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OSCILLATING MOTION OF A DOUBLE-FREQUENCY SCREEN

1. Introduction

It is widely known that the shape of trajectory in the oscillating motion of the screen has a relevant meaning for obtaining of the best processing properties of the machine. Therefore, the trajectories of oscillating motion, which will lead to the intensive segregation of the grain layer moving on the sieve, have been searched for a long time. Seemingly, it is possible to obtain a double-frequency screen. Two rotational vibrators of the same or different static moments are applied for the drive of such a screen. As the name indicates, it is a screen which is characterised by two different rotational speeds of those drive vibrators. The construction of the screen enables to regulate (for research objectives) all the basic operation parameters of the machine, such as: the inclination of the sieve against the level, setting of the engines against the middle part of the sieve, exciting forces generated by the engines, the engine rotational speeds. The presentation of the kinematics of this screen in a wide range of variability of the aforementioned parameters constitutes the main objective of the present study. Furthermore, it should allow (in the further stage of the research) to find the optimal constructional solutions of the fully-dimensioned industrial machine.

2. The configuration variants of double-frequency screen drive

The experimental screen which is the focal point of the present study was constructed in a laboratory at the Process Equipment Department, Technical University of Lodz. The machine was mounted on the research stand, the scheme of which is demonstrated in Figure 1.

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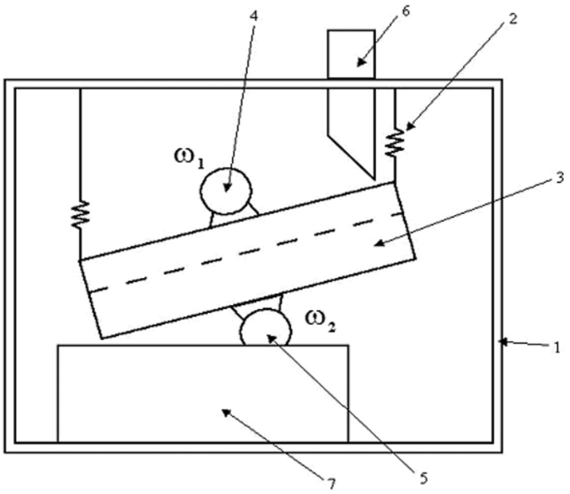

Fig. 1. The scheme of the research stand: 1 — supporting structure; 2 — spring and chain suspension of the screen; 3 — riddle with a sieve; 4, 5 — electrovibrators; 6 — charging hopper with a bolt; 7 — a container for the product under the sieve

The screen used in the experiment has a cubicoidal sieve elastically suspended which makes it possible to regulate the inclination angle in the range of 0 to 25 degrees. The concrete investigations were carried out for the following sieve inclination angles against the level: 0, 10, 15, 20°.

The construction of the screen allowed the change of vibrator setting (Fig. 2). The examinations were carried out for four different engine settings, i.e. when they are drawn aside against the central part of the sieve: an upper engine in the direction of the feeder, a bottom one in the direction of the end of the screen at the distance of 0, 110, 220, 380 mm.

The change of the separation of vibrators causes the change in the oscillating sieve trajectory angles β (Fig. 3). In the case of such settings of vibrators, as it is presented in Figure 2, the angles of trajectories of the sieve oscillations are equal to $\beta_1 = 0°$, $\beta_2 = 27{,}5°$, $\beta_3 = 42{,}2°$, $\beta_4 = 61°$.

The screen also displays the possibility of the exciting force regulation of the selected drive vibrators. It occurs through the change of location of unbalanced masses on the shaft of the given vibrator. The mass at each end of the vibrator shaft comprises two identical parts. To change the exciting force it is sufficient to separate one mass from another one by the appropriate angle. The investigations were carried out for three variants of settings which are as follows:

- maximal exciting force — 2 N
- ½ of maximal exciting force
- ¼ of maximal exciting force.

The principle of this regulation is schematically demonstrated in Figure 4.

