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ELABORATION AND RESEARCHES OF A VIBRO-PRESS FOR DEHYDRATION OF DAMP DISPERSIVE MATERIALS

Vibro-pressing loading is one from most effective methods of dehydration of damp dispersive materials such as alcoholic bard, beer pellets, beet press, coffee and barley slime for their further use as valuable additives to agricultural fodders or as a fuel. Main efficiency characteristics of the equipment for dehydration by the method of vibro-pressing loading are: productivity of liquid removal up to 20 ÷ 25 t / h, energy efficiency 2,7 ÷ 3,2 kW / t, final humidity of processed material 20 ÷ 25%. High efficiency of the method conditioned by periodical overdistribution of solid particles of processed material in a press-form of the equipment with their mutual rotations, sliding and movements in locations of more stable balance, with more dense stacking of particles and removal of liquid from spaces between them. There are several types of drives for vibro-pressing equipment: mechanical (unbalanced), hydraulic and electromagnetic. Each this type of drives has some advantages and disadvantages. One of tasks of this article is to analyze these types of drive and to select an optimal variant that will provide maximal productivity of working process, minimal energy expenses and humidity of processed material. A scheme of a versatile vibro-press that can be equipped with unbalanced, hydraulic pulse or electromagnetic drive is presented in the article. There is elaborated dynamic and mathematic models of the vibro-press. Equations of the mathematic model set connection between of working parameters of dehydration process, design parameters of the equipment and physical-mechanical characteristics of processed material. These equations can be used as a foundation for elaboration of a design calculation method for determination of optimal parameters of the vibro-press depending from given characteristics of material and parameters of dehydration efficiency.

Kee words: *dehydration, vibro-press, damp dispersive materials, unbalanced, hydraulic and electromagnetic drive, dynamic and mathematic models.*

Problem formulation. A problem of utilization of wastes of food and processing productions (alcoholic bard, beer pellets, beet press, coffee and barley slime) is actual for some of enterprises of Ukraine and for other countries. These wastes belong to damp dispersive materials and in case of their dehydration to humidity 20 ÷ 25% their hard phase can be used as a valuable additive to agricultural fodders or as a high-calorie fuel [1].

For realization of dehydration processes there are used mechanical, thermal, electro-physical, chemical and biological methods [1, 2]. Mechanical methods excel methods of other groups by productivity and provide significant decrease of energy expenses, especially in comparison with thermal dehydration [1]. By the author notion, one from the most effective methods of mechanical group is a method of vibro-loading on a vibro-press with the hydraulic pulse drive [1, 3 – 5]. Main efficiency characteristics of the equipment are: productivity of liquid removal up to 20 ÷ 25 t / h, energy efficiency (2,7 ÷ 3,2 kW / t), final humidity of processed material 20 ÷ 25% [1]. High efficiency of the method conditioned by periodical overdistribution of solid particles of processed material in press-form of the equipment in course of vibro-blowing loading with their mutual rotations, sliding and movements in locations of more stable balance, with more dense stacking and removal of liquid from spaces between the particles [1]. In turn all these processes are caused by waves of tensions and deformations in medium of processed material in the press-form, that are moved in direction from its bottom to the punch and backwards under impact of periodical fluctuations of the press-form and its shock interaction with a vibro-press foundation [1].

But the vibro-presses with the hydraulic pulse drive have quite complex design [3 – 5], so an actual task is improvement of dehydration vibro-presses in direction of their design simplification and increase of versatility with keeping of efficiency characteristics of the equipment.

Besides, high parameters of efficiency are provided in case of using of a thermo-mechanical method of dehydration – removal of damp under impact of secondary thermal energy and mechanical fluctuations in a closed working chamber [6, 7].

Analysis of last researches and publications. There are several types of drives for vibro-pressing equipment: mechanical (unbalanced), hydraulic and electromagnetic [6]. Each from these types of drives has some advantages and disadvantages. One of tasks of this article is to analyze these types and to select an optimal variant that will provide maximal productivity of working process, minimal energy expenses and humidity of processed material.

