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Substantiation of amplitude-frequency characteristics and design parameters of the vibration exciter of the separator of volume vibrations

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Abstract. Evaluation of the influence of amplitude-frequency and power parameters of external technological action on bulk products in the process of separation of the impact, the way of low-frequency oscillations of the working bodies of the separator and the angle of inclination of the container during processing determines the main indicators of technical and economic efficiency of the explored process, which is the relevance of the research. The purpose of the study is to substantiate the operating parameters of the explored separator of volume vibrations by determining the patterns of change in the kinematic and power characteristics of the vibration drive. To determine the rational parameters of the vibration screening process, the equations of motion of the working bodies in the form of a conical sieve surface were obtained using the method of Lagrange equations of the 2nd kind. Using the solution of the Cauchy problem for linear inhomogeneous differential equations, the solution of the latter was obtained. Using the Math CAD mathematical environment, the dependences of the amplitude of oscillations, vibration velocity and vibration acceleration, and the intensity of oscillatory motion were obtained, which allowed performing a mathematical analysis of the power and energy characteristics of the vibration drive of the explored separator. The main effects of the developed design of the vibrating separator are an increase in the driving force of the process of separation of bulk solids in this work, which was achieved by providing the working cylindrically-conical

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container with vibratory motion; improvement of the conditions for the passage of product particles through the perforations, which was achieved by providing the sieve surface with volumetric vibrations; reduction of energy consumption and improvement of the operating conditions of the supporting units during the operation of the designed vibrating screen, which was achieved by installing additional elastic elements between the separator body The inclined arrangement of the conical sieve surface allows for spatial gyratory or circular translational motion, which allows implementing of the advantages of bulk separation of bulk solids. The results of the analytical study allowed substantiation of the optimal angle of inclination of the working sieve surface. Based on the analysis, the design parameters of the vibration exciter were substantiated and specified and the design of this technical system was presented. The practical value of the conducted research can be attributed to using the designed kinematic combined vibration exciter of volumetric oscillations in the separator, which allows reducing the weight of the oscillating parts of the drive and, accordingly, the energy consumption for the separation process

Keywords: vibration separation, conical sieve surface, vibrating screen, volumetric oscillations, amplitude-frequency characteristics, energy consumption for the drive, vibration velocity, vibration acceleration, mechanical combined vibration drive, feed mixture, low-frequency oscillations

Introduction

Using low-frequency oscillations to intensify the separation processes in the processing agricultural and food industries becomes effective during the processing of solid bulk heterogeneous systems at minimum humidity, which eliminates the influence of adhesive and sorption factors. Such conditions determine the effective implementation of the processes of vibration separation of grain mixtures and seed material.

The main distinguishing feature of mechanical vibrations as one of the types of mechanical impacts is the ability to transfer the energy of high specific power to the processed products. Therewith, the possibility of adjusting the parameters of vibration in a wide range allows extending its effect to both significant volumes of products and its local layers (Palamarchuk *et al.*, 2020a; Wei *et al.*, 2020); the possibility of combining the process of material transportation with its technological processing, and for products that vary significantly in their physical and mechanical properties; simplicity of machine design; no restrictions on the granulometric composition of the material; possibilities of complex mechanisation and automation of several production processes; intensification of technological processes by establishing a vibrating fluidised layer during technological processing (Palamarchuk *et al.*, 2020a). These processes are accompanied by a rapid increase in the surface of the interaction of components or phases, an increase in the rate of convective diffusion, and a decrease in viscosity, which determines the effects of their intensification and ensuring the completeness of the flow. Thus, vibration can be considered as a universal form of mechanical impact on processed materials and is widely used in the implementation of separation of bulk technological masses, which is one of the most common processes of food production, in particular, primary processing of agricultural raw materials and products.

The course of change of these processes, in turn, is determined by both the features of the physical and mechanical structure of the material, and the laws of low-frequency technological action, namely the amplitude-frequency and force impact, the way of oscillations of the working body, the angle of its inclination to the horizon. The influence of these factors on oscillatory systems is understudied, and the design of the corresponding experiments does not reach sufficient accuracy, which substantiates the *relevance* of this scientific work and has broad prospects for development.

