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ANALYSIS OF VIBRATIONS OF CONICAL SIEVES WITH OSCILLATING MOTION USING LABVIEW

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Research carried out aimed to establish the influence of kinematic parameters of a conical sieve on the parameters of its vibration.

Experimental determinations aimed to determine the vibration parameters of the suspended conical sieve under different working conditions, namely different frequencies of oscillation and different amplitudes of the sieve oscillation. The vibration spectra for the imposed working conditions and their interpretation were analysed.

Experimental research related to the vibration parameters of sieve was related to the identification of an optimal frequency and amplitude leading to a relatively uniform movement of the sieve imposed by the process of material separation on the surface of the sieve with oscillating movement.

Keywords: conical sieve, oscillations frequency, vibration spectra

1. Introduction

Vibrations are dynamic phenomena that arise in elastic or quasi-elastic environments, following the introduction of an excitation, through a certain process, at one or more points of a mechanical structure or system. Every mechanical structure has a balance position, the movement of the structure around this position is defined as vibrational motion, [1,2,3].

One of the major problems, raised by the analysis of vibrational phenomena, it is the measurement of both the vibration level and the dominant frequencies. Measurement of quantities related to vibrational phenomena, in the case of mechanical structures, is based on the use of specialized devices that highlight vectorial kinematic sizes (displacements, velocities and accelerations) or the excitation quantities (forces and / or moments), [4].

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In any measurement activity, at the beginning of it, two actions are particularly important: the parameter to be measured and implicitly, choice of transducer and determining places (positions) in which the transducers are located.

Regardless of the type of measured parameter and the place where the transducer is located, signal recording can be related to two basic domains: time domain and frequency domain.

From the point of view of the way of fixing the vibration transducers, these can be fitted as they exist, or direct contact with the analysed structure, either there is a gap between the structure and the transducer.

The mounting can be done by means of a mounting pin, by magnet (where the material of the structure allows it), or through intermediate clips that are glued to the structure, [5,6].

In the processes of processing and conditioning of cereal seeds and other agricultural crops are used, in general, the vibrating movement of the work surfaces of the cleaning and separating machines.

For cleaning, separating and sorting seeds, the main work surfaces are the sieves (perforated sheets or braids made of wire and / or plastic wires). They can have different forms depending on the type of agricultural crop, of the seed form and the content of impurities, [7].

In order to determine the influence of the frequency of oscillations on the vibrational motion of a conical sieve experimental determinations were performed under laboratory conditions on a stand with conical sieve, for both no-load working and with load working.

The vibrational movement was obtained by means of an eccentric mechanism located horizontally, acting on the tangential direction of the sieve at adjustable distances. The sieve was used for sorting rapeseed seeds with the dimensions between ϕ1.6 mm and ϕ2.5 mm, in percentage of 90%.

Experimental research was carried out, mainly, for testing the effectiveness of such a sieve, the results being encouraging.

2. Material and method

For the study of vibrational phenomena in machinery in the field of agricultural products processing was considered the conception, design and creation of an experimental stand having an outer conical separation surface with vertical axis, suspended in three equidistant points, at a distance equal to the vertical axis of the cone, with the help of three non-expandable metal cables, fastened to both the top and bottom.

The scheme of the experimental installation is presented in fig.1.