The unbalanced drive [5, 6] has most simple design, relatively low price and high reliability. Vibro-presses with this drive provide efforts at the executive element up to 120 kN and more, frequency of its fluctuations up to 50 Hz and amplitude up to 4 10^{-3} m [6]. Disadvantages of the drive is an impossibility of an independent regulation of frequency and amplitude of the loading. Besides, this drive creates a significant dynamic loading at the equipment foundation.

The hydraulic pulse drive [6] as a kind of hydraulic drives provides significant efforts at the executive element – up to 300 kN, frequency up to 150 Hz, amplitude up to 3 10^{-3} m and has quite compact dimensions [6]. The hydraulic pulse drive provides a possibility of independent stepless and fluent regulation of loading effort, frequency and amplitude, but it has high enough complexity and price.

The electro-magnetic drive provides intensive regime of loading: frequency of fluctuations of an executive element up to 3000 Hz (some experimental installations realize frequency up to 30000 Hz), amplitude up to 2 10^{-3} m [6]. Disadvantage of the drive is quite high energy expenses at the unit of mass of removed liquid and high price of the equipment.

So, as we can see, each type of the drive for vibro-pressing equipment can provide an effective working process and using of all these types is prospective.

Purpose formulation. A purpose of the of this work is elaboration of a scheme of a versatile vibro-press that can be equipped with unbalanced, hydraulic pulse or electromagnetic drive. There is need also to elaborate dynamic and mathematic models of the vibro-press. Equations of the mathematic model should set connection between of working parameters of dehydration process, design parameters of the equipment and physical-mechanical characteristics of processed material. These equations will allow to determine the optimal parameters of the vibro-press depending from given characteristics of material and parameters of dehydration efficiency.

Presentation of main material. There is a scheme of a vibro-press for dehydration of damp dispersive materials, elaborated by the article's author and presented at the fig. 1. For realization of dehydration of the portion of processed material there is need to lift the cross-arm 2 with tubes 4, punch 5 and displacers 17 with help of four hydraulic cylinders 3 in the upper position (see also the cross-section A – A at the fig. 1). Side slabs 19 and 27 are situated in positions as on cross-section A – A of the fig. 1. Processed material from the bunker 1, through the opened slide-valve 9 and over the chute 10 is fed into the press-form 11. After filling of the press-form the slide-valve is closed and the cross-arm with help of hydraulic cylinders 3 is went down. The punch 5 with displacers 17 create static mechanical loading of the portion 24 of processed material in the press-form 11 from above. Then there is turn on a hydraulic pulse drive of the vibro-press [8] and pressure of working liquid in chambers of four hydraulic cylinders 16 is began to change in limits 4 ÷ 12 MPa [2, 8]. As a result, press-form that connected with plunges of hydraulic cylinders 16 and the portion of processed material in it make periodical reciprocal movements with frequency up to 150 Hz and with amplitude up to 2 mm. At that movements of the press-form upwards are provided as a result of increased pressure of working liquid in the cavities of the hydraulic cylinders 16. In course of these movements upwards rods 12 with clamps press the springs 13. Return of the press-form 11 with the processed material 24 in lower position is carried out under impact of their own gravitation and force of resilience of the pressed spring 13. In the end of each movement of the press-form in the initial low position it is hit at the foundation 20. So, the portion 24 of material in the press-form 11