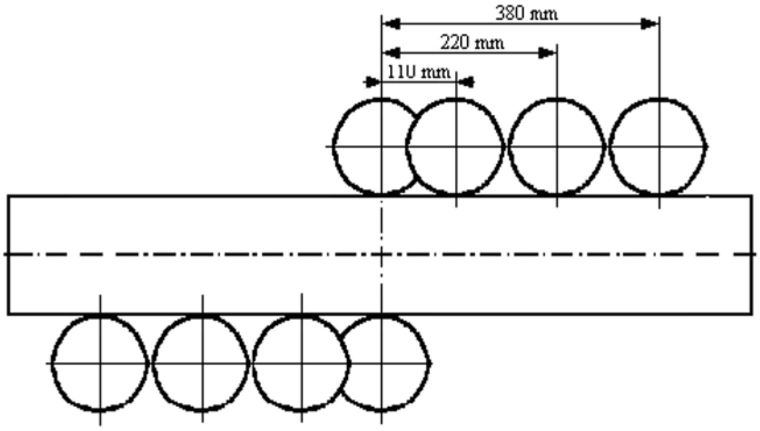

Fig. 2. Settings of vibrators

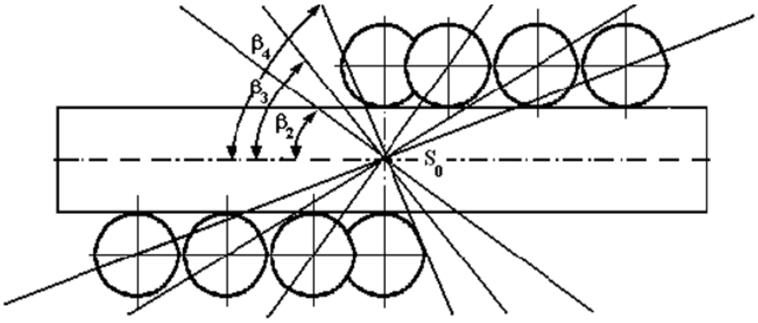

Fig. 3. The angles of trajectories of the sieve oscillations

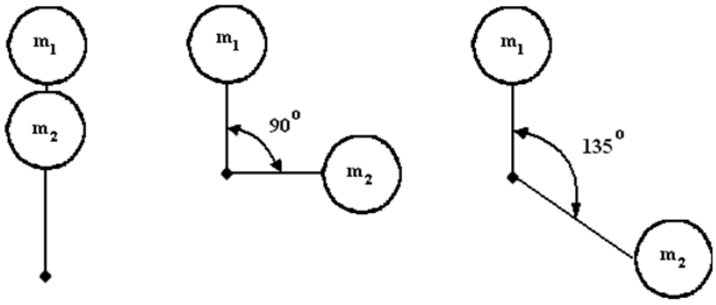

Fig. 4. Settings of unbalanced masses

It must be underlined that the exciting force was decreased in one of the two drive vibrators, i.e. in the one which rotated at the nominal rotation frequency (1500 rot/min) whereas the exciting force was always maximal (2 kN) in the second vibrator whose rotation frequency was lower than the nominal one.

The rotational speeds of vibrators ω assumed in the investigations attained the following values:

- $\omega_{max} = 1500$ rot/min.
- $^{2}/_{3}\ \omega_{max} = 1000$ rot/min.
- $½\ \omega_{max} = 750$ rot/min.
- $^{1}/_{3}\ \omega_{max} = 500$ rot/min.

The regulation of the engine rotational speed was carried out using the inverters. To summarize, 28 various combinations of speed and rotation directions were possible.

3. The kinematic investigations of a double-frequency screen

The measurements of the sieve oscillation amplitude were performed using the scheme which is presented in Figure 5. The scheme comprises the piezoelectric sensors, the integrating system and a laptop equipped with a measurement card in which the measurements were recorded.

