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Аннотация. *Рассмотрено предложенные для отечественного комбайностроения основные конструктивно-технологические характеристики базовых моделей перспективных зерноуборочных комбайнов малой, средней, высокой и над высокой производительности с соответствующими пропускными способностями: 1,5–3 кг/с; 3–6 кг/с; 6–15 кг/с; 15–25 кг/с технологического материала.*

Ключевые слова: ***зерно, комбайн, стратегия***

Consider proposed for combine harvester major structural and technological characteristics of basic models of perspective grain harvesters of low, medium, high and above the high-performance with adequate capacity: 1.5–3 kg/s; 3–6 kg/s; 6–15 kg/s; 15–25 kg/s of the process material.

Key words: ***grain, harvester combine, strategy***

УДК 531.2.16

METHOD OF CALCULATION OF BASIC PARAMETERS OF VIBRATION DEVICE TO FORM HORIZONTAL SURFACES

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Annotation. *The proposed method of engineering calculation vibrating compactors for forming horizontal surfaces based on consideration of the interaction of processable concrete mixture with the realization of the set operating parameters of the working body*.

Key words: ***method, calculation, parameters, vibration***

Actuality of theme. Modern technology of monolithic construction requires the necessary equipment and devices for laying and compaction of concrete. At stacking the construction of vertical walls mixture is in the formwork using additives that enhance mobility and easily staking of concrete mix with little or no vibration application. And when constructing of horizontal surfaces, mostly in rooms large area (underground garages for parking of vehicles, warehouses, location, communication, etc.) is needed in applying hard mixes, seal which requires the use of vibration to produce high quality products. Existing platforms vibrators, screed rails have a small size in length.

Arises the problem of creating vibration sealing rails considerable lengths to ensure greater productivity, but for their calculation must consider longitudinal vibrations and possible tear-off modes. Therefore, an important issue to the creation screed rails is the development refined design scheme of the system "working body - the environment", the definition of the interaction of these subsystems influence rheological properties of concrete under the action of complex vibrations.

Therefore, the actual topic is the analysis of of concrete mix models, evaluation of structural parameters of existing vibration devices determine the effect of the mixture on the dynamics of the working body and based on their own research to develop algorithm of calculation of the basic parameters and modes of operation.

Analysis of previous studies. Mixtures that will compacting when forming horizontal surfaces exhibit rheological properties, which include elastic, viscous and plastic properties. In the literature there are different, often conflicting opinions [1] on their changes and impact on the dynamics of the vibrating device. Thus, changing the internal resistance forces is treated as a result thixotropy [2] or changes of dry friction [3]. According to the research found that changing the rheological properties of moving mixtures can be described by the equation Binhama-Shvedova [4]:

$$\tau = \tau_0 + \eta_{PV} \frac{\partial v}{\partial t}. \quad (1)$$

where: τ – shear tension, τ_0 – limit tension of displacement; η_{PV} – plastic viscosity with shear, $\frac{\partial v}{\partial t}$ – speed shear strain.

The motion of rigid concrete mixtures during compaction described Coulomb equation:

$$\tau = \sigma \cdot tg\varphi + C, \quad (2)$$

where: σ – pressure, $tg\varphi$ – tangent of the angle of internal friction, C – grip.

From equations (1) and (2) follows that in the equation Binhama-Shvedova of displacement resistance is proportional to the plastic viscosity and of displacement strain rate, and the equation of Coulomb – pressure and tangent of the angle of internal friction. The nature of the deformation while is also different: continuous deformation occurring in the bulk of material without destroying its continuity (1) and shift layers of material on contact planes (2).

Practical application of equation (1) or (2) depends on the choice of model environment. Provided that the mixture is a solid and resistance to shear it has a bunch of nature and while proportional to strain rate of displacement – used the equation (1).

Where the mixture is a discrete environment that responds to external action as a dry contact friction is proportional to the pressure, which is perpendicular to the shear plane, we can use equation (2). This shear resistance does not change due to the transition to dry friction materials, as adopted in [1] as a result of purely mechanical effects [5], which lead to a change in the effective coefficient of dry friction.

In [1] The physical models based on their representation purely viscous fluids, described the current number of laws of flow (Prandlya, Reiner-Filinova, Ostwald de Vilya, De Haven, etc.).

