

# IDENTIFYING THE INHERENT PULSATION OF THE FOLLOWER AND CRITICAL RESONANCE SPEED FOR THE TRANSLATING CAM MECHANISM AND ROLLER TRANSLATING FOLLOWER

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**Abstract:** *Causes of vibrations. Determined elastic system. The vibrator system consisting of a translation cam and a pushrod with a roller. The own pulsation of the pushrod and the critical speed of the cam at which occurs the resonance. The resonance occurs when the own pulsation of the p pushrod is equal to the pulsation of the vibrational movement due to the movement on the  $\omega$  cam profile*

**Keywords:** vibrations, critical resonance speed, cam profile

## 1. Introduction

The vibrations produced by an elevator during operation are sent as elastic waves. The vibrations of the elevator are transmitted by the supporting systems also to the other equipment found in the same location. The active insulation (from the vibration source to the foundation) or the passive insulation (from the foundation vibrating due to cars or the devices which must be protected against vibrations) is necessary in order to ensure an efficient protection against vibration. [1].

## 2. Causes of vibrations. Determined elastic system

One considers a body that alternatively executes a series of movements around a balance position. In this case, the respective body is under a vibration movement. The causes of vibrations encountered with machines and plants are very diverse [2]. These may be related to:

- The technological process
- The operation manner of the respective machine
- The inaccuracy in execution or installation
- The wear or operation defects

An elastic system is determined when one knows:

- The mass of the system
- The elastic properties of the system which are given by the elastic features of the deformable elements in the system. If the relation between the deformation of the elastic element and the effort causing it is proportional, then the elastic element is linear and may be characterised by an elastic constant.

For a prismatic bar with a square section, with side **b (m)**, length **L (m)**, on which stress is

applied upon stretching or compression by a force  $G$  (N), which is made of an material with a linear elasticity module  $E$  (N/m<sup>2</sup>), the elastic constant [3]. [4]. [5]. is:

$$k = EA / L = Eb^2 / L \text{ (N/m) ..... (1)}$$

### 3. The vibrating system made up of a translating cam and roller translating follower. The inherent pulsation of the follower and the critical speed of the cam at which resonance occurs

One considers a system made up of a translating cam and a roller translating cam that executes an alternative movement from left to right, as shown in figure 1. In this figure, the following are indicated:

- 1) Translating cam
- 2) Roller translating follower
- 3) The platform on which the vehicle is parked

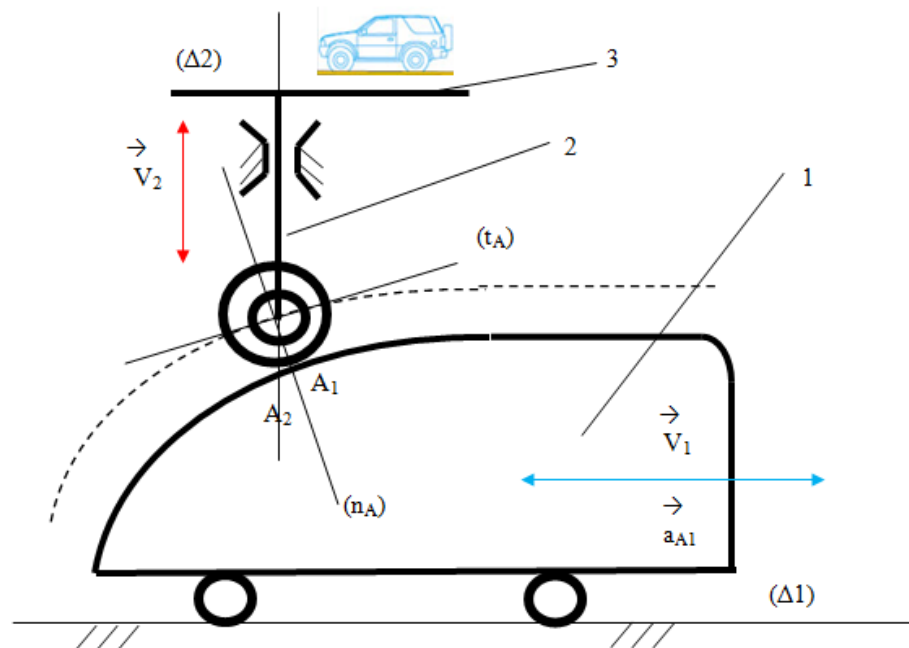


Fig.1. The system made up of a translating cam and a roller translating follower

During the alternative movement from left to right of the cam (1), the follower (2) executes an alternative vertical translation around a balance position, so that it is considered that a vibration movement occurs, as mentioned at item 2.