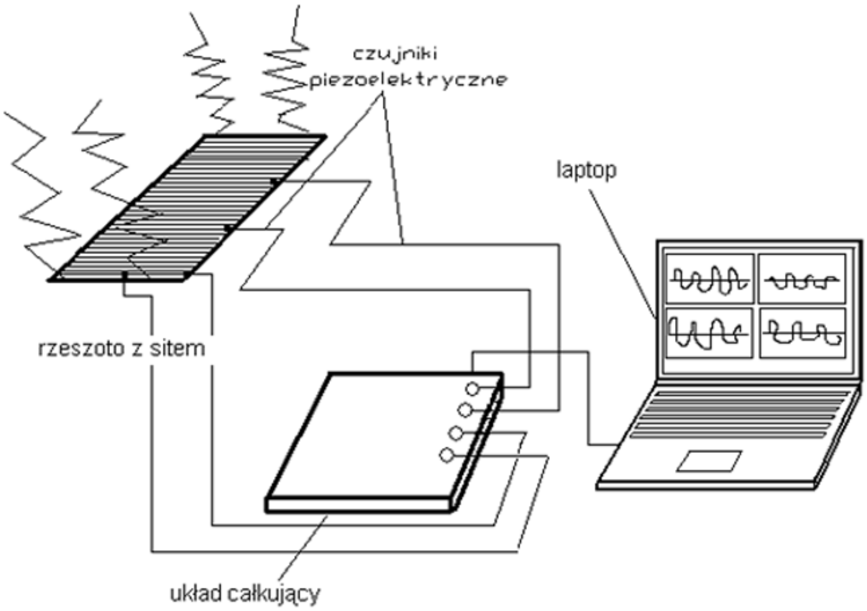

Fig. 5. The system for oscillation measurements

Due to four sensors mounted on the sieve the data concerning its inclination were recorded. The measurement sensors were mounted on the sieve in such a way that the lines of their measurement crossed in the area of the screen centre of gravity or at the initial and end points of the sieve in accordance with Figure 6.

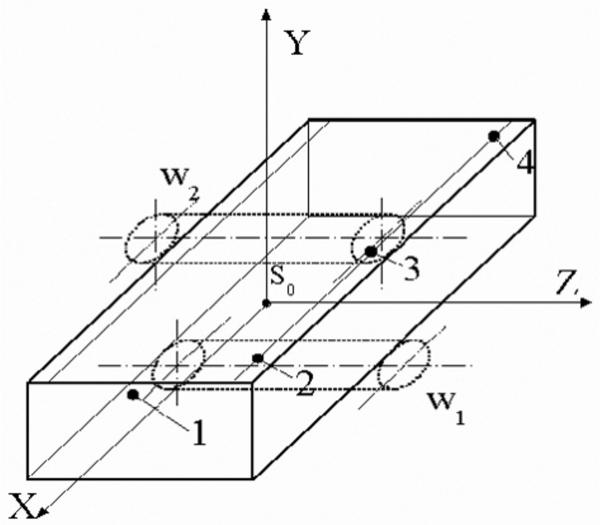

Fig. 6. The mounting points of the sensors

Under the acceleration the sensors generate the tension signal which is subsequently sent to the integrating system. Next, the tension signal generated by the sensors is doubly integrated and, as a result, one obtains the inclination value of the sieve. Those signals were gathered by the measurement card and recorded in the computer memory.

In Figures 7–10 the example trajectories of the motion at the beginning, centre and the end of the sieve for chosen drive configurations of the screen are presented. In Figure 7 one may observe a typical ellipsoidal motion of the sieve — characteristic of the drive configuration with the same rotational speeds of both vibrators. In next three figures it may be observed how the trajectory motion changes after diminishing the rotational speeds in one of the vibrators to the following values: 2/3, 1/2 and 1/3 in relation to the rotational speed of the other vibrator which remains constant.

In Figure 11 and 12 the chosen example distributions of the sieve inclination in the normal direction which occur at the beginning, centre and end of the sieve are presented. One may observe the symmetrical regular motion of the whole sieve at the drive with the analogous rotational speeds (Fig. 11) and the lack of such regulation with the change of the drive into a double-frequency drive (Fig. 12).