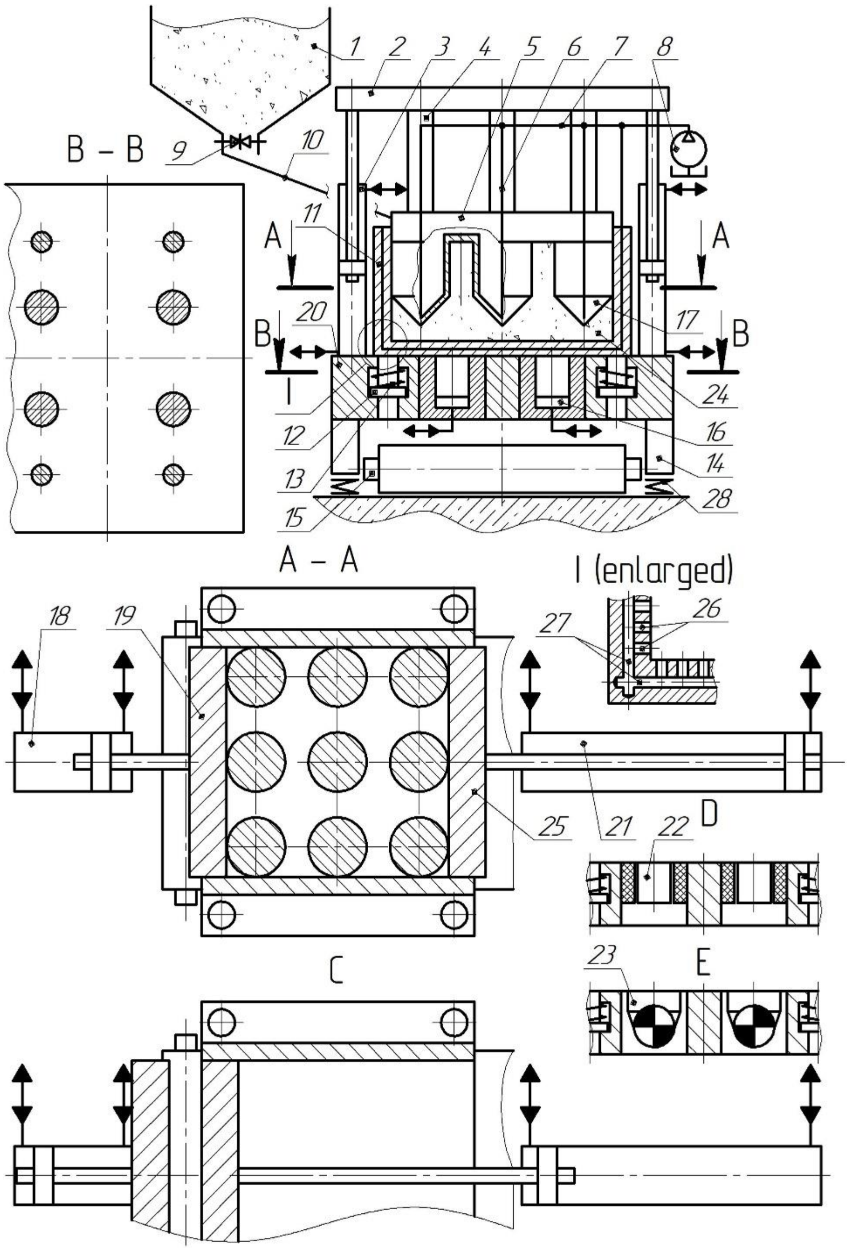

Figure 1 – Scheme of a vibro-press for dehydration of damp dispersive materials:
1 – bunker; 2 – cross-arm; 3, 16, 18, 21 – hydraulic cylinders; 4 – tubes; 5 – punch; 6, 7 – channels; 8 – vacuum pump; 9 – slide valve; 10 – chute; 11 – press-form; 12 – rods; 13 – springs; 14 – supports; 15 – belt conveyer; 17 – displacers; 19, 25 – side slabs; 26 – openings; 27 – channels; 28 – vibro-supports