A large galaxy of scientists and engineers provided the development of areas of application of vibration impact in the processes of separation of solid bulk heterogeneous systems.

In particular, I.I. Blekhman solved the problem of the motion of a material point and particles with a flat and rounded shape on a rough surface that performs periodic oscillations, and determined the optimal law of oscillations, substantiating the effective coefficient of friction during vibration transportation. Goncharevich I.F. (Palamarchuk, Tsurkan, & Kostenko, 2016) developed the classification, theory, methods of calculation and basics of design of vibrating transport and technological machines, established the basics of theory and methods for determining the optimal modes of vibration transportation of bulk solids, considering the dynamic loads of the machine. V.S Bykov. (Palamarchuk, Tsurkan, & Kostenko, 2016) established the dependences between the structural and kinematic parameters of the separation process on flat oscillating sieves, substantiating the effective modes of implementation of the working processes of modern grain cleaning machines. Based on studies of the vibration movement of finely dispersed bulk products by V.V. Gortynsky (Bal-Prylypko, Palamarchuk, & Nikolaenko, 2019), the theoretical foundations of the layer-by-layer movement of masses on a vibrating surface were developed, the movement of bulk bodies in a vessel with circular and translational oscillations was explored, and recommendations for the process of vibratory separation of bulk mixtures were substantiated. The research on the mechanics of bulk material movement on the working body of vibrating machines allowed B.I. Kryukov to determine the resistance caused by aerodynamic forces, the nature of the movement of individual particles, and the forces of their mutual friction and collisions; to approximate the influence of these factors by linear functions of the absolute and relative velocities of the product layer. P.M. Vasylenko (Palamarchuk *et al.*, 2020b) determined the value of the critical speed of sieving particles through the holes of the sieve, at an angle of inclination of the latter not exceeding 10° in particle decent area, considering air resistance. The most complete theoretical studies of the operation of a flat sieve that performs longitudinal oscillatory movements were performed in the fundamental works of I.E. Kozhukhovskyi and P.M. Zaika (Palamarchuk *et al.*, 2020a), in which the dependences of the quality of separation of a flat sieve on such parameters as the angle of inclination of the sieve to the horizon, the oscillation angle, the shape and location of the holes, the sieve dimensions, their specific loading, moisture content and contamination of the grain material were obtained. P.M. Zaika (Palamarchuk *et al.*, 2020a; Palamarchuk *et al.*, 2022) for the first time recorded a system of differential equations of spatial motion of the working body of a vibrating machine with several mechanical vibrators, the axes of which are arbitrarily oriented in space; which allowed solving the problem of moving agricultural materials as discrete solids on the working surfaces of separators; to cover the mechanism of self-sorting processes, rumbling, to solve the problems of clogging and cleaning the holes of sieves. M.V. Bakum explored the possibility of sifting and post-cleaning grain material on serial grain cleaning machines and grain cleaning machines with high-frequency modes of movement of working bodies. A.V. Zilbernagel developed a method for calculating the limiting velocity of the relative movement of grain depending on the angle of the elongated sieve opening under the condition of particle passage through the opening. O.V. Chernyakov based on modelling the movement of grain material on the sieve established that biharmonic vibrations of the sieve are one of the effective ways to improve the technological process of grain separation. B.I. Kotov and S.P. Stepanenko confirmed that a promising area for further productivity increase, with a standardised quality of grain cleaning on vibrating sieve separators, is the intensification of loosening of the grain layer by braking elements-rippers, in particular when using gravitational-inertial, centrifugal, vibration-centrifugal executive bodies. L.M. Tishchenko (Rogovskii *et al.*, 2020; Cherntongchai *et al.*, 2019) has developed methods for calculating the intensification of vibrating centrifugal separation processes in terms of technical indicators of productivity and quality. The study of the process of vibro-pneumatic centrifugal separation of seed mixtures by V.V. Bredikhin allowed obtaining analytical dependences of the separation time and the speed of movement of the mixture layer on the main operating and design parameters of the process. O.M. Vasylkovsky received a model of the process of separation of the grain mixture on the inertial straight-through separator, which allowed establishing that the completeness of the separation of the grain mixture and the specific productivity of the separator simultaneously increase with the increase in the speed of movement of the material on the sieve, the maximum value of which is limited by the conditions of possible degradation of the grain in interaction with the rotor blades. O.B. Kozya established that the quality of the process of separation of seed materials on non-perforated friction oscillating surface significantly depends on the structural and kinematic parameters of the vibrating grain cleaning machine: amplitude, frequency and angle of oscillation, and angles of inclination of the working body to the horizon in the longitudinal and transverse ways (Bazaluk *et al.*, 2022; Barrero, Taiebat & Dafalias, 2020).