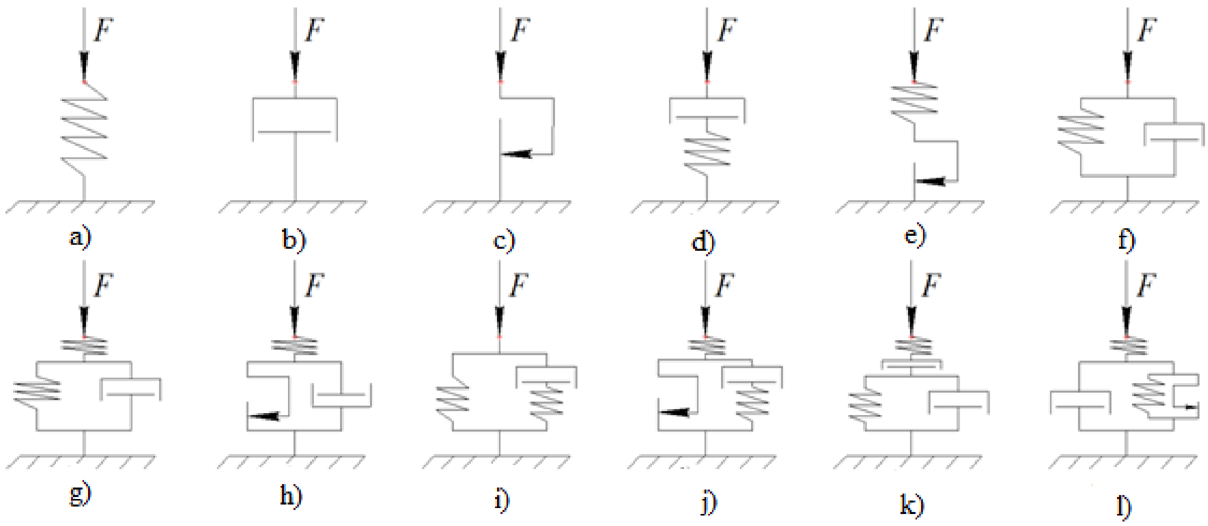

Fig. 1. The main rheological models, where F – external force: a – Hooke; b – Newton; c – Saint-Wenan; d – Maxwell; e – Prandl; f – Voigt; g – Kelvin; h – Binham; i – Poynting-Thomson; j – Shvedov; k – Burgers; l – Imlinskiy.

They accepted to classify newtonian, pseudo-plastic, dilatant. These models reflect only the properties of simple liquids (Fig. 1, a, b, c). To describe the concrete used more sophisticated so-called visco-plastic mixtures that show its movement along with viscous and plastic properties. Among these models is the model known Maxwell, Kelvin-Voigt, Binham-Shvedov and others (Fig. 1, d-l) [3].

For dependencies (1) and (2) models (see. Fig. 1, h and j) formed concrete mixture model presented by Binham-Shvedov, which is a serial connection of elastic, viscous and plastic elements; equation of state which is:

$$\begin{cases} \varepsilon = \frac{\sigma}{E} \quad where\, \sigma < \sigma_m; \\ \varepsilon = \frac{(\sigma-\sigma_m)\cdot t}{v} + \frac{\sigma}{E} \quad where\, \sigma > \sigma_m, \end{cases} \tag{3}$$

where: ε – deformation, σ – tension E – modulus of elasticity of concrete mix, v – coefficient of viscosity of the system, σ_m – limit state of mixture.

Thus, using the relation (3), it is possible to determine the mode of deformation of concrete mix in terms of consolidation and considered in the equations of motion of the device using a tension of (3), presenting it as a constituent of the inertial forces of resistance.

Methodology and results of research. By the methodology was provided the conduct research on vibrating device (Fig. 2), which consists of two longitudinal beams 1, which are interconnected and are mounted vibrators 2. The amplitude was measured at 1–4 points with different modes including vibrators.

