energy an explicable fact through the diminution of movement amplitudes on OZ direction.

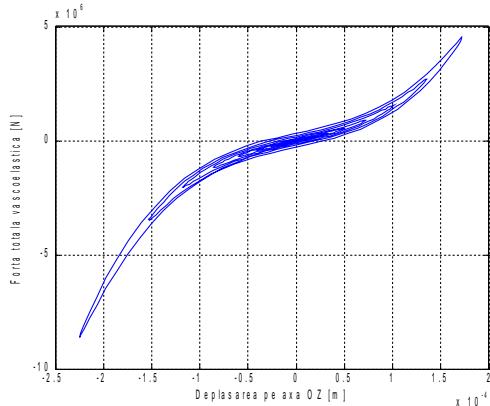


Fig. 10

## 2. Conclusions:

This work presents a theoretical model able to characterize from dynamical viewpoint, a diverse of real situations of the technological equipments who utilize in the production process shocks and vibration.

The nonlinear character of the rigidity viscous-elastic elements are reflected about dynamically response of systems in time and in frequency:

- in time response is remarked a diminution an movement amplitude on OZ direction;
- in frequent response , noticed increase of a constitutive spectral amplitudes, fact who can made a negativ behavior of vibration toward environment and human factor, throught resonant phenomena.

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