According to the results of the analysis, it can be concluded that the problem of exploring the influence of mechanical drive bodies of separators on the dynamics of their work and energy consumption has not been practically performed.

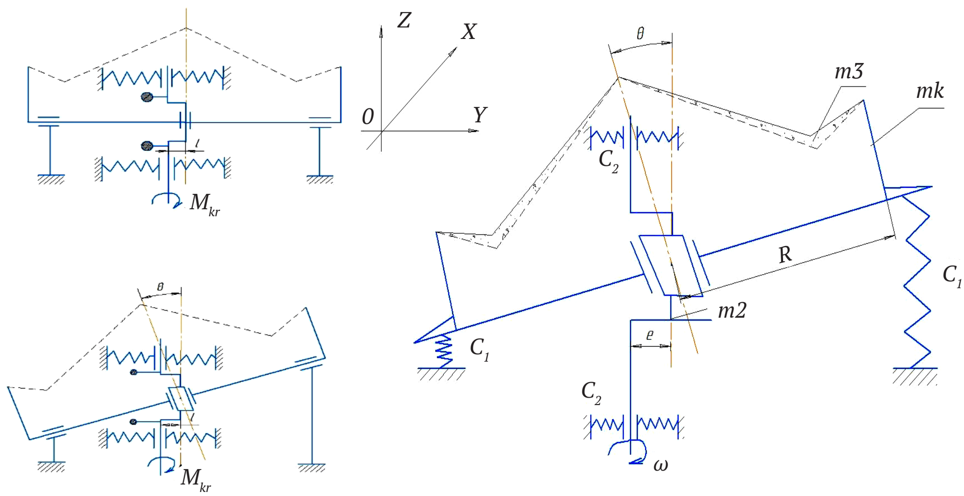
The purpose of the study is to determine the mode parameters of the drive of volumetric oscillations of the conical working body of the separator of coarse grain products through the theoretical analysis of the amplitude-frequency and energy characteristics of this process. To achieve this purpose, the following main *objectives* of the scientific work were defined: to analyse the current state of analytical studies of the processes of vibration separation of bulk solids, to determine the patterns of change in the main parameters of vibration and to substantiate the design scheme of the separator being explored.

Materials and Methods

To perform the above objectives, a prototype model of the vibrating screen was developed, and a set of special devices was manufactured that provide a measurement of amplitude-frequency and energy characteristics and automatic control of the drive shaft rotation speed of the vibrating exciter. During the analytical studies, the Lagrange method was used to compile the equations of motion of the actuators, and the Delambert method to determine the main power and energy characteristics of the oscillating system. Processing of the obtained dependencies was performed in the mathematical environment of MathCAD.

Results and Discussion

The explored process of separation of a bulk heterogeneous system as a driving force contains centrifugal alternating force and moment load on the technological environment, for the establishment of which the development of a vibration exciter of spatial oscillations was provided to set the sieve surface in motion. The developed mechanism rationally fits into the design of a vibrating screen with a conical sieve and can be used to generate both plane and spatial vibrations (Palamarchuk *et al.*, 2020c, Deng et al., 2019). This drive is characterised by kinematic vibration excitation and the presence of spring-bearing units. The vertical arrangement of the drive shaft of this vibrating exciter with the horizontal arrangement of the bearing surface of the conical screen (Fig. 1, a) allows for establishing a gyratory, i.e. gradual movement of the working bodies of the machine in the horizontal plane. To increase the speed of movement of the loading mass, it is advisable to perform the sieve surface inclined (Fig.1, a,b), for which a sleeve with an inclined outer surface was used. Fixing the support sleeve on the drive shaft of the vibrating exciter and the presence of a spring-loaded sieve platform results in the gyratory spatial movement of the working bodies of the vibrating screen (Fig. 1, a). The elastic elements of the support nodes partially eliminate parasitic vibrations that can be transmitted to the structure.