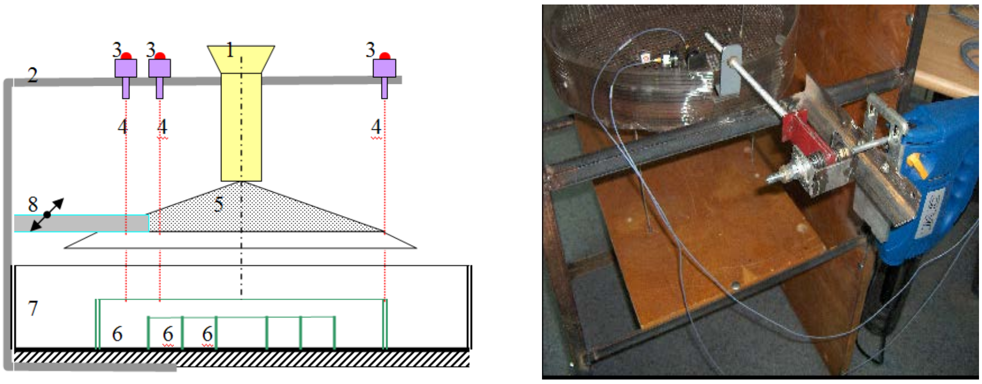


Fig.1. Scheme of experimental stand with conical sieve suspended [8]
1.material feed funnel; 2. fixed frame; 3. thread tensioning screws (drilled) ; 4. three-wire fastening system at the top and three elastic straps at the bottom; the wires and strings are arranged horizontally at 120 degree angles, one against the other; 5. conical sieve (hatched), made of sheet metal, on which holes with a diameter of 4.2 mm are drilled, the tip angle is 2α, with $\alpha=76°=1.33$ rad; 6. cylindrical tank for collecting separate material; 7. box with concentric circular cells for separate material collection; 8. drive coupling via a pendular electric motor.

The conical separation surface is made of perforated sheet with circular holes having the diameter ϕ 4.2 mm and the diameter at base of the cone ϕ 430 mm.

The inclination of the cone generatrix the horizontal surface is approx. 8^o and the diameter of the steel cables is ϕ1.5 mm. The actuating mechanism of the sieve has been designed so as to ensure, mainly, an alternative circular motion with a certain amplitude, measured at the edge of the conical sieve, on one side and the other of the neutral oscillation position in which a link arm is fixed of length d = 480 mm, at the actuating mechanism (of type pendular saw).

As shown in fig.1, the actuating mechanism is composed of an electric motor of alternating current with the power of 710 W and a actuating system of worm and wheel type with oscillating slide, with the actuator button positioned eccentrically on the gear wheel of the transmission mechanism.

The travel of the oscillating slide of the actuating system is 16 mm, the arm of the slide being articulated by a spherical joint at the arm reinforced with the sieve disposed in a radial direction at the basic circle of the cone.

Experimental stand is provided with the possibility of adjusting the parameters of oscillating motion namely the oscillation frequency, f, and the oscillation amplitude, A_i. Frequency of oscillation can be changed from the electric motor by changing the parameters of the electric current, and the amplitude of the oscillation can be changed by changing the disposition position of the actuating mechanism in relation to the radial arm of the sieve, hinged together by the spherical joint 6, (fig.1).

So, for experimental vibration and process research, have been used oscillation frequencies of 4.1 Hz , 8.6 Hz, 13.1 Hz and amplitudes (3.58; 3.74; 3.91; 4.10 mm), by changing the actuating arm at distances 480, 460, 440 and 420 mm from the base of the cone.

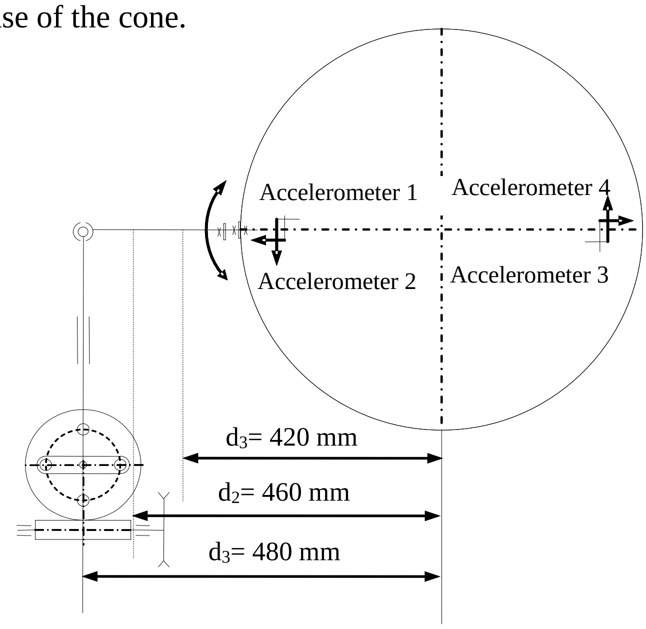


Fig.2. Accelerometer positioning scheme, [9]