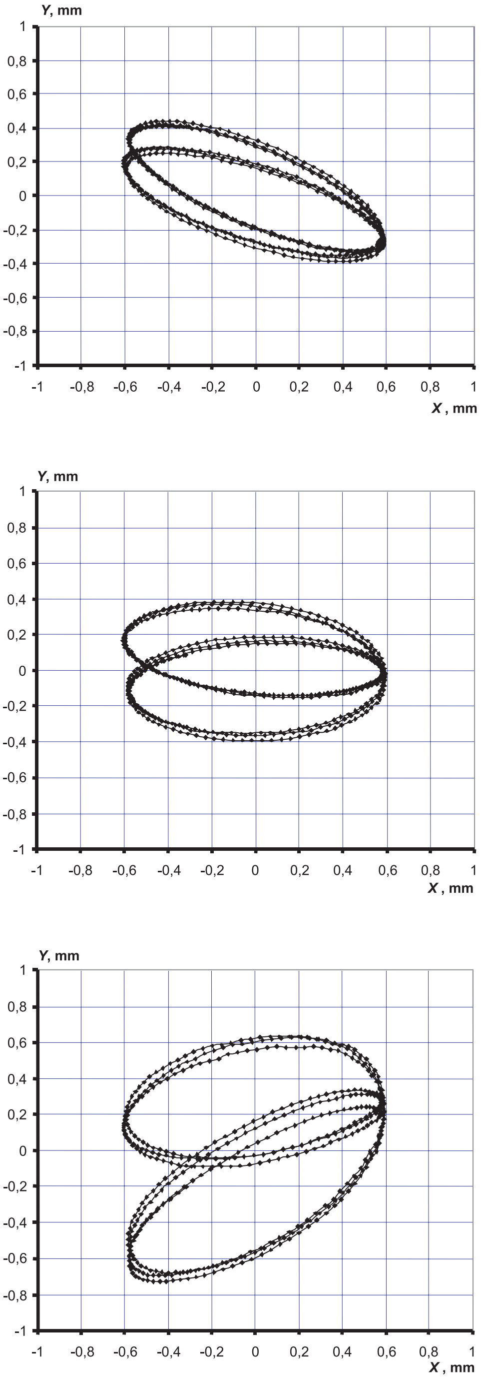

Fig. 7. The trajectory of motion for the following settings: $\beta = 0^{\circ}$, $-\ \omega_1/\omega_2$, $1/4F_{max}$

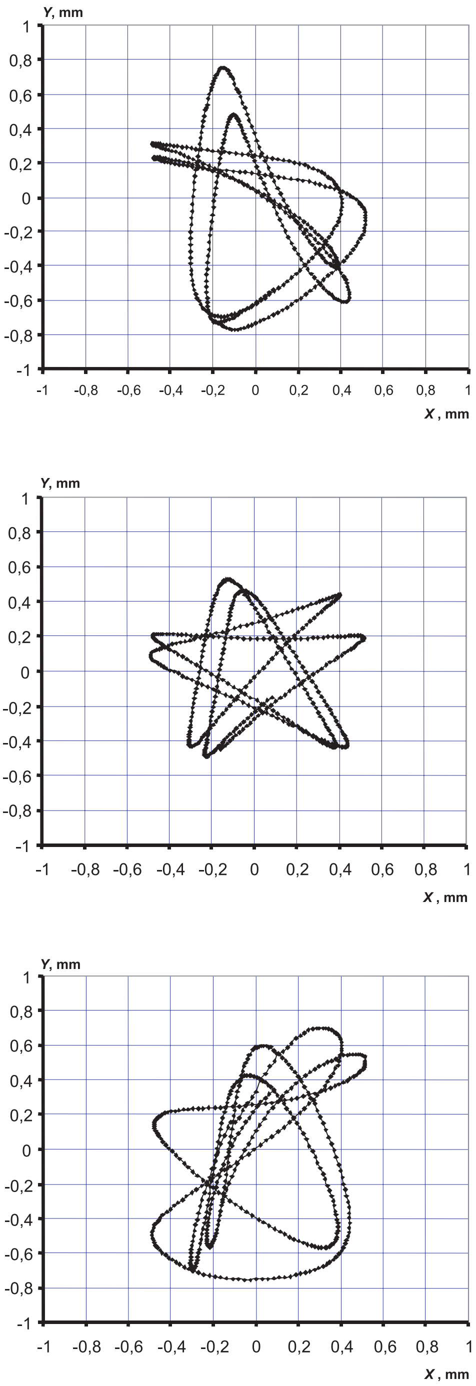

Fig. 8. The trajectory of motion for the following settings: $\beta = 0°$, $- \omega_1 / 2/3\omega_2$, $1/4F_{max}$