a) b)

Figure 1. Schematic diagram of the developed vibrating screen with the drive of volumetric vibrations at the straight and inclined arrangement of the working sieve surface: M_{kr} – torque on the drive shaft; ω – angular speed of rotation of the drive shaft; C_1 and C_2 – stiffnesses of elastic elements, respectively, of the conical working body and the drive shaft; θ – the angle of inclination of the sleeve for adjusting the inclination of the sieve surface

Using the Lagrangian method, the basic equations of motion of the working container were obtained (Palamarchuk *et al.*, 2019, Zhu *et al.*, 2019, Ashtiani, Salarikia and Golzarian, 2017) and their solution using Cauchy solutions:

$$x = e^{-0.5\alpha_x t}\left[\frac{F_m(\omega_2^2-k_x^2)}{(k_x^2-\omega_2^2)^2+\alpha_x^2\omega_2^2}\cos\rho_x t + \left(\frac{\vartheta_{x0}}{\rho_x} - \frac{0.5F_m\alpha_x\rho_x^{-1}(k_x^2+\omega_2^2)}{(k_x^2-\omega_2^2)^2+\alpha_x^2\omega_2^2}\right)\sin\rho_x t + \frac{F_m(\alpha_x\omega_2\sin\omega_2 t+(k_x^2-\omega_2^2)\cos\omega_2 t)}{(k_x^2-\omega_2^2)^2+\alpha_x^2\omega_2^2} \quad (1)$$

$$y = e^{-0.5\alpha_y t}\left(\frac{F_m\alpha_y\omega_2\cos\rho_y t}{(k_y^2-\omega_2^2)^2+\alpha_y^2\omega_2^2} + \left(\frac{\vartheta_{y0}}{\rho_y} + \frac{F_m\omega_2\rho_y^{-1}(0.5\alpha_y^2-k_y^2+\omega_2^2)}{(k_y^2-\omega_2^2)^2+\alpha_y\omega_2^2}\right)\sin\rho_y t\right) + \frac{F_m\left((k_y^2-\omega_2^2)\sin\omega_2 t-\alpha_y\omega_2\cos\omega_2 t\right)}{(k_y^2-\omega_2^2)^2+\alpha_y^2\omega_2^2} \quad (2)$$

where ω_2 is the angular velocity of the drive shaft of the vibration exciter; $k_x^2 = \frac{C_x}{m_0}$ and $k_y^2 = \frac{C_y}{m_0}$ – the natural frequencies of the system; $\alpha_x = 2\sqrt{k_x^2 - \omega_2^2}$ and $\alpha_y = 2\sqrt{1485 - \omega_2^2}$ – the dissipation coefficients of the system in the corresponding areas; $F_m = \frac{m_1}{m_0}e\omega_2^2$ – the specific modulus of the forcing force; $\rho_x = \sqrt{k_x^2 - 0.25\alpha_x^2}$ and $\rho_y = \sqrt{k_y^2 - 0.25\alpha_y^2}$ – the reduced frequencies of the system.

The following indicators were used as criteria for evaluating the developed vibration drive: the amplitude of oscillations of the working container for the nominal mode A; angular velocity of the drive shaft ω; power consumption for the drive of the oscillating system for the nominal mode N and its minimum value N_{min}; vibration velocity $\upsilon = A\cdot\omega$ and vibration acceleration, $a = A\cdot\omega^2$ of oscillatory motion; vibration intensity $I = a\cdot\upsilon = A^2\cdot\omega^3$.