The measurements were made for both the no-load working, as well as for load working in two directions, both radially (accelerometers 4 and 2), as well as on the tangential direction (accelerometers 1 and 3), as can be seen from the accelerometer positioning presented in fig.2.

The four accelerometers were connected to the data acquisition board via a computer provided with printer for tracing graphics of purchased signals.

Before each sample, the kinematic parameters of the oscillating sieve were modified accordingly, namely the oscillation frequency, respectively the amplitude of oscillation.

Rapeseed seeds were used for load working, the determinations being made approximately in the same flow conditions. It was tried to keep it constant in all experimental determinations, respectively around 0.01 kg/s.

The acquisition time was a few seconds (8-12 seconds), from the acquired signals, taking only those corresponding to a relatively uniform movement of the work sieve.

The acquisition of the signal was done through the LabVIEW program, before the data acquisition, a program structure was created with which it was made, both the acquisition and the processing of the signals.

3. Results and discussions

The experimental data processing was done with the LabVIEW program, [10]. The acquired signals were processed and transformed into acceleration units (m/s^2), which were then integrated in order to obtain the speed values of the points on the sieve where the transducers were placed, [10].

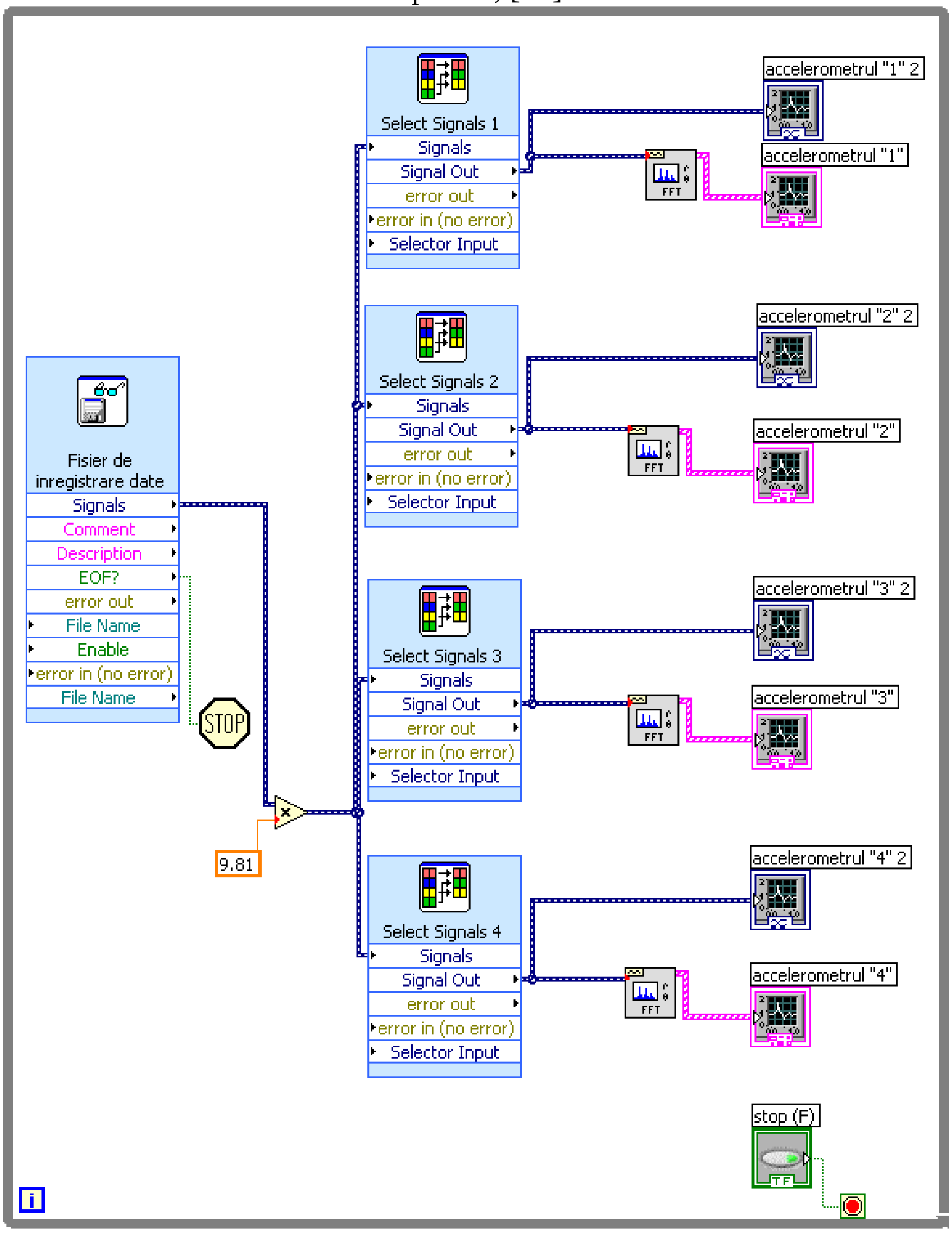


Fig.3 The program written under LabVIEW for signal processing

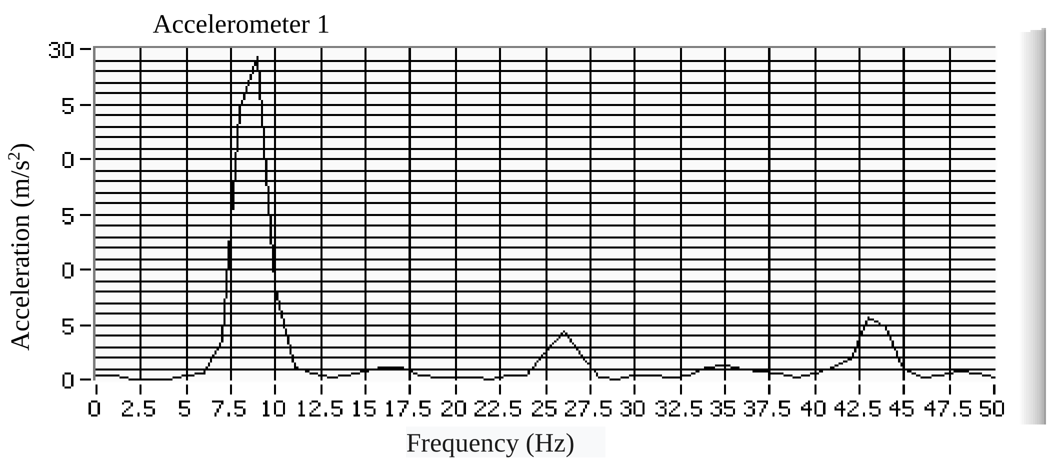
Below is the program written under LabVIEW for signal processing and graphical representation of the speeds resulting from the integration of the measured accelerations and the amplitude spectra of these speeds.