For the system in figure 1, one adopts a model presented in figure 2 that includes the cam with height  $H$  and total length  $L$ , the follower with mass  $m$  (that also includes the mass of the vehicle on the platform) and the elastic coefficient of the follower bar  $k$  (determined using the formula (1) at item 2).

The cam alternatively moves from left to right at speed  $v$ . Adding a vector equal as a module, on the same direction but with a different sense, we cancel the speed of the cam and introduce a speed  $v$  of the follower. In this case, we consider [4]:

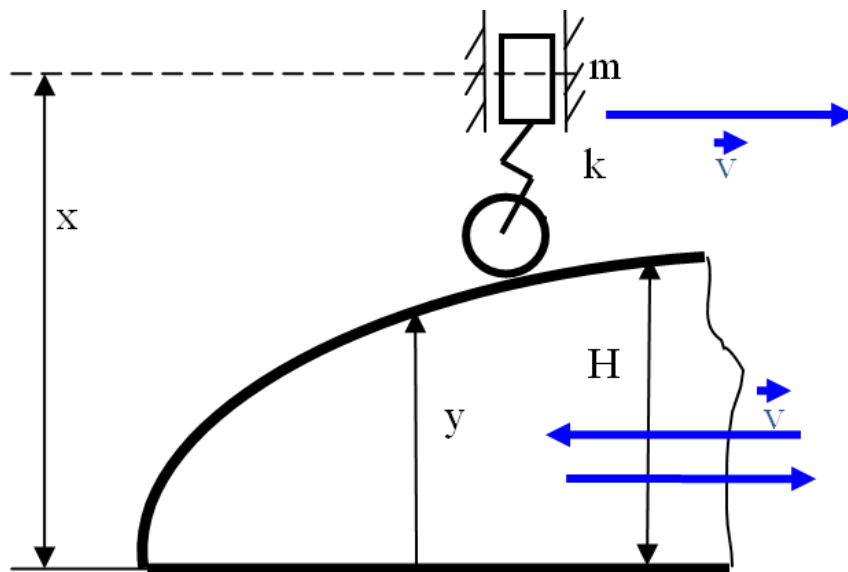


Fig. 2. The model for identifying the inherent pulsation of the system translating cam – roller translating follower for the analysis of vibrations

The elongation of the follower at a certain point is

$$y = H \sin \omega t \quad \dots\dots\dots (2)$$

At a certain point, the equation of the follower movement is

$$ma + k(x - y) = 0 \quad \dots\dots\dots (3)$$

$$ma + kx - kH \sin \omega t = 0 \quad \dots\dots\dots (4)$$

The particular solution of the equation is

$$x_1 = X_0 \sin \omega t = H \quad \dots\dots\dots (5)$$

and satisfies equation

$$m\omega^2 H \frac{1}{1 - \frac{\omega^2}{p^2}} \sin \omega t + kH \frac{1}{1 - \frac{\omega^2}{p^2}} \sin \omega t = kH \sin \omega t \quad (6)$$

The inherent pulsation of the follower on which the vehicle can be found

$$p = \sqrt{\frac{k}{m}} \quad \dots\dots\dots (7)$$

The result is

$$k - m\omega^2 = k \left(1 - \frac{\omega^2}{p^2}\right) \quad \dots\dots\dots (8)$$

where

$$p^2 = \frac{k}{m} \quad \dots\dots\dots (9)$$

the previous relation becomes an identity.