Using the composite equations of motion of the executive bodies of the vibrating screen and their mathematical analysis, graphical dependences for the kinematic and energy parameters of the investigated vibrating drive of the separator for 50 positions of the support sleeve were obtained in the mathematical environment MathCAD, the average values of which are presented in Figures 2, 3, 4.

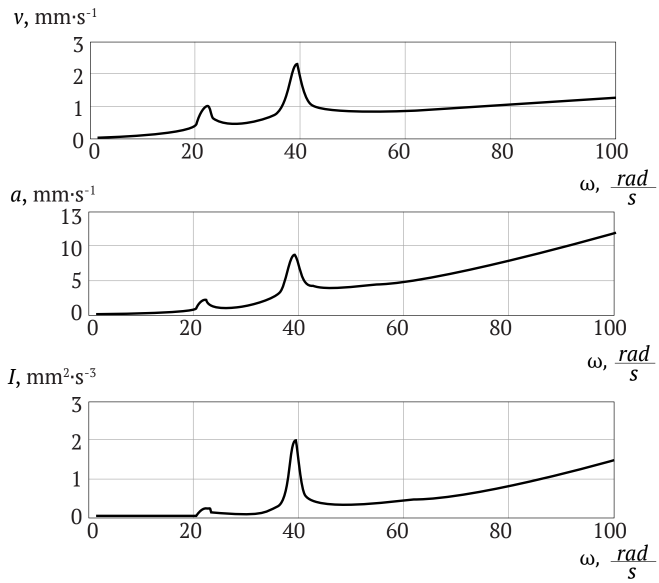


Figure 2. Dependences of the average values of the kinematic characteristics of the screen vibrating exciter on the angular velocity of the drive shaft: v – vibration velocity; a – vibration acceleration; $I = a\cdot v$ – vibration intensity

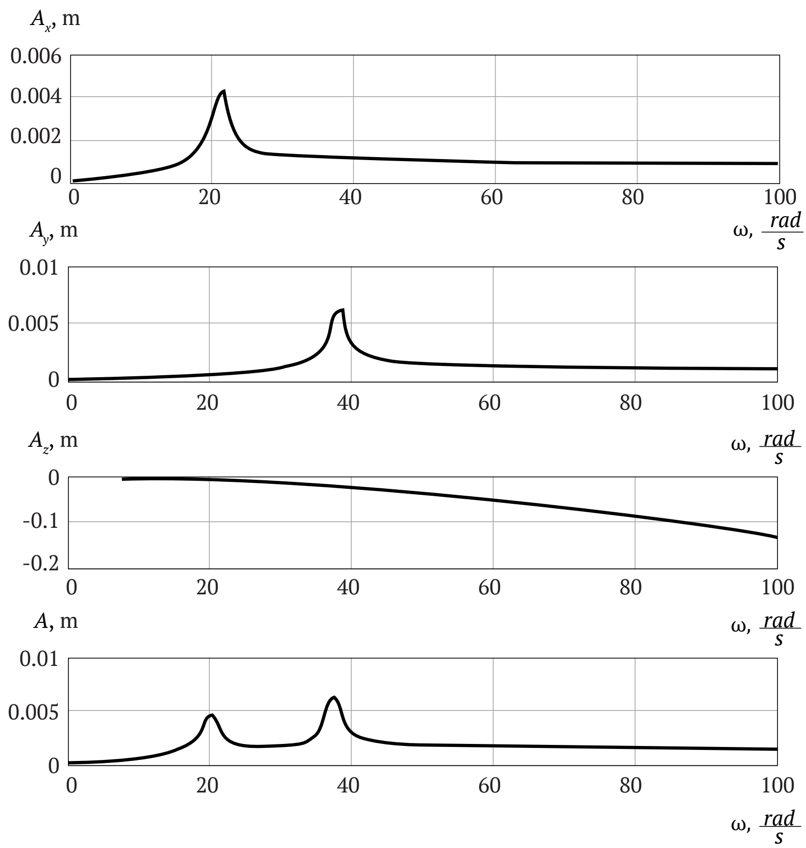


Figure 3. Dependence of the average values of the components of the vibration amplitude on the angular speed of the drive shaft