The measured data is generally affected by the different types of errors, [8, 11] due to causes, like:

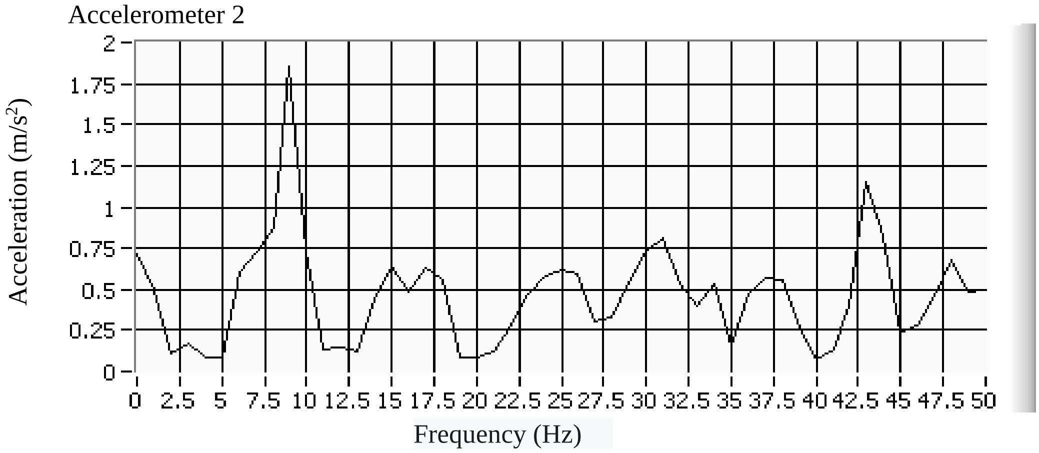
- calibration of the devices (sensors, acquisition board, etc.);
- numerical processing methods (numeric integral, truncation of numbers with decimals, etc.).

In the analysis of the influence of the oscillation frequency on the vibrational motion of the sieve acquired signals were used, for sieve acceleration, for three values of the actuating arm length and three positions of the actuating mechanism button for loading work of sifting separation machine.

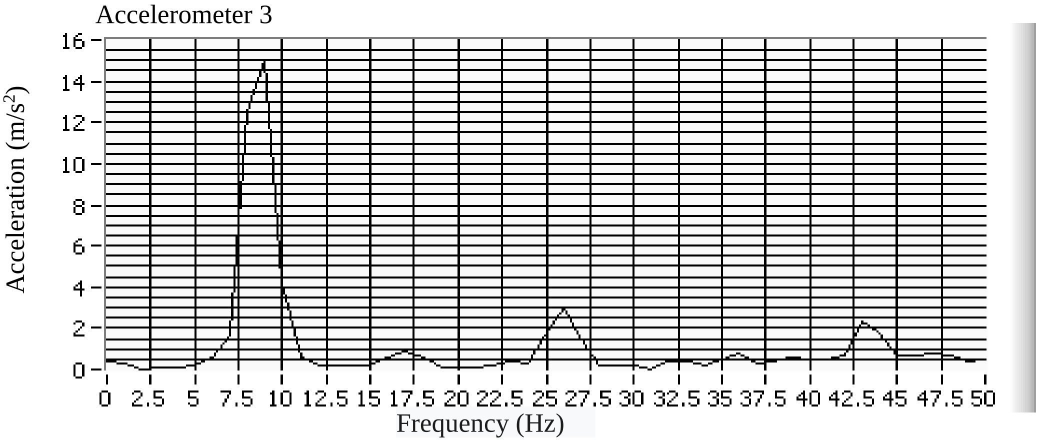
From the analysis of the graphs presented in fig.4, regardless of the length of the sieve arm, it is found that the general and mediated sinusoidal oscillation is much diminished with the increase of the oscillation frequency at all four accelerometers. For the tangential direction (accelerometers 1 and 3), sinusoidal oscillation is very visible at low oscillation frequencies (f_1 = 4.1Hz), value of the sieve amplitude acceleration increasing proportionally with the frequency of oscillation at the same length of the arm.