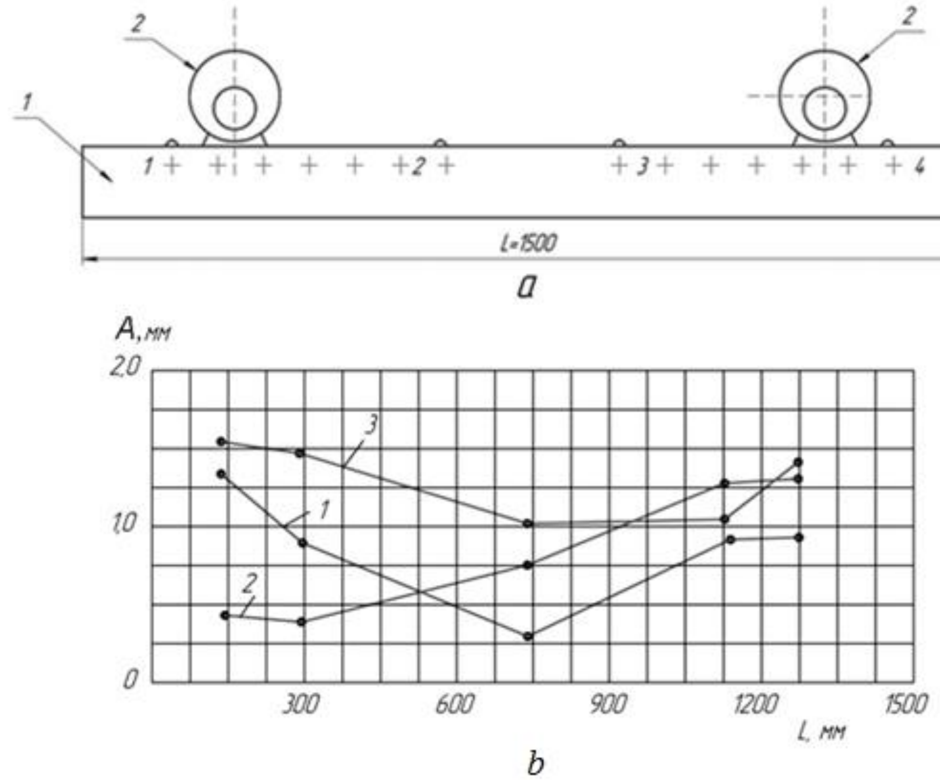

Fig. 2. Scheme of vibrating compactors (a) and results of the distribution of the amplitude A (b) along the length of the rail, where 1 – unbalance rotation counterclockwise; 2 – one rotating unbalance, second fixed; 3 – rotation unbalance in different side.

With all possible directions of rotation unbalance (Fig. 2, b) was observed a similar picture: at the ends amplitude was greater than in the middle, and the difference was two times higher (Curves 1, 3).

With a sudden switch of a vibrator or when you run one of these oscillation mode of vibrating compactors change. From Figure 2, we can see that there is a sharp decrease in amplitude with increasing distance from the vibrator, which should not be at work of two vibrators, the more with synchronous in their work.

Obviously, an important aspect of oscillations vibrating compactors is placing vibrators that can`t be done arbitrarily, without the rigidity of the working body. With the lack of rigidity vibrating compactors amplitude is distributed evenly along the length, often in the middle of it less than at the ends. This leads to the separation of the ends of vibrating compactor from the treated environment.

Thus, for example, the research found that the amplitude of vibration device during compaction of concrete mix was in the middle of 0.3 mm and 0.5 mm at the edges.

Our studies show that solving the problem of providing the specified modes of vibration device requires a considerable length account of the interaction of the working body of the device with concrete mixture and assess the movement of the vibrating device when he vibrates the mixture. This is important from two points of view: the presence of a special form with the front edge of the beam, when she moved, the device to avoid stratification stock mixture and mix in time vibration mode device on a separate site. So it is necessary to determine the speed of movement of v_0 to v_r – rational values of the speed at which there is no stratification and the required density. An important aspect is also the distance between the two beams of vibrating compactor, which must be reconciled not in terms of the support surface of the vibrator, and eventually sealing zone at bars. To install the vibration modes oscillations device (before-resonant or behind-resonant) frequency of natural oscillations is determined by a vibrating device. Thus, the frequency of natural oscillations of the beam ,than lying on elastic foundation can be determined by the formula:

$$\omega_N = \sqrt{\omega_{0N}^2 + \frac{c_0}{m_0}}, \tag{4}$$

where: ω_{0N} – the frequency of natural oscillations lying freely beam; $\frac{c_0}{m_0}$ – square of the frequency of free oscillations mass m_0 lying on a basis which has elasticity coefficient c_0.

The frequency of natural oscillations of the beam is given by:

$$\omega_{0N} = \frac{\alpha_n^2}{l^2}\sqrt{\frac{EJ}{m}}, \tag{5}$$

where: E – the modulus of elasticity, N/m^2; J – moment of inertia about the axis of the beam cross section perpendicular to the plane of bending, m^4; l – length of the beam, m; m – mass per unit length of the beam, kg/m.

