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BASICS OF THE VIBRATING TRANSPORTER DESIGN

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Abstract: *The aim of this paper is to offer an introduction of the mechanics of the vibrating transporter that has a loading chute for different kind of pieces. It is considered a harmonic motion caused by a harmonic force, active comparing with the motion direction of the parts. At the end there are given some suggestions about data design of the vibrating transporters.*
Key words: *vibration transport machines, dynamic model, transporter dynamics, transport systems*

1. INTRODUCTION

In industrial activities, many times, it is necessary to be used some vibrating devices to move parts or components. The main parts of these devices are: one or more unbalanced masses (working devices), elastic elements (flat springs, coil springs, rubber pads), one or more vibration exciters (mechanical, electromagnetic, electrodynamic, etc.) (Balcu, 1996).

The vibrating transporters with one unbalanced mass with kinematic chain are characterized by the fact that it is only one working part that has a vibrating motion and the carry-forward is done by a mechanism with a well known act function. The working part can be fixed on linear or nonlinear elastic elements. In case of large and medium quantities transported, on long distances, there are used elastically couplings. In such way the advantage consist of a proper chose for coupling parameters and, as a result one can obtain optimum working regime from dynamic point of view (Munteanu, 1987).

The use of the rigid coupling assures constant and high level of amplitudes indifferent of frequency. Unfortunately, the main disadvantage consists of the starting moment needed at the beginning of the work. The disadvantage is generated by the small amplitude, out of the resonance domain, where the motion is unstable. The stability can be done using some damping couplers (Rosca, 2009).

The vibrating transporters with nonlinear elastic elements work in the resonance domain. The elements nonlinearity, that sustain the working part, lead to the technological stability of the vibrating transporters in the resonance domain (Munteanu, 1987).

Frequently there are used exciters with statically unbalanced fly wheels. In this case, the working part of vibrating transporters is mounted on a bed frame only by elastic elements (Dimarogonas, 1996).

Other used equipment is deck vibrating screens. In this case, the working part is represented by the vibrating screens that are mounted at an angle of 15º ÷ 20º. The exciter consists of an unbalanced mass which develop an excitation force with constant amplitude.

Another type of vibrating transporter is that with two unbalanced masses. As main advantages can be mentioned a better possibility to choose the working regime according with the input frequency, existence of the equilibrium mass assure a law transmissibility of the vibrations, and small noise level.

The working part and the balance mass have a motion with four degrees of freedom: three of the balancing mass and one of the working mass part. Such vibrating machine can not be fully balanced. The condition of a stable work is that of a π radians angle of phase difference between the two masses.

The main problem in vibrating transporter deign is to create the mathematical model. The basics of the model design are described considering a body, with a variable shape, placed on the surface of the vibrating chute feeder that has a slope angle $\chi(t)$, according with the horizontal reference line (Fig.1) (Balcu, 1996).

2. MECHANISM OF THE VIBRATING TRANSPORTER

The research work is focused on the transported body dynamics and the equations that describe the vibrating transporter work. The motion study is referred at the system xOy, attached to the shaker screen. The vibrating chute feeder motion can be described using the motion equation:

$$\chi(t) = A \sin \omega t \tag{1}$$

generated by an harmonic force that is acting under a slope angle β according with the motion direction along the chute feeder (Fig.1). According with the orthogonal reference frame xOy the motion:

$$\begin{cases} x(t) = A_x \sin \omega t = A \cos \beta \sin \omega t\,, \\ y(t) = A_y \sin \omega t = A \sin \beta \sin \omega t\;. \end{cases} \tag{2}$$

The body of mass *m* that is on a relative motion on the chute feeder is loaded with the following forces:

The gravity force:

$$G = mg \tag{3}$$

The inertia forces:

$$\begin{cases} F_{ix}(t) = m\ddot{x} = mA_x \omega^2 \sin \omega t\,, \\ F_{iy}(t) = m\ddot{y} = mA_y \omega^2 \sin \omega t\;. \end{cases} \tag{4}$$

The reaction force of the chute feeder:

$$N = m\left(g + A_y \omega^2 \sin \omega t\right) \tag{5}$$

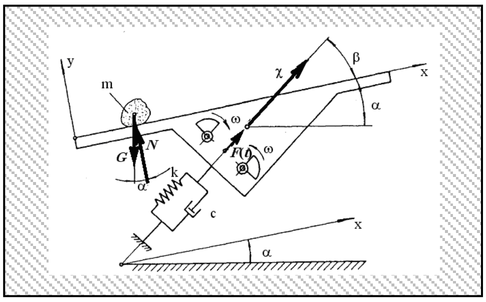

Fig. 1. Basic scheme of the vibrating chute feeder

The friction force:

$$F_f = \mu N = \mu m \left(g + A_y \omega^2 \sin \omega t\right) \tag{6}$$

The direction and orientation of these forces there are shown in Fig.2 a and b. One can see that the friction force, which is in opposite direction with the body motion, is minimum in the case presented in Fig.2,b. This means that the body displacement on the chute feeder is made on the right direction. According with the Fig. 2,a, the force equilibrium equations that load the body leads, on the two axes, to the following relationships:

$$\begin{cases} m\ddot{x} = \mu m \left(g \cos\alpha + \ddot{y}\right), \\ m\ddot{y} = -mg \cos\alpha . \end{cases} \tag{7}$$