is also exposed vibro-blowing inertia loading from below. All this creates conditions for effective extraction of liquid from the processed material that is poured out through a metallic filtering net on internal surfaces of the press-form 11, punch 5 and displacers 17 (it is not shown on the scheme), openings 26, channels 27 (see the element I on the fig. 1). This liquid is pumped out through hydraulic lines 6, 7 with help of the vacuum pump 8. Reciprocal movements of the press-form 11 with the portion 24 of processed material can be provided with help of four electromagnetic vibro-exciters 22 (see view D on the fig. 1), that installed instead of hydraulic cylinders 16 inside of the foundation 20, or by four mechanical unbalanced vibro-exciters 23 (see view E on the fig. 1). So, the same scheme of the vibro-press can be realized at the base of various types of the drive. After achievement of the necessary humidity of processed material in the press-form 11 the drive of reciprocal movements of the press-form is turned out. Cross-arm 2 with tubes 4, punch 5 and displacers 17 with help of four hydraulic cylinders 3 are raised in the upper position. Side slabs 19, 25 are moved by hydraulic cylinders 18, 21 into positions that presented in the view C of the fig. 1. As a result, the portion 24 of dehydrated material is pressed out from the press-form 11 on the belt conveyer 15. Then the slabs 19, 25 are returned in the initial positions (see the cross-section A - A on the fig. 1), there is opened the slide-valve 9 and the next portion of processed material is loaded in the press-form 11. The described working process of dehydration is repeated.

Determination of optimal design and working parameters of the vibro-press (fig. 1) depending from given parameters efficiency (productivity *P*, specific energy expanses *E* and final humidity U_f of processed material [1]) should be fulfilled with help of equations of a mathematic model that include these parameters.

For elaboration of equations of the mathematic model of the proposed vibro-press we use its dynamic model, that presented on the fig. 2.

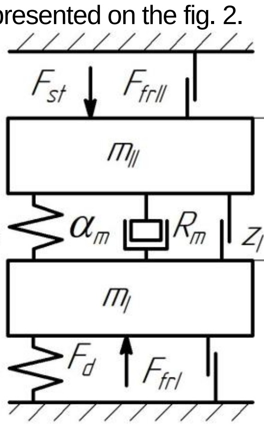

Figure 2 - Dynamic model of the vibro-press for dehydration of damp dispersive materials

At the model are designated such parameters:

m_I – mass of the lower executive element of the vibro-press, that includes masses m_{pl} of plungers of four hydraulic cylinders 16 (see also the fig. 1) – in case of using of the hydraulic pulse drive, mass m_{pf} of the press-form 11, masses m_r of four rods 12 and mass $m_m(t)$ of the portion 24 of processed material in the press-form (it is changed in the course of time, because a part of liquid phase of the material is removed from the press-form in the course of dehydration process) [9]:

$$m_I(t) = 4 \cdot m_{pl} + 4 \cdot m_r + m_{pf} + m_m(t);$$
$$0 \le t \le t_I, \qquad (1)$$

where t_I– durability of the I stage that for a hydraulic pulse drive with a generator of pressure impulses “on the exit” is determined by formulas of the work [8]; for electromagnetic and unbalanced drives t_I is approximately equal to half of a period *T* of fluctuation of the press-form 11

$$t_I = \frac{1}{2}T = \frac{1}{2 \cdot \nu}, \qquad (2)$$

where *v* – frequency of fluctuations of the press-form 11.

In case of using in the vibro-press of electromagnetic or unbalanced drive (see views D and E on the fig. 1) in the formula for definition of m_I there is need to set instead of the masses m_{pl} the masses m_{ee} of four executive elements of these drives:

$$m_I(t) = 4 \cdot m_{ee} + 4 \cdot m_r + m_{pf} + m_m(t);$$
$$0 \le t \le t_I; \qquad (3)$$

m_{II} – mass of the upper executive element of the vibro-press, that includes masses m_d of four displacers 17, masses m_t of four tubes 5, mass m_p of punch 5, mass m_{ca} of the cross-arm 2 and masses m_{pr} of pistons and rods of four hydraulic cylinders 3:

$$m_{II} = 4 \cdot m_d + 4 \cdot m_t + 4 \cdot m_{pr} + m_p + m_{ca}; \qquad (4)$$

z_I, z_{II} – movements of the masses m_I, m_{II};

