UPGRADING A SWINGING SCREENING SYSTEM WITH LINEAR MOTIONS IN A HORIZONTAL PLANE

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ABSTRACT. This research proposes and proves a method of upgrading swinging screening systems with linear motions in the horizontal plane – namely, replacing the rigid link between the housing and the vibration exciter with an elastic one. This can be achieved with the introduction of an elastic connecting rod. With the help of methods from analytical mechanics and the mechano-mathematical models of the initial and improved constructions we prove that this leads to reduced dynamic bearing reaction forces and significantly improved vibroisolation.

Keywords: swinging screening systems, elastic connecting rod, upgrading

МОДЕРНИЗАЦИЯ НА ЛЮЛКОВА ПРЕСЕВНА УРЕДБА С ПРАВОЛИНЕЙНИ ДВИЖЕНИЯ В ХОРИЗОНТАЛНА РАВНИНА

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РЕЗЮМЕ. В настоящата работа се предлага и обосновава един начин за модернизация на люлковите пресевни уредби с праволинейни движения в хоризонтална равнина – замяна на твърдата връзка между корпуса и вибровъзбудителя с еластична. Това може да се осъществи с въвеждането на еластична мотовилка. С помощта на изградените механо-математични модели на съществуващата и на модернизираната конструкции, с методите на аналитичната механика се доказва, че по този начин се намаляват стойностите на динамичните опорни реакции и значително се подобрява виброизолираността.

Ключови думи: люлкови пресевни уредби, еластична мотовилка, модернизация

Introduction

The main advantages of swinging screening systems with linear motions in the horizontal plane are:

- simple construction;
- easy maintenance;
- small magnitude of the friction forces;
- insignificant operating costs.

Because of them, such systems continue to be used today despite their serious disadvantage, namely the large unbalanced forces transmitted to supporting structures and surrounding facilities.

This work proposes and proves an easy method for upgrading swinging screening systems with linear motions in the horizontal plane – namely, replacing the rigid link between the housing and the vibration exciter. This can be done by installing an elastic connecting rod. With the help of the established mechanometric models and the methods of the analytical mechanics, it is proved that in this way the values of the dynamic bearing reaction forces are reduced and the vibro-isolation and working conditions in the mining enterprises are significantly improved.

Description of existing swinging screening systems with linear motions in the horizontal plane

Representatives of this type of screening system are characterized by constant kinematic parameters at all points of the screening surface because of the rigid connection between the drive and the housing, as well as the inelastic attachment of the housing to the foundation. Fig. 1 shows the schematic diagram of a swinging screening systems with linear motions in the horizontal plane (Denev 1964; Tsvetkov 1988). The housing together with the screening surfaces is secured by the cylindrical joints A and B and levers AB. It moves translationally. The distance $AB = b$ from the support A to the housing is much larger than the eccentricity e of the vibrator, and therefore it can be assumed that the sieve surface moves in a horizontal line instead of a circle. The source of oscillation is the eccentric shaft OD that rotates with a constant angular velocity ω. Movement is transmitted to the screening surfaces with the help of the connecting rod BD.