According with the relationships (7), the body displacement on the chute feeder starts at the moment t_1, when is realized the condition:

$$A_y \omega^2 \sin \omega t_1 = g \cos\alpha \tag{8}$$

where from one can obtained:

$$\sin \omega t_1 = \frac{1}{\lambda} \tag{9}$$

where,

$$\lambda = \frac{\ddot{y}_{max}}{g \cos\alpha} = \frac{A_y \omega^2}{g \cos\alpha} = \frac{A\,\omega^2 \sin\beta}{g \cos\alpha} \tag{10}$$

represents the basic index of the vibrating transporter performance (Balcu, 1996).

The analysis of the physic process of the vibrating transporter permits to be found the values domain of l (Legendi & Pavel, 2002).

At the moment t_1, when the vertical chute feeder acceleration exceeds the gravity, the body stand out on the chute feeder having a micro-jump above.

At the moment t_2, the body is, again, in contact with the chute feeder, being than accelerated until the moment $(t_1 + 2\pi/\omega)$, and then the processes are repeated.

Integrate the equations (7), and taking into consideration that at the moment t_1 the body had passed through normal direction on chute feeder the space y_1, and along the chute feeder direction the space x_1, with the velocities V_{y1}, and V_{x1}, respectively, there are obtained the following equations:

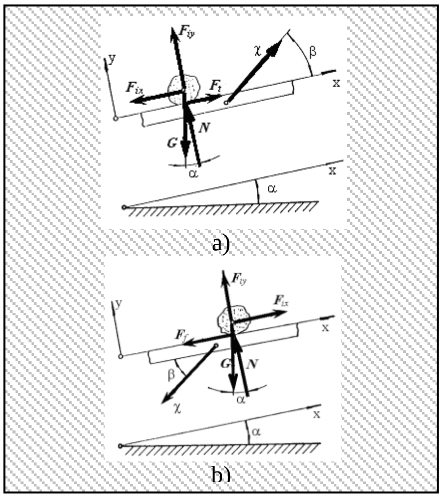

Fig. 2. The forces that are acting on the moving body seated on cute feeder

$$\begin{cases} A_y \sin \omega t_2 = A_y \sin \omega t_1 + A_y \omega (t_2 - t_1) \cos \omega t_1 - \frac{g}{2}(t_2 - t_1)^2 \\ A_x \sin \omega t_2 = A_x \sin \omega t_1 + A_x \omega (t_2 - t_1) \cos \omega t_1 \end{cases} \tag{11}$$

The condition of time contact between the chute feeder and the body is:

$$t_2 \le t_1 + \frac{2\pi}{\omega} \tag{12}$$

At the limit, the relationship (12) becomes:

$$\omega(t_2 - t_1) = 2\pi \tag{13}$$

Combining relationships (13) and (10), and taking into consideration (8) one can obtain:

$$\tan(\omega t_1)_{cr} = \frac{1}{\pi} \tag{14}$$

Based on (8) and (10) results that vibrating transporter is working properly if is reached the condition:

$$1 < \lambda < \frac{1}{\sin(\omega t_1)_{cr}} \tag{15}$$

or,

$$1 < \lambda < \sqrt{1 + \pi^2} \tag{16}$$

that leads to the following values:

$$1 < \lambda < 3.3 \tag{17}$$

The analysis of the physical process of the vibrating transporter can be continued by taking into consideration the displacement x given by (2), finally being obtained information about the velocity of the body of mass *m* along the chute feeder (Legendi & Pavel, 2002).

3. CONCLUSIONS

In the case of abrasive bodies, that strongly attrite the chute feeder, it is recommended a value of λ close to 3.3. This value offers the possibility to have a short time contact between the piece and the chute feeder. For a small scuff of the chute feeder it is need to have a small value of λ. The values of λ = 2.4 – 3 leads to optimal transport velocities.

In case oh the vibrating transporter with advance per attack, the advance velocity of the pieces depends on the following parameters: the angle α, the frequency *f*, the amplitude *A*, and the slope *β*, mechanical properties of the pieces material, etc.

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