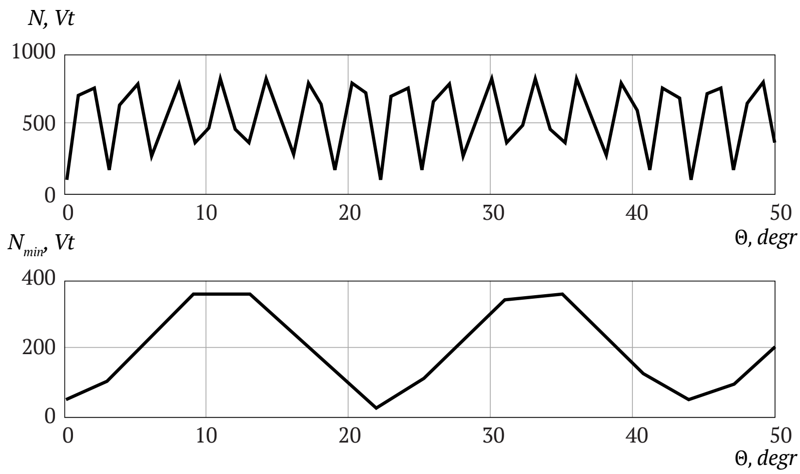


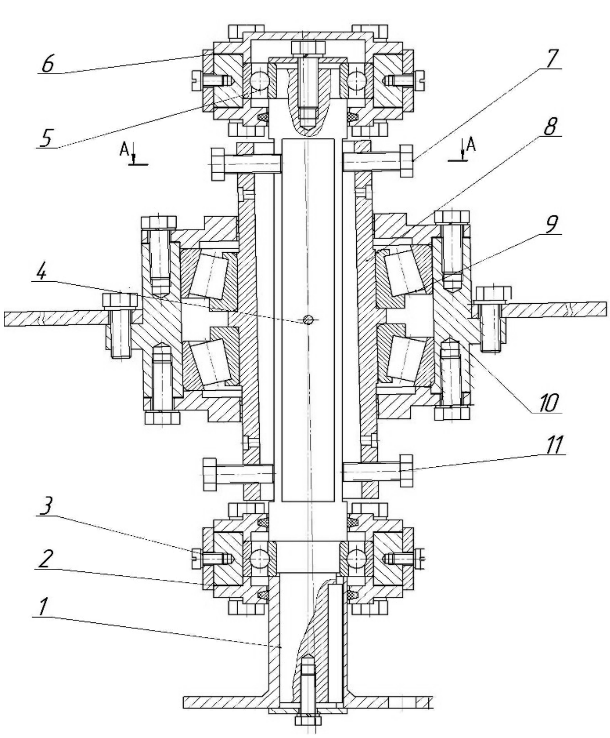
Figure 4. Dependence of average values of power consumption for the vibration separation process on the angular speed of the drive shaft: N – power on the drive shaft; N_{min} – minimum power value on the drive shaft; Θ – the angle between the drive shaft axis and the OZ axis

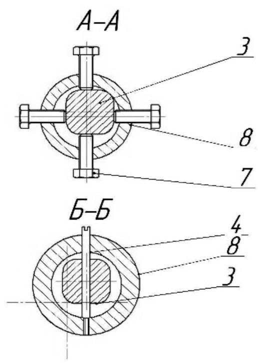
Exploring the changes in power on the drive shaft depending on the angle of rotation of the support sleeve, a sinusoidal nature of the change in this value was noted (Fig. 3). It allowed determining the peaks of minimum energy consumption for specific angles of rotation of the sleeve. The double peaks of the kinematic characteristics indicate the presence of two elastic couplings in the system.