The maximum allowable pitch between vibrators [6]:

$$l_{max} = 3\sqrt[4]{\frac{EJ}{\rho\omega^2}}, \tag{6}$$

where: ρ – linear density; ω – angular frequency of forced oscillations.

Self-synchronization of two vibrators provided the following conditions [6]:

$$(\lambda^2 - 1)\cos(\alpha_1 - \alpha_2) \gg 0, \quad (7)$$

where: λ – the ratio of own ω_N to forced oscillations ω of the vibration device; α_1, α_2 – phase oscillations of the first and second vibrators respectively.

Condition (7) ensure stability of the vibrating device by preconditions:

$$\alpha_1 - \alpha_2 = const; \omega_N > \omega. \quad (8)$$

The reduced dependence (4)–(8) taken into account in the model "working body – mixture" and are part of the engineering methods of calculation of the vibrating compactor.

To determine the parameters included in the equations of motion of the system "vibrating compactor – concrete mixture" used [7]:

$$\mathrm{C} = \omega_R^2 \sqrt{m^2 - \left(\frac{m_0 r_0}{A}\right)^2}; \quad (9)$$

$$b = \sqrt{2C\left(m - \frac{C}{\omega_R^2}\right)}; \quad (10)$$

$$tg\varphi = \sqrt{\frac{(m_0 r_0)^2 \omega^4}{(C - \omega^2 m)^2 A^2} - 1}, \quad (11)$$

where: C, b – coefficient of elasticity and dissipation of concrete mixture, respectively; ω, ω_R – forcing power frequency and resonance frequency respectively; m – vibrating compactor mass and reduced weight concrete mixture: $m = m_{w.b.} + m_b$; $m_0 r_0$ – static moment mass unbalance; A – amplitude of oscillations of the vibrator.

Independence (9)–(11) obtained by from the solution of the equation of motion vibration device that is in contact with a concrete mixture. In formulas (9)–(11) elastic properties into account the coefficient C and dissipative coefficient b. The coefficient of elasticity is based on the hypothesis of "air" nature of the link between tension and strain in the concrete mix [7]:

$$C = \frac{S(p_0 + p_{st})^2}{h_h \varepsilon p_0}, \quad (12)$$

where: S – area of the vibrator that comes into contact with the concrete mixture; p_0, p_{st} – atmospheric and static pressure on the mixture; h_h – height concrete mix; ε – coefficient of voids in the mixture, equal to the reduced height of the air pockets full height to the mix.

Dependence of speed limits formation of viscosity η concrete mix during its compaction and layer height of mix *h*:

$$v = \frac{k_1 k_2 h}{\eta}, \quad (13)$$

where: k_1, k_2 – coefficients that take into account the composition of the mixture and reinforcement respectively.

So you can define the following parameters of vibrating compactor, which for convenience will present a dimensionless form:

$$\left.\begin{array}{c} k_C = {}^{\rho}/_{\rho_0} \\ n_g = {}^{fl}/_{v} \\ k_F = {}^{F_0}/_{mg} \\ k_p = {}^{p}/_{\rho_0 h} \\ k_n = {}^{e}/_{h} \\ \bar{X} = {}^{m_0 r_0}/_{mh} \end{array}\right\}, \tag{14}$$

where: k_C – coefficient of compaction; n_g – the number of vibrations in the elementary section of the sealing surface of the mixture; k_F – coefficient of vibration; k_p – pressure coefficient; k_n – coefficient of relative movement; $\bar{X}$ – relative amplitude of oscillations; ρ, ρ_0 – final and the initial density; f, l, v – vibration frequency, length of the surface in the direction of movement and speed of movement of the vibrating device, respectively; F_0, mg – forcing power amplitude and vibration device weight; p, h – pressure on the mixture and its height; $m_0 r_0$ – static moment mass of unbalance; m – mass of the vibrating device.

An important parameter that determines the mode of the vibrating compactor, is the ratio of the weight of the vibrating device $Q = mg$ and forcing power $F_0 = m_0 r_0 \omega$:

$$K_F = {}^{Q}/_{F_0}. \tag{15}$$

By the research has found that this ratio should be between 0.5...0.7, thus provided the optimum mode of the system "Vibration device – working mixture."