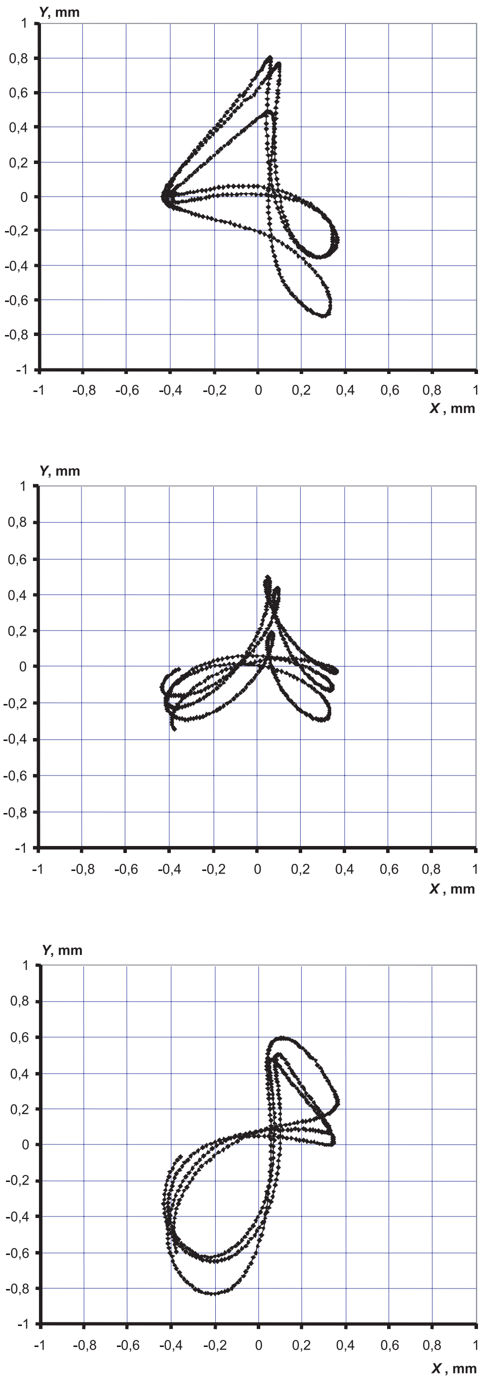

Fig. 9. The trajectory of motion for the following settings: $\beta = 0^\circ$, $-\ \omega_1/\ 1/2\omega_2$, $1/4F_{max}$