F_d – driving force from plungers of hydraulic cylinders 16 or from executive elements of electromagnetic – 22 or unbalanced – 23 drives of the vibro-press on the press-form 11;

F_{st} – effort, that created by hydraulic cylinders 3 on punch 5 and displacers 17;

F_{frI} – force of dry friction in sealings of plungers of hydraulic cylinders 16 (this force will be absent in case of using electromagnetic or unbalanced drives).

F_{frII} – force of dry friction in sealings of pistons and rods of hydraulic cylinders 3;

c_m – coefficient of rigidity of processed material in the press-form 11 [1];

α_m – coefficient of viscous friction inside of the portion 24 of processed material [1];

R_m – force of dry friction between particles of processed material in the press-form 11 and between the particles and internal surfaces of the press-form;

c_s – coefficient of rigidity of the springs 13;

A working cycle of the lower drive of the vibro-press, that provides periodical oscillation movements of the press-form 11 with the portion 24 of processed material can be divided at two stages:

I stage – movement of the mass m_I from the initial lower position in the upper position;

II stage – movement of the mass m_I from the upper position in the initial lower position.

So, a differential equation of movement of the mass m_I at the I stage of a working cycle in accordance with the dynamic model (fig. 2) relatively axle *z* has an appearance

$$m_I \ddot{z}_I = F_d(t) - m_I g - F_{frI}(t) - c_s(z_p + z_I) -$$
$$-c_m z_I - \alpha_m \dot{z}_I - R_m(t); \; 0 \le t \le t_I, \qquad (5)$$

where z_p– previous compression of the springs 13.

The driving force $F_d(t)$ for the hydraulic pulse drive can be determined as

$$F_d(t) = 4 \cdot p_c(t) \cdot S_c; \; 0 \le t \le t_I, \qquad 6)$$

where S_c – cross-section area of the plunger of the hydraulic cylinders 16; $p_c(t)$ – pressure in working chambers of the hydraulic cylinders 16 of hydraulic pulse drive with a generator of pressure impulses “on the exit” [8]. Value of $p_c(t)$ is changed linearly from minimal - $p_{c.min}$ to maximal - $p_{c.max}$. Value $p_{c.max}$ corresponds to the sum of all forces, creating resistance for movement of the mass m_I (see equation

(5). Stepless and accurate adjustment of values $p_{c.min}$, $p_{c.max}$ is realized with help of the generator of pressure impulses [8] of the vibro-press.

The driving force $F_d(t)$ for an unbalanced drive is changed in course of the I stage from 0 to maximal value and again to 0

$$F_d(t) = 0\ when\ t = 0;$$
$$F_d(t) = 4 \cdot m_d \omega_d^2 R_d;\ when\ t = \frac{t_I}{2}; \qquad (7)$$
$$F_d(t) = 0\ when\ t = t_I,$$

where m_d – mass of rotating elements of one vibro-exciter 23; ω_d – pulsatance of its rotation; R_d – radius of fastening of the vibro-exciter.

For an electromagnetic drive value of the driving force F_d is stable in course of all I stage and its equal to tractive effort on the electromagnetic vibro-exciter 22:

$$F_d = F_{te}. \qquad (8)$$

Force of friction $F_{frI}(t)$ in the equation (5) we can find with help of formula [8]

$$F_{frI}(t) = 0{,}1 \cdot F_d(t);\ 0 \le t \le t_I, \qquad (9)$$

where $F_d(t)$ is determined by the formula (6).

An influence of the $R_m(t)$ one should take into account only at the final stage of the dehydration process under direct contact of solid particles of the portion 24 with each other and with walls of the press-form 11. But at the beginning of the describing working process under material's humidity 90 ÷ 95% such direct contact is absent, so for this initial period of the working process we can take, that $R_m(t)$ = 0.