The amplitude of the follower vibration is

$$X_0 = H \frac{1}{1 - \frac{\omega^2}{p^2}} \quad \dots\dots\dots (10)$$

The period of the vibration movement is

$$T = 2\pi / \omega \quad \dots\dots\dots (11)$$

In a period, the cam advances by

$$L = vT \quad \dots\dots\dots (12)$$

From the latest two relations, the result is

$$\omega = 2\pi v / L \quad \dots\dots\dots (13)$$

Resonance takes place when the inherent pulsation of follower  $p$  is equal to the pulsation of the vibration movement, due to the movement on the profile of cam  $\omega$ .

The critical speed  $V_{cr}$  for the cam movement in order to identify the resonance, results when

$$\omega = p \quad \dots\dots\dots (14)$$

$$\frac{2\pi V_{cr}}{L} = \sqrt{\frac{k}{m}} \quad \dots\dots\dots (17)$$

The result is

$$V_{cr} = \frac{L}{2\pi} \sqrt{\frac{k}{m}} \dots\dots\dots (18)$$

#### 4. Example of calculation

One considers both the cam, and the follower made of steel. (density **d= 7850 kg/m<sup>3</sup>** and linear elasticity module **E= 2.1\* 10<sup>11</sup> N/m<sup>2</sup>**). The follower has a square section, side **b= 0.5 m** and its length, including the plate on which the vehicle is parked is **L= 5 m**.

The height of the cam is **H = 3m**, and the total length of the cam (segments of elevation, upper parking and lowering of the follower) is **L= 6 m**.

The mass of the follower is

$$m_0 = d \cdot A \cdot L = d \cdot b^2 \cdot L = 7850 \cdot 0.25 \cdot 5 = 9812.5 \text{ kg.}$$

Also considering a vehicle with a mass **m<sub>1</sub>= 1500 kg**, the resulting total mass is

$$m = m_0 + m_1 = 11312.5 \text{ kg}$$

The elastic constant of the follower bar is

$$k = EA / L = Eb^2 / L = 2.1 \cdot 10^{11} \cdot 0.25 / 5 = 10.5 \cdot 10^9 \text{ N/m}$$

The inherent pulsation of the follower is

$$p = \sqrt{\frac{k}{m}} = \sqrt{\frac{10.5 \cdot 10^9}{11312.5}} = 963.4 \text{ rad/s}$$

The inherent period of free oscillation of the follower is

$$T = 2\pi/p = 6.28/963.4 = 0.65 \cdot 10^{-3} \text{ s}$$

The critical movement speed of the cam for the occurrence of resonance appears (according to ) when

$$\omega = p \dots\dots\dots (19)$$

It is absolutely necessary that the wave pulsation is different from the own pulsation of the studied system so as to avoid the resonance phenomenon leading to the system's destruction.[4]

The critical speed is thus

$$V_{cr} = \frac{L}{2\pi} \sqrt{\frac{k}{m}} = (6/6.28) * 963.4 = 920 \text{ m/s}$$

The calculation shows that the system is free from resonance because  $V_{cr} \gg V$ , where  $V$  is the linear movement speed of the cam of approx.. 2.....3 m/s.

## 5.Conclusions

According to the above, the following conclusions can be drawn:

- the model of the system including the cam type, the type of the rod and the law of its movement are essential for determining the sizes considered
- the characteristics of the cam and the rod (their profile and mass) determine the necessary sizes in order to evaluate the resonance phenomenon in the case of the analyzed system

## ReferenceS

- [1] Carmen Elisabeta Radu, Edward Rășchitor, Iosif Tempea - *Studies on optimizing lifting mechanisms. evaluating the behavior of a lifting mechanism at an elevator during an earthquake* –Editura "Academica Brâncuși" ISSN 1842-4856, seria Inginerie nr. 2/2018, ISSUE 2/2018, pg. 84
- [2] Ioan Deutsch- *Material resistance* - Editura Didactică și Pedagogică- București 1979
- [3] Gh. Buzdugan- *Material resistance* - Editura Academiei – București 1986
- [4] Gh. Buzdugan, I.Fetcu, M.Radeș- *Mechanical vibrations* - Editura Didactică și Pedagogică- București 1979
- [5] R.Voinea, D.Voiculescu, V.Ceaușu- *Mechanics* - Editura Didactică și Pedagogică- București 1983
- [6] Ioan Magheți, Mariana Savu- *The theory and practice of the mechanical vibrations* - Editura Didactică și Pedagogică 2007