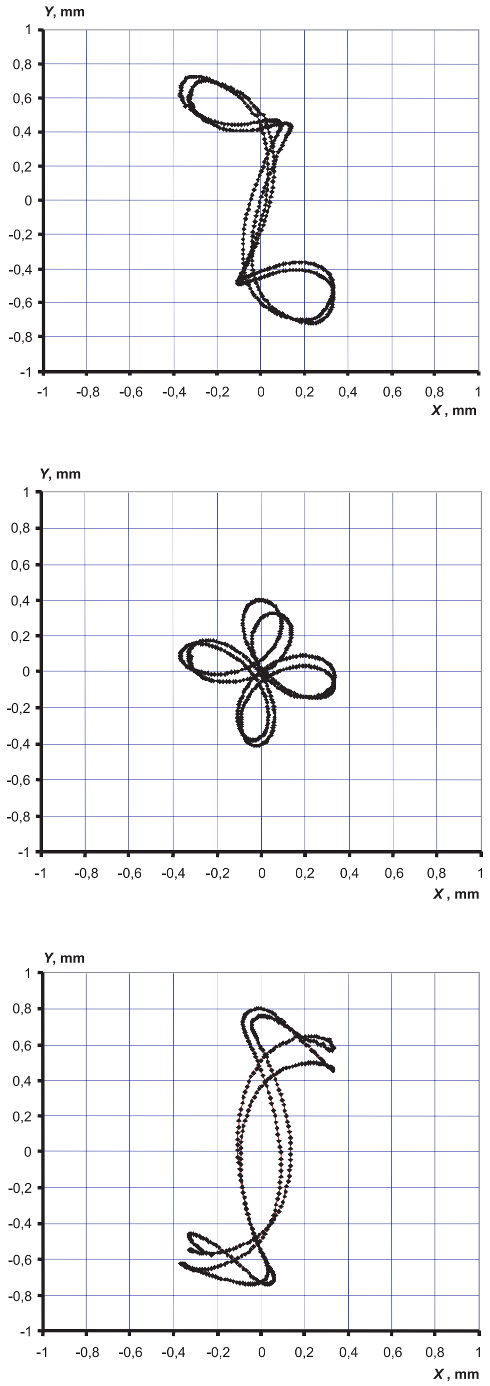

Fig. 10. The trajectory of motion for the following settings: $\beta = 0^\circ$, $-\omega_1 / 1/3\omega_2$, $1/4F_{max}$

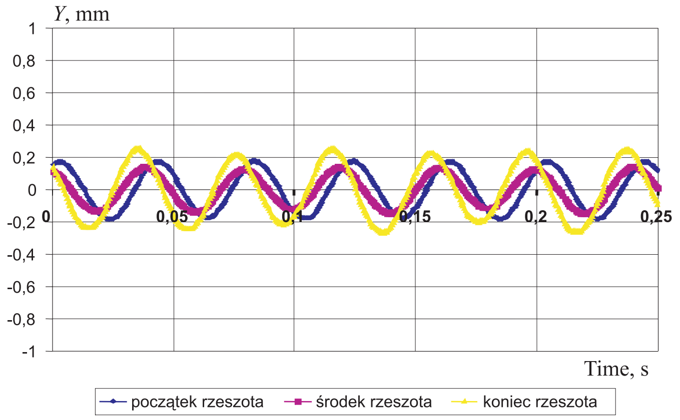

Fig. 11. The sieve inclination for the following settings: $\beta = 0^\circ$, $-\ \omega_1/\omega_2$, $1/2F_{max}$

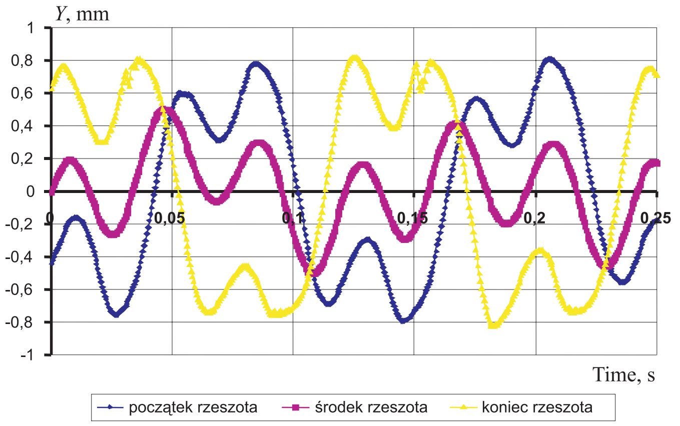

Fig. 12. The sieve inclination for the following settings: $\beta = 0^\circ$, $-\ 1/3\omega_1/\omega_2$, $1/2F_{max}$

4. Conclusions

Based on the investigations which have been carried out up to the present moment it may be stated as follows:

1) A slight change of some parameters of the drive contributes to the considerable alteration of shape of the sieve trajectory of motion.
2) One shall attach the importance to the value of the exciting force in respect of the shapes of motion of trajectories and to the rotational speed of the vibrating engines whereas to a lesser extent to the change of the angle of the sieve trajectory β. The change of the sieve inclination angle is of the least importance.

3) The countercurrent synchronization of vibrators is better from the kinematic point of view.
4) The location of vibrators against the mass centre does not influence considerably the screen kinematics.
5) The occurrence of twisting vibration is a potential drawback at a number of the drive configurations.
6) The most characteristic and complex motion trajectories occur for the following drive configurations: ω_1/ ½ω_2 and – ω_1/ 2/3ω_2.
7) Other configurations of the drive settings give a complex motion of the sieve in many cases which should be beneficial for the efficacy of the screening process.
8) The process examinations should be carried out with a view to verifying the assumption that such complex motion trajectories allow to obtain high efficiency of screening.

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