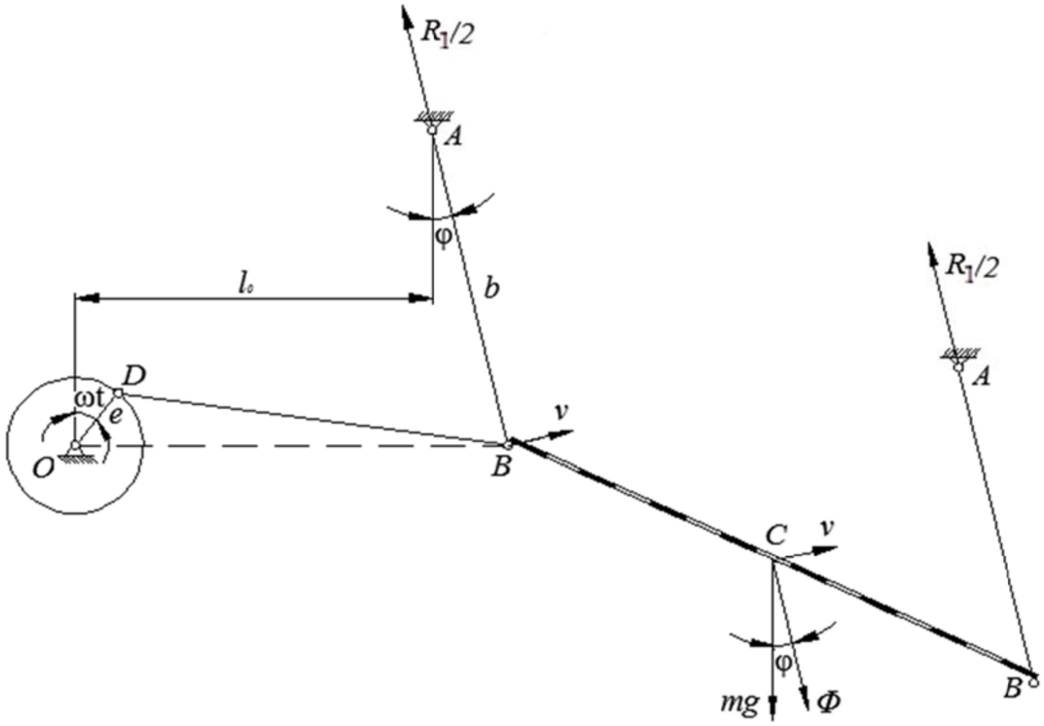

Fig. 1. A swinging screening systems with linear motions in the horizontal plane

The described screening system is considered to be a one-mass swinging system with one degree of freedom. For the coordinate φ, the angle of rotation of the levers AB relative to the vertical is selected. The mass of the housing and the screening surfaces is m. The distance from the axis O of the eccentric shaft to the joint B in the position of static equilibrium is indicated by l_0. The levers AB, the connecting rod BD and the eccentric are considered lean, due to the fact that their weight is hundreds of times smaller than that of the screen housing. Friction in the cylindrical joints is disregarded.

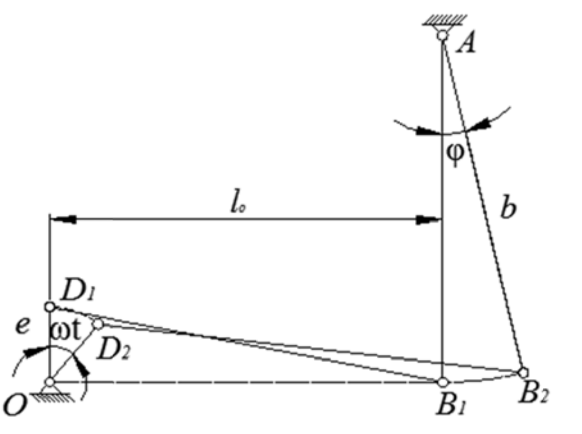

Fig. 2. Determining the relationships between kinematic parameters

Fig. 2 presents a scheme for determining the relationships between kinematic parameters. At the initial moment of motion, the crank of the vibrator and the housing suspension lever are respectively OD_1 and AB_1. At any point in the movement they occupy positions OD_2 and AB_2. On the one hand, point B can be viewed as part of the vibrator and its motion will be represented as $e.sin\omega t$. On the other hand, the same point belongs to the lever AB and moves along the arc

$$B_1B_2 = l.\varphi .$$

Therefore, the following equality applies (Pulev, 2014)

$$b.\varphi = e.sin\omega t \text{, or } \varphi = \frac{e}{b} sin\omega t .$$

The speed of the housing and the screening surfaces at any point in time is

$$v = b\dot{\varphi} = e\omega\cos\omega t .$$

The centrifugal inertial force acting on the screen body is

$$\Phi = \frac{mv^2}{b} = \frac{m}{b}\left(e\omega\cos\omega t\right)^2 .$$

The dynamic bearing reaction force R_1 is

$$R_1 = mg\cos\varphi + \Phi = m\left[g\cos\varphi + \frac{\left(e\omega\cos\omega t\right)^2}{b}\right]. \quad (1)$$

Description of the upgraded swinging screening system

Fig. 3 shows a dynamic model of the upgraded swinging screening system with linear motions in the horizontal plane.