For the final period of dehydration in coarse of the I stage of the working process an approximate value of the $R_m(t)$ one can calculate by equation

$$R_m(t) = \begin{bmatrix} F_d(t) - m_I \ddot{z}_I - m_I g - F_{frI}(t) - \\ c_s(z_p + z_I) - c_m z_I - \alpha_m \dot{z}_I \end{bmatrix} \times$$
$$\times (\mu_{mm} + \mu_{mp}), \quad 0 \le t \le t_I \qquad (10)$$

where μ_{mm}; μ_{mp} - coefficients of friction between of neighboring particles of processed material in the press-form 11 and friction between of the particles and internal surfaces of the press-form.

Then pressure $p_{mI}(t)$ in lower layer of processed material that has direct contact with the bottom of the press-form 11 in the course of the I stage of a cycle of vibro-blowing loading is

$$p_{mI}(t) = \begin{bmatrix} F_d(t) - m_I \ddot{z}_I - m_I g - F_{frI}(t) - \\ c_s(z_p + z_I) - c_m z_I - \alpha_m \dot{z}_I - R_m(t) \end{bmatrix} \Big/ S_{pf}\ ;$$
$$0 \le t \le t_I, \qquad (11)$$

where S_{pf} - the cross-section area of the press-form 11.

The formulas (10, 11) were compiled with consideration of a supposition that the pressure $p_m(t)$ is distributed in medium of processed material inside of the press-form 11 equally in all directions. From our point of view this supposition is well founded, because at the beginning of the dehydration process initial humidity of processed material amounts 90 ÷ 95% (for wastes of food productions – alcoholic bard, beer pellets, beet press, coffee and barley slime), so by structure they are close to Newtonian liquids [1, 2].

The differential equation of movement of the mass m_{II} at the I stage of a working cycle in accordance with the dynamic model (fig. 2) relatively axle *z* has an appearance

$$m_{II}\ddot{z}_{II} = -F_{st} - m_{II} g + F_{frII} + c_m z_{II} + \alpha_m \dot{z}_{II} + R_m(t);$$
$$0 \le t \le t_I. \qquad (12)$$

Force F_{st} in the equation (12) can be calculated as

$$F_{st} = 4 \cdot p_{ca} S_{ca}, \qquad (13)$$

where p_{ca} – an adjusted pressure of working liquid in rod ends of hydraulic cylinders 3; S_{ca} – cross-section area of the rod end of the hydraulic cylinder 3.

Force of friction F_{frII} in the equation (12) we can find with help of the formula

$$F_{frII} = 0{,}1 \cdot F_{st}, \qquad (14)$$

where F_{st} is determined by the formula (13).

Force $R_m(t)$ in the equation (12) in the final period of dehydration in coarse of the I stage of the working process one can calculate by formula

$$R_m(t) = \big[F_{st} + m_{II}\ddot{z}_{II} + m_{II} g - F_{frII} - c_m z_{II} -$$
$$-\alpha_m \dot{z}_{II}\big] \cdot (\mu_{mm} + \mu_{mp});\ 0 \le t \le t_I. \qquad (15)$$

Most intensive movement z_{II} will take place at the very beginning of the dehydration process in course of removal of free liquid phase from layers of the portion 24, that have direct contact with working surfaces of the press-form 11, displacers 17 and punch 5. At the same time will realized compression of liquid phase and solid particles of the portion.