As can be seen from Fig. 4, the envelope of minimum power values on the drive shaft changes according to a sinusoidal law with a period of change in the angle between the axes of the working container and the drive shaft equal to $\Theta_{min} = 22°$. Such a sufficiently large value of this design parameter is not appropriate for technological and structural reasons. Therefore, when choosing the optimal angle Θ, the dependence can be used

$$\Theta_{min} = 360 - z_{max}\Theta \qquad (3)$$

where z_{max} – the maximum integer to obtain a positive value in equation (3): it is obvious that for $z_{max} = 16$; $\Theta_{min} = 14°$





1 – elastic element
2 – vibrating plate
3 – shaft
4 – axis
5 – bearing support
6 – adjustable spring
7 – upper group of adjusting stops
8 – bushing
9 – bearing
10 – body
11 – lower group of adjusting stops

Figure 5. Structural diagram of the vibration exciter with the guide sleeve of the explored sieve separator

Based on the theoretical studies, the design of the gyratory vibration drive of spatial oscillations was developed (Fig. 5), which presents the main structural components of the developed vibration exciter, in particular, the mechanism for adjusting the inclination of the working surface of the support sleeve.

Conclusions

1. Using the Lagrange equation of the second kind, the dependences for the main independent movements of the executive bodies of the explored vibrating screen were compiled, and their solution was obtained using the Cauchy method, which allowed determining the patterns of change.

2. Based on the obtained equations of motion of the executive bodies of the vibrating screen, the dependences of the main kinematic and energy parameters of the explored vibration excitation scheme of the separator were obtained.

3. The modes of minimum power consumption on the drive shaft alternate approximately every 22° of rotation of the working surface of the support sleeve to the vertical; the optimal angle between the axes of the working container and the drive shaft for the technological and structural features for the explored machine is 14°, which allowed clarifying the design scheme of the vibrating exciter of the developed screen.

References

[1] Palamarchuk, I., Rogogvskii, I., Titova, L., & Omelyanov, O. (2020). Experimental evaluation of energy parameters of volumetric vibroseparation of bulk feed from grain. *Engineering for Rural Development*, 20, 291-298.

[2] Mushtruk, M., Bal-Prylypko, L., Slobodyanyuk, N., Boyko, Y., & Nikolaienko, M. (2022). Design of Reactors with Mechanical Mixers in Biodiesel Production. *Lecture Notes in Mechanical Engineering*, 197-207. doi: 10.1007/978-3-031-06044-1_19

[3] Bal-Prylypko, L.V, Palamarchuk, I.P, & Nikolaenko, M.S. (2019). Modeling the intensification of industrial wastewater treatment at meat processing plants. *The Agro-Food Industry*, 3(4), 10-15.

[4] Palamarchuk, I., Mushtruk, M., Sukhenko, V., Dudchenko, V., Korets, L., Litvinenko, A., Deviatko, O., Ulianko, S., & Slobodyanyuk, N. (2020). Modelling of the process of vybromechanical activation of plant raw material hydrolysis for pectin extraction. *Potravinarstvo Slovak Journal of Food Sciences*, 14, 239-246.

[5] Rogovskii, I.L., Palamarchuk, I.P., Voinash, S.A., Troyanovskaya, A.F., & Butenko, V.A. (2020). Engineering of constructive parameters of vibroaspiration separator of oil-containing grain seeds. *Journal of Physics: Conference Series*, 1679(4), article number 042034.

[6] Palamarchuk, I., Mushtruk, M., Vasyliv, V., & Zheplinska, M. (2020). Substantiation of regime parameters of vibrating conveyor infrared dryers. *Potravinarstvo Slovak Journal of Food Sciences*. 13(1), 751-758.

[7] Deng, F., Sun, D., Sun, J., & Wen, M. (2019). Experimental simulation of erosion behavior of monolayer metal screen in sandstone reservoir. *Engineering Failure Analysis*, 105, 255-265.

[8] Palamarchuk, I., Kiurchev, S., Kiurcheva, L., & Verkholantseva, V. (2019). Analysis of main process characteristics of infrared drying in the moving layer of grain produce. *Modern Development Paths of Agricultural Production: Trends and Innovations*, 317-322.

[9] Zhu, Z., Li, Y., Sun, D.W., & Wang, H.W. (2019). Developments of mathematical models for simulating vacuum cooling processes for food products – A review. *Critical Reviews in Food Science and Nutrition*, 59(5), 715-727.