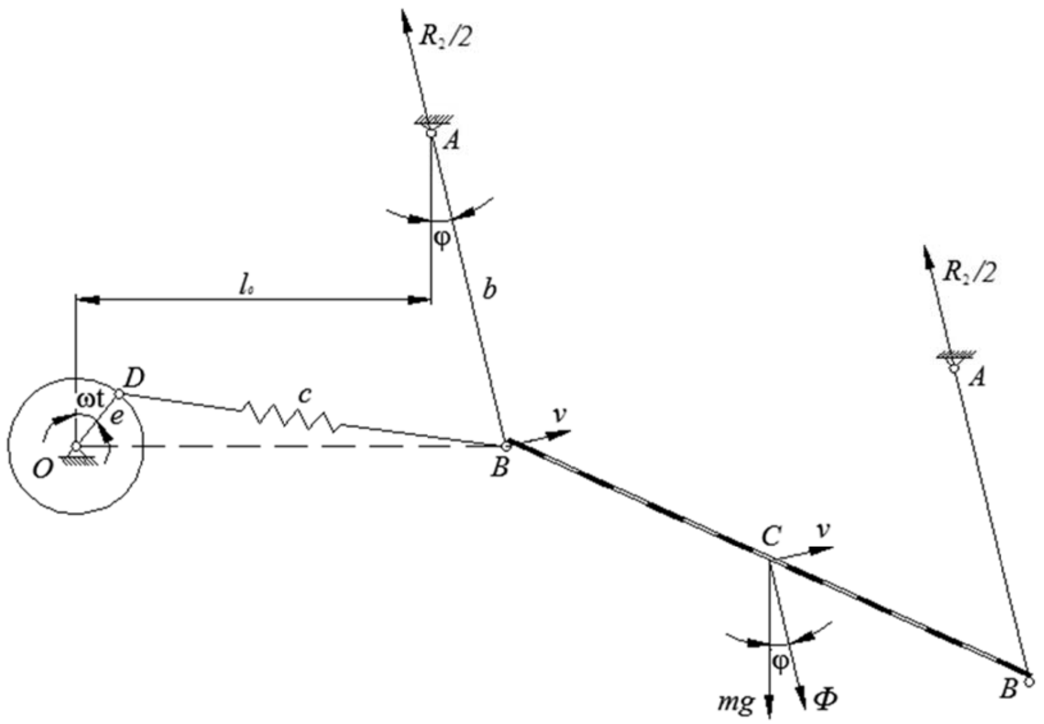

Fig. 3. Schematic diagram of the upgraded swinging screening system with linear motions in the horizontal plane

The elasticity of the newly installed connecting rod is characterized by the coefficient c.

An analysis of this model has been carried out with the methods of analytical mechanics (Pulev, 2016). The approximate differential equation of movement is

$$\ddot{\varphi} + k^2\varphi = \frac{ce}{mb}\sin\omega t\,.$$

The law of motion of the screening surfaces is

$$\varphi = \frac{ce}{\left(k^2-\omega^2\right)mb}\left(\sin\omega t - \frac{\omega}{k}\sin kt\right), \quad (2)$$

and the expression for the variation in the speed is

$$\dot{\varphi} = \frac{ce\omega}{\left(k^2-\omega^2\right)mb}\left(\cos\omega t - \cos kt\right), \quad (3)$$

where

$$k = \sqrt{\frac{mg+cb}{mb}}$$

is the system´s circular frequency of vibration.

With the help of the deduced expressions (2) and (3), the centrifugal inertial force $\Phi = mb\dot{\varphi}^2$, acting on the screen body, can be determined, as well as the dynamic bearing reaction force R_2 of the support A, namely

$$R_2 = mg\cos\varphi + \Phi = m\left(g\cos\varphi + b\dot{\varphi}^2\right). \quad (4)$$

Numerical experiment

To prove the positive effect of the upgade, a numerical experiment is carried out with the help of MATLAB. The aim of the experiment is to compare the values of the dynamic bearing reaction force between the initial and upgraded swinging screening system. The values of the parameter are

$$c = 200\,000\ N/m$$
$$m = 2000\,kg$$
$$\omega = 600\ s^{-1}$$
$$l_0 = 0{,}7\ m$$
$$b = 0{,}8\ m$$
$$e = 0{,}03\,m$$

Fig. 4 presents the graph of time-varying values of the bearing reaction force R_1 in the initial system. Formula (1) is used. A maximum value of 24804 N is recognized.