So, the corresponding pressure $p_{mII}(t)$ in an upper layer of processed material that has a direct contact with displacers 17 and punch 5 in the course of the I stage of a cycle of vibro-blowing loading

$$p_{mII}(t) = \begin{bmatrix} F_{st} + m_{II}\ddot{z}_{II} + m_{II} g - F_{frII} - \\ c_m z_{II} - \alpha_m \dot{z}_{II} - R_m(t) \end{bmatrix} \Big/ S_{pf}\ ;$$
$$0 \le t \le t_I. \qquad (16)$$

After completion of removal from the portion 24 of free liquid phase that located nearby working surfaces of press-form 11, displacers 17 and punch 5 intensity of dehydration process will be decreased [1]. In coarse of this period of dehydration the movement z_{II} in the equation (12) will depend from flow $Q_l(t)$ of liquid phase of processed material from internal layers of the portion 24 to the openings of press-form 11, displacers 17 and punch 5. The value of the $Q_l(t)$ is determined by change of middle diameter and length of channels between of solid particles of processed material in the press-form 11 in course of a cycle of vibro-blowing loading. Equations for determination of these parameters of processed material are presented in the work [1].

An equation for determination of z_{II} in course of the final period of the dehydration process and at the I stage of the vibro-blowing loading of the portion of processed material has an appearance

$$\dot{z}_{II} = \frac{Q_I(t)}{S_{pf}};\ 0 \le t \le t_I. \qquad (17)$$

The differential equation of movement of the mass m_I at the II stage of a working cycle in accordance with the dynamic model (fig. 2) relatively axle z has an appearance

$$-m_I\ddot{z}_I = -F_d(t) + m_I g - F_{frI}(t) + c_s\big(z_p + z_I(t_I) - z_I\big) + c_m(z_I(t_I) - z_I) - \alpha_m\dot{z}_I - R_m(t);\quad t_I < t \le t_{II}. \qquad (18)$$

The driving force $F_d(t)$ for the hydraulic pulse drive can be determined as

$$F_d(t) = 4 \cdot p_c(t) \cdot S_c;\ t_I < t \le t_{II} \qquad (19)$$

Pressure $p_c(t)$ in working chambers of the hydraulic cylinders 16 of hydraulic pulse drive with a generator of pressure impulses "on the exit" at the II stage is changed linearly from maximal - $p_{c.max}$ to minimal - $p_{c.min}$.

The driving force $F_d(t)$ for the unbalanced drive is changed linearly in course of the II stage from 0 to maximal value and again to 0

$$F_d(t) = 0\ when\ t = t_I;$$
$$F_d(t) = 4 \cdot m_d\omega_d^2 R_d;\ when\ t = \frac{t_{II}}{2};$$
$$F_d(t) = 0\ when\ t = t_{II}. \qquad (20)$$

For electromagnetic drive value of the driving force F_d is stable in course of all II stage and its equal to tractive effort of the electromagnetic vibro-exciter 22 (see the formula (8).

Force of friction $F_{frI}(t)$ in the equation (18) we can find with help of formula (9) with substitution there $F_d(t)$ is determined with help of the equation (20).

Force $R_m(t)$ in the equation (18) one should take into account only for the final period of the dehydration (see above). The approximate value $R_m(t)$ in coarse of the II stage of the working process one can calculate by equation

$$R_m(t) = \begin{bmatrix} m_I\ddot{z}_I - F_d(t) + m_I g - F_{frI}(t) + \\ +c_s\big(z_p + z_I(t_I) - z_I\big) + \\ +c_m(z_I(t_I) - z_I) - \alpha_m\dot{z}_I \end{bmatrix} \times \times \big(\mu_{mm} + \mu_{mp}\big),\ t_I < t \le t_{II}. \qquad (21)$$

Pressure $p_{mI}(t)$ in lower layer of processed material in the course of the II stage of a cycle of vibro-blowing loading is

$$p_{mI}(t) = \begin{bmatrix} m_I\ddot{z}_I - F_d(t) + m_I g - F_{frI}(t) + \\ +c_s\big(z_p + z_I(t_I) - z_I\big) + \\ +c_m(z_I(t_I) - z_I) - \\ -\alpha_m\dot{z}_I - R_m(t) \end{bmatrix} \Big/ S_{pf};\quad t_I < t \le t_{II}. \qquad (22)$$

The differential equations of movement of the mass m_{II} at the II stage of a working cycle and for change of pressure $p_{mII}(t)$ in the upper layer of processed material are the same as for the I stage (see formulas (12 – 17).