[10] Ashtiani, S.H.M., Salarikia, A., & Golzarian, M.R. (2017). Analyzing drying characteristics and modeling of thin layers of peppermint leaves under hot-air and infrared treatments. *Information Processing in Agriculture*, 4(2), 128-139.

[11] Wei, L., Zhang, B., Lu, C., Lu, Y., & Wang, C.H. (2020). Experimental investigation of pressure fluctuation propagation in two orthogonal directions using a clapboard-type internally circulating fluidized bed. *Advanced Powder Technology*, 31(8), 3395-3407. doi: 10.1016/j.apt.2020.06.026.

[12] Cherntongchai, P., Chaiwattana, S., Leruk, R., Panyaruean, J., & Sriboonnak, S. (2019). Influence of standing wave characteristics on hydrodynamic behaviors in sound-assisted fluidization of Geldart group A powder. *Powder Technology*, 350, 123-133. doi: 10.1016/j.powtec.2019.01.031.

[13] Barrero, A.R., Taiebat, M., & Dafalias, Y.F. (2020). Modeling cyclic shearing of sands in the semifluidized state. *International Journal for Numerical and Analytical Methods in Geomechanics*, 44(3), 371-388. doi: 10.1002/nag.3007.

[14] Palamarchuk, I., Zozulyak, O., Mushtruk, M., Petrychenko, I., Slobodyanyuk, N., Domin, O., Udodov, S., Semenova, O., Karpovych, I., & Blishch, R. (2022). The intensification of dehydration process of pectin-containing raw materials. *Potravinarstvo Slovak Journal of Food Sciences*, 16, 15-26. doi: 10.5219/1711.

[15] Bazaluk, O., Struchaiev, N., Halko, S., Miroshnyk, O., Bondarenko, L., Karaiev, O., & Nitsenko, V. (2022). Ways to Improve the Efficiency of Devices for Freezing of Small Products. *Materials*, 15(7), 2412. doi: 10.3390/ma15072412.

Обгрунтування амплітудно-частотних характеристик та конструктивних параметрів віброзбуджувача сепаратора об'ємних коливань

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Анотація. Оцінка впливу амплітудно-частотних та силових параметрів зовнішньої технологічної дії на сипку продукцію у процесі її сепарації впливу, напрямку низькочастотних коливань робочих органів сепаратора та кута нахилу контейнера у процесі обробки визначає основні показники техніко-економічної ефективності досліджуваного процесу, що становить актуальність проведених досліджень. Метою дослідження є обгрунтування режимних параметрів досліджуваного сепаратора об'ємних коливань за рахунок визначення закономірностей зміни кінематичних та силових характеристик віброприводу. Для визначення раціональних параметрів процесу вібраційного грохочіння були отримані рівняння руху робочих органів у вигляді конічної ситової поверхні використовуючи метод рівнянь Лагранжа 2 роду. Застосовуючи рішення задачі Коші для лінійних неоднорідних диференціальних рівнянь було отримано розв'язок останніх. Використовуючи математичне середовище Math CAD, були отримані залежності амплітуди коливань, віброшвидкості та віброприскорення, інтенсивності коливального руху дали змогу здійснити математичний аналіз силових та енергетичних характеристик віброприводу досліджуваного сепаратора. Основними ефектами розробленої конструкції вібраційного сепаратору є збільшення рушійної сили процесу сепарації сипкої маси в цій роботі, що досягли через надання робочому циліндрично-конічному контейнеру вібраційного руху; поліпшення умов проходження часток продукції через перфорації, що досягли завдяки наданню ситовій поверхні об'ємних коливань; зменшення енерговитрат та поліпшення умов роботи опорних вузлів під час експлуатації проектованого віброгрохоту, що досягли внаслідок встановлення додаткових пружних елементів між корпусом сепаратора та підшипниковими вузлами вертикального приводного валу віброзбуджувача. Похиле розташування конічної ситової поверхні дає змогу здійснювати просторовий гіраційний або коловий поступальний рух, що дає можливість реалізувати переваги об'ємного розділення сипких мас. Результати