Fig. 5 shows the variation of the bearing reaction force R_2 in the upgraded version by applying formulas (2), (3) and (4). Values do not exceed 19663 N. Difference between the minimum values of the two systems is not observed. After comparing the data in Fig. 4 and 5, a reduction in the maximal value of the dynamic backlash was observed by 5141 N or by 20.73% in favor of the upgraded version.

The results of the numerical experiment clearly demonstrate the benefits of installing an elastic connecting rod. The upgrade costs are low, but the the vibrations are significantly reduced.

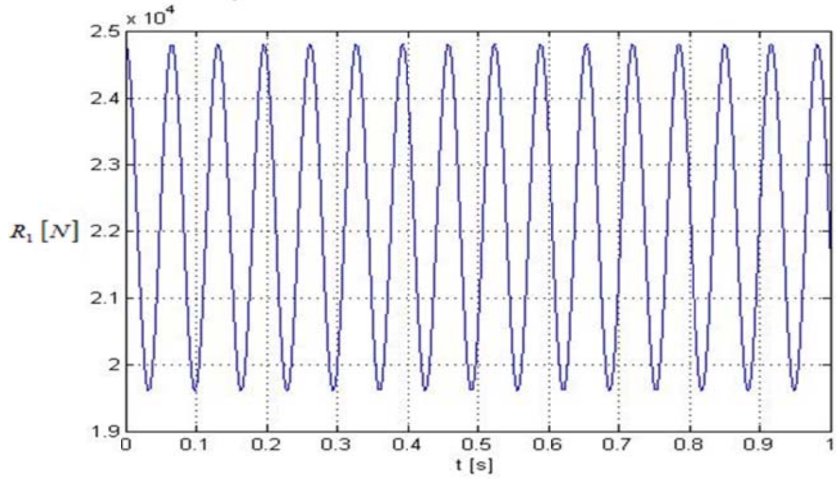

Fig. 4. Variation of the dynamic bearing reaction force in a conventional swinging screening system

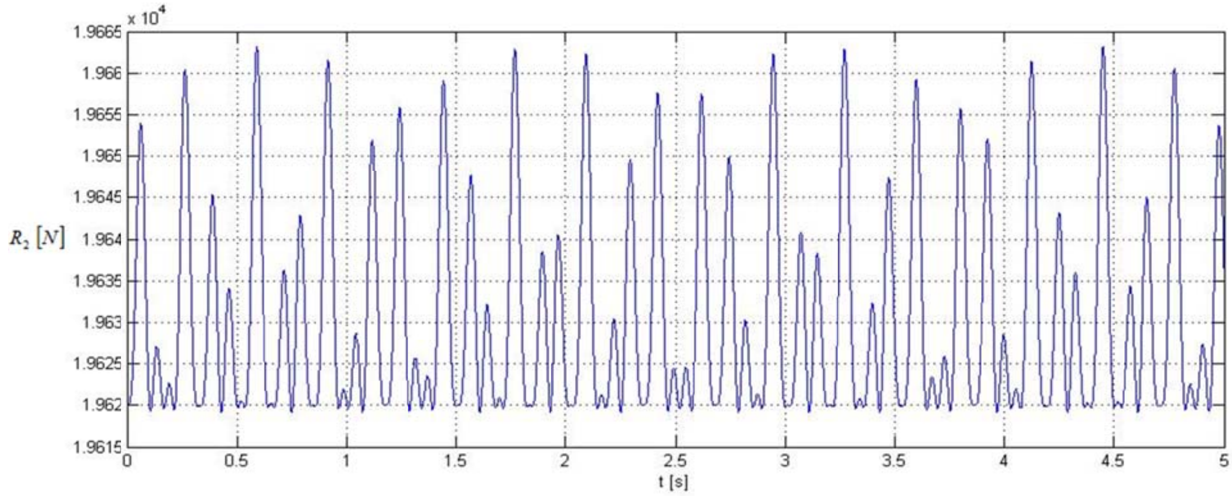

Fig. 5. Variation of the dynamic bearing reaction force in the upgraded swinging screening system

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