Equations and formulas that connect main working parameters of vibro-blowing dehydration and physical-mechanical characteristics of the processed damp dispersive material with parameters of efficiency (productivity, specific energy expenses, final humidity of processed material) presented in the work [1].

Conclusions. 1. Mechanical methods are most effective for dehydration of damp dispersive materials because in comparison with thermal, chemical, electro-physical and biological methods they provide higher productivity of the working process and lower specific energy expenses.

2. One from prospective mechanical methods of dehydration is a method of vibro-blowing loading in a closed press-form. Vibro-presses for realization of the method can be equipped with mechanical (unbalanced), hydraulic or electromagnetic drive. Each from these drives has some advantages and disadvantages.

3. A scheme of versatile vibro-press that can brought with unbalanced, hydraulic pulse or electromagnetic drive is presented in the article. The vibro-press has simple and reliable design, provides high intensity of loading of processed material in the closed press-form and high productivity of dehydration with minimal energy expenses.

4. There are elaborated differential equation of movement of executive elements of the vibro-press in course of two stages of its working cycle. The equation connects main working parameters of process of vibro-blowing dehydration (pressure, created by executive elements of the vibro-press in upper and lower layers of processed material in the press-form, amplitude and frequency of the press-form fluctuations), design parameters of the vibro-press and physical-mechanical characteristics of processed material. These equations can be used as a foundation for creation of a method of design calculation of the proposed vibro-press.

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РОЗРОБКА ТА ДОСЛІДЖЕННЯ ВІБРОПРЕСА ДЛЯ ЗНЕВОДНЕННЯ ВОЛОГИХ ДИСПЕРСНИХ МАТЕРІАЛІВ

Вібропресування є одним з найбільш ефективних методів зневоднення вологих дисперсних матеріалів, таких як спиртова барда, пивна дробина, буряковий жом, кавовий та ячмінний шлам, для подальшого їх використання як цінних добавок до сільськогосподарських кормів або як палива. Основні параметри ефективності обладнання для зневоднення методом вібропресового навантаження: продуктивність за зневодненим матеріалом до 20 ÷ 25 т/год, енергоефективність 2,7 ÷ 3,2 кВт/т, кінцева вологість матеріалу, що переробляється 20 ÷ 25%. Висока ефективність методу обумовлена періодичним перерозподіленням твердих частинок матеріалу, що переробляється в прес-формі обладнання з їх взаємними обертаннями, ковзанням і переміщенням в положення більш стійкої рівноваги, з більш щільним укладанням частинок і видаленням рідини з проміжків між ними. Існує кілька типів приводів вібропресового обладнання: механічний (дебалансний), гідравлічний та електромагнітний. Кожен із цих типів приводів має свої переваги та недоліки. Одним із завдань цієї статті є аналіз цих типів та вибір оптимального варіанту, який забезпечить максимальну продуктивність робочого процесу, мінімальні енерговитрати та вологість оброблюваного матеріалу. У статті представлено схему універсального вібропресу, який може бути оснащений дебалансним, гідроімпульсним або електромагнітним приводом. Розроблено динамічну та математичну моделі вібропресу. Рівняння математичної моделі встановлюють зв'язок між робочими параметрами процесу зневоднення, конструктивними параметрами обладнання та фізико-механічними характеристиками матеріалу, що переробляється. Ці рівняння може бути покладено в основу розробки методики проектного розрахунку оптимальних параметрів вібропреса залежно від заданих характеристик матеріалу та параметрів ефективності зневоднення.

Ключові слова: *зневоднення, вібропрес, вологі дисперсійні матеріали, дебалансний, гідравлічний та електромагнітний привід, динамічна та математична моделі.*

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