Accelerometer 2

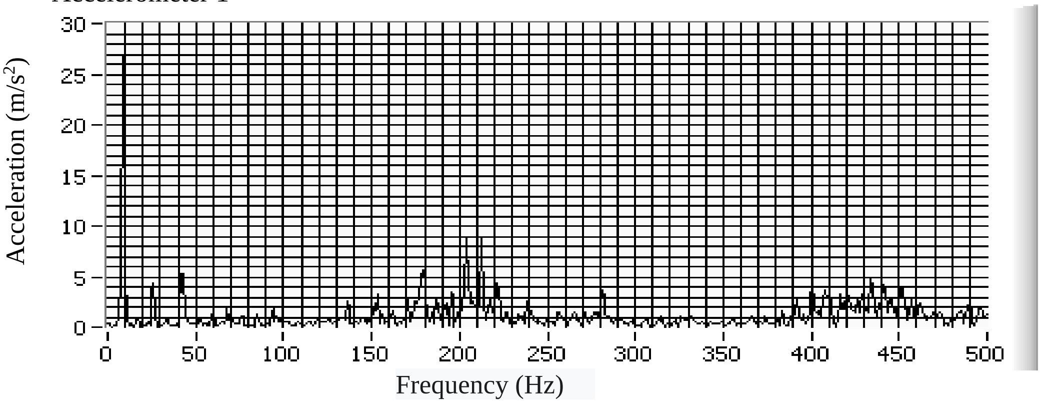


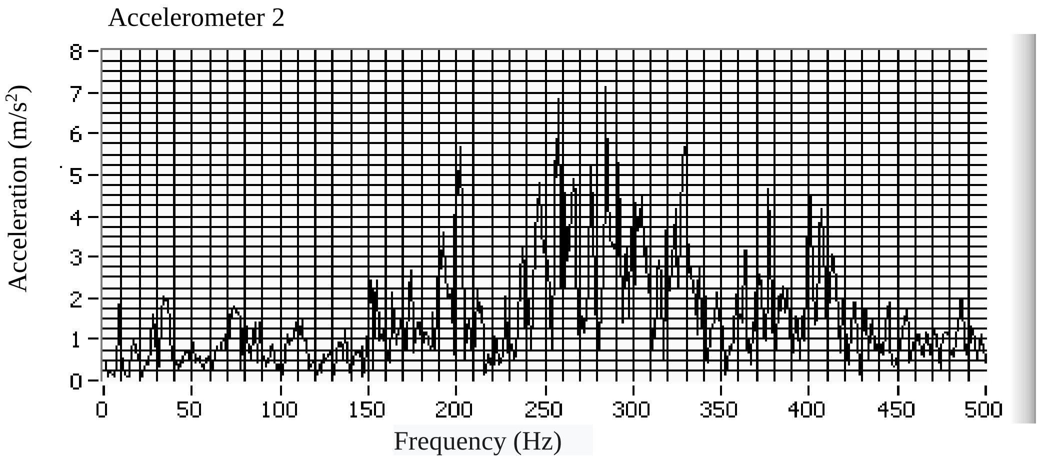
Accelerometer 3

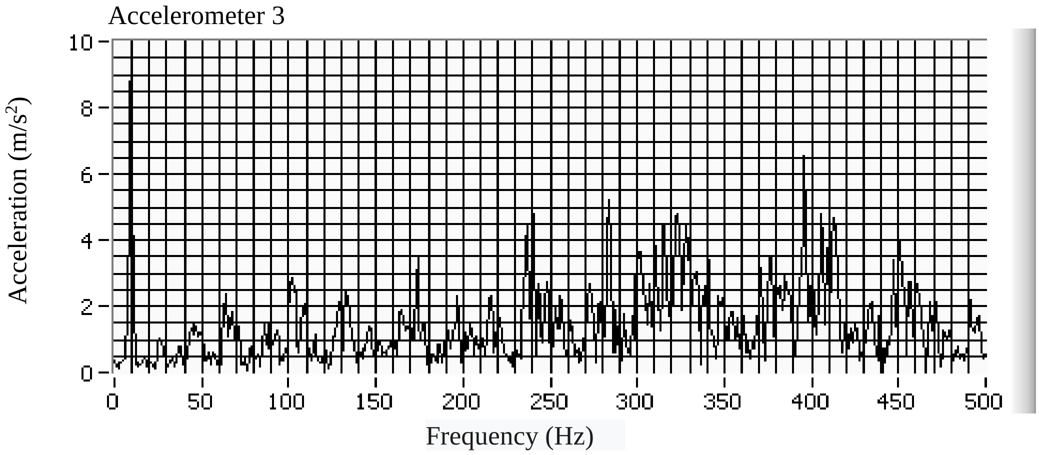


Spectra of oscillation speed of the sieve at f_2= 8,6 Hz and A_3= 4.10 mm

Accelerometer 1







Spectra of oscillation speed of the sieve at f_2= 8,6 Hz and A_1= 3.58 mm

Fig. 4. Measurements made in load working at frequency f_2= 8,6 Hz for three different amplitudes of the sieve oscillations

So, for the length of sieve arm of 480 mm (smallest angular displacement of the arm), value of the sieve acceleration amplitude increases from approx. 6 m/s^2 for the oscillation frequency f_1 = 4.1 Hz, at about 75 m/s^2 for the oscillation frequency f_2 = 8.6 Hz and around 85-90 m/s^2 for frequency f_3 = 13.1 Hz, the oscillation period increasing with the frequency at the accelerometer 1, located near the actuator.

For accelerometer 3, which also records values in the tangential direction, but which are diametrically opposite to the accelerometer 1, at a much greater distance from the point of action, the oscillation acceleration amplitude is much smaller, but it has the same increasing tendency as the oscillation frequency increases, from 3-3.5 m/s^2 for f_1 = 4.1 Hz, at 10-15 m/s^2 for oscillation frequency f_2 = 8.6 Hz, and at 50-60 m/s^2 for oscillation frequency f_3 = 13.1 Hz.

For accelerometers arranged in radial direction there is, also, the increasing tendency of sieve oscillation acceleration amplitude, from values of approx 2 m/s^2 for f_1 = 4.1 Hz, la 35 m/s^2 for oscillation frequency f_2 = 8.6 Hz and at 70-75 m/s^2 for oscillation frequency f_3 = 13.1 Hz. However, it is noticeable, an increase in disruptive vibrations, both in amplitude and pulse, at all four accelerometers, as the frequency of oscillation increases.

For arm length d_2 = 460 mm, the trend noted above remains, but the values of the sieve amplitude acceleration are slightly higher, because the angle of the sieve's arm increases from the previous position.

For accelerometer 1, the amplitude of the sieve acceleration, is around 8-9 m/s^2, instead it grows to approx. 70-75 m/s^2 for f_2 = 8.6 Hz and at 80-90 m/s^2 for oscillation frequency f_3 = 13.1 Hz.

At accelerometer 3, the acceleration amplitude values are lower, with sinusoidal aspect visible for the oscillation frequency f_1 = 4.1 Hz, growing around 5-6 m/s^2 for oscillation frequency f_1 = 4.1 Hz, at 30-40 m/s^2 for oscillation frequency f_2 = 8.6 Hz and at 60-70 m/s^2 for oscillation frequency f_3 = 13.1 Hz.

At accelerometers 2 and 4, sieve acceleration amplitude, grows to about 4m/s^2 for f_1 = 4.1 Hz, at 30-40 m/s^2 for f_2 = 8.6 Hz and 70- 80 m/s^2 for f_3=13.1Hz, but the disturbing vibrations are very visible especially when the oscillation frequency increases.

The increase of the general oscillation pulse is observed, as the frequency of oscillation increases, as well as the visible presence of the disruptive vibrations given by the metal cable suspension system and the perforated sheet separation surface, on all four accelerometers, but especially on accelerometers 2 and 4.

Oscillation acceleration amplitude values taken from the graphs presented in fig.4, shows the same increasing tendency as for the other two arm lengths analysed.

Thus, if at the oscillation frequency f_1 = 4.1 Hz, sieve oscillation acceleration amplitude is of 10-12 m/s^2, it grows to 50-60 m/s^2 at the frequency f_2=8.6 Hz and at 80-90 m/s^2 for f_3 =13.1 Hz, at which the sinusoidal variation is no longer as visible as at the other two frequencies.

The same thing we notice in the accelerometer 3 also placed in a tangential direction, but at a greater distance from the point of action, values of the sieve oscillation acceleration amplitude being slightly lower.

At all oscillation frequencies, accelerometers 2 and 4 recorded variations of the acceleration of the sieve with a noticeable sinusoidal aspect, but with large and pronounced variations of disturbing vibrations.

We believe that a review of the suspension mechanism of the sieve is necessary, this is also evident from the mathematical modelling of the movement of the sieve [4] which shows a complex, random motion on the separation surface.

We also consider that the central axis of the sieve may be subject to an alternative translation movement, in the direction of the drive arm, also noticed in the theoretical analysis of the drive mechanism, achieving such an actuation mechanism, which allows the centre of the conical sieve to move only in a straight line (along the average position of the arm of the sieve).

In this way, the sine wave oscillation movement would be much more visible, especially at accelerometers 1 and 3 that record vibration signals in a tangential direction at the sieve, but this may be noticeable and may also occur for accelerometers 2 and 4 that record signal in the radial direction (actually in a direction parallel to the arm of the sieve).

4. Conclusions

Determination of vibration signals and spectra at the separation machine, designed, allowed the identification of the oscillation frequency showing the least influence of the disturbing factors of the oscillating system.

This is the frequency of 4.1 Hz, at which the acceleration signals (vibration) presents the most obvious sine wave harmonic oscillation, especially for accelerometers that record vibration signals in a direction perpendicular to the arm of the sieve, the one that is stiffened with the sieve and connects to the rod of the drive mechanism.

Noticeable harmonic variations of the sieve acceleration are recorded at the frequency of 8.6 Hz, especially for small angular displacements of the arm of the sieve (that is, for given amplitudes of the large arm length: d_1 = 480 mm and d_2 = 460 mm).

- the accelerometer 1 and 2 are located at a greater distance from the axis of vertical symmetry of the acceleration device;
- from the spectral analysis it can be concluded that the sieve does not have a pure rotation motion but a complex general movement, which can be reduced to a parallel plane motion, because, the displacements in the vertical direction are very small, considering its grips;
- due to the asymmetrical drive (the sieve is actuated in the application area of accelerometers 1 and 2), it can be seen from the spectrum of accelerations that the amplitude is greater in this area than in the area of accelerometers 3 and 4;
- the tests were performed, as seen from the frequency spectra in the range 4.1–13.1 Hz which is the dominant frequency of the spectrum when measuring the tangential acceleration (accelerometer 1 and 3);
- accelerations in the radial direction (accelerometer 2 and 4), stand out, both the main operating frequency, as well as other parasitic frequencies,

which are probably the proper frequencies of the conical sieve that are highlighted, especially in the radial direction;

- from the spectrum of accelerations it can be emphasized that the radial accelerations are very small (from 3-5 times smaller than the tangential accelerations), which leads to the conclusion that the parallel plane motion of the sieve is very close to a rotation (the instantaneous centre of accelerations is located in an area close to a fictitious rotation centre that would be on the axis of symmetry of the sieve);
- on the accelerometer 2 (located in the area of the actuation point), radial accelerations are insignificant, the appearance of a tip on the accelerometer 2 may be due to the auxiliary elements for catching the accelerometers;
- from the observations made after the experimental tests, a better sifting is found in the area opposite to the drive where, it can be seen from the acceleration spectra that, the accelerations are much lower in amplitude compared to the ones in the drive area. This leads to high speeds of the sieve that exceed the technological speed limit of sifting.
- to avoid areas with inefficient sifting, it should, somehow introduced restrictions on sieve binding or symmetrical drive. There is also, the possibility to operate with a vibration generator with unbalanced masses that is placed on the axis of symmetry of the sieve.

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