These dependencies (3)–(15) form the basis of the algorithm of the basic parameters of the vibrating device (Fig. 3).

Conclusions

1. The influence of rheological characteristics at motion parameters of vibrating device.

2. Refined physical and mathematical model of "working body – sealing mix" with the significant change of rheological parameters of the mixture during the processing.

3. Identified the design parameters, conditions of synchronization of vibrators and stabilization of the vibrating device for forming the horizontal surfaces.

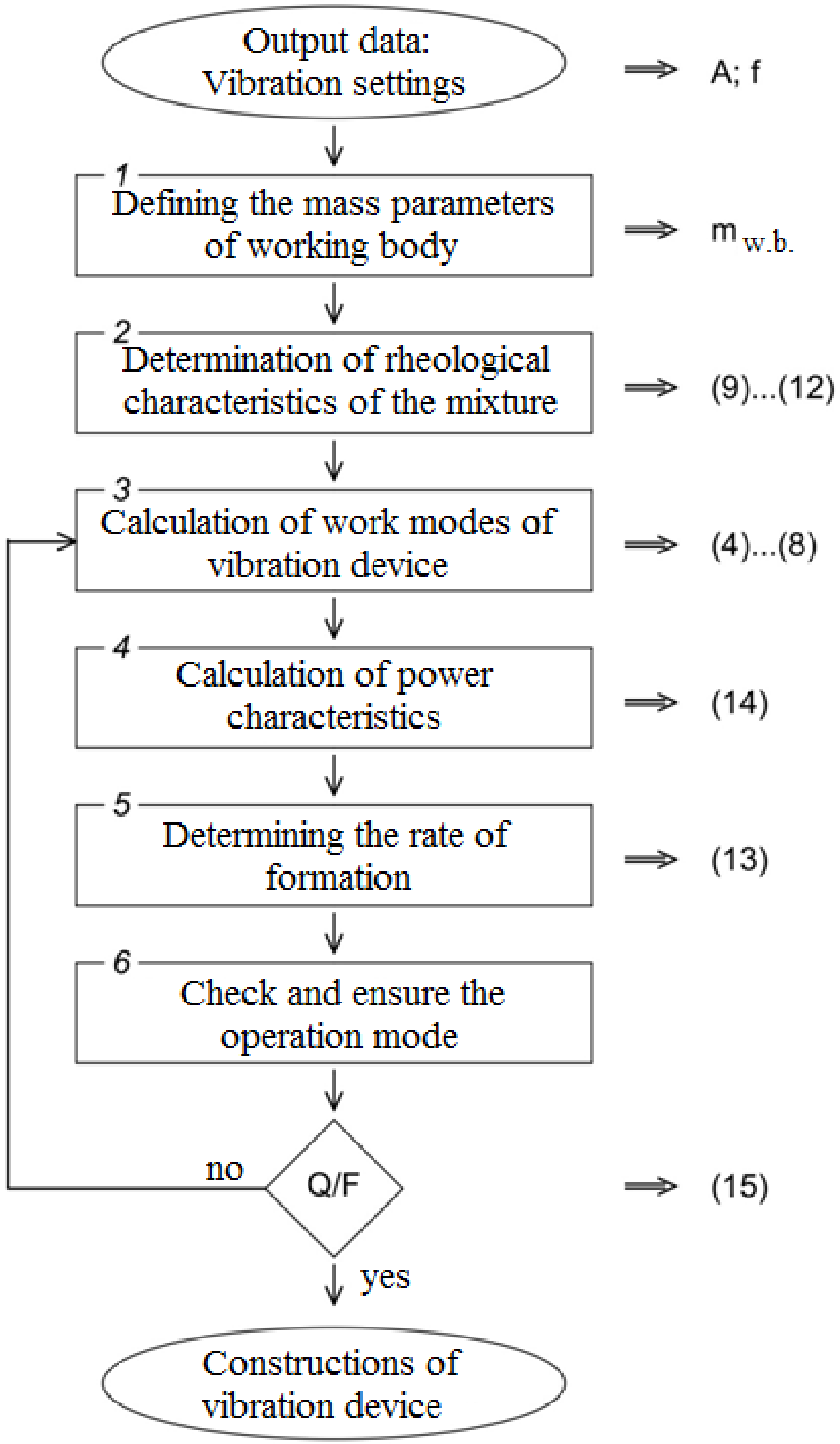

Fig. 3. Algorithm for calculating the main parameters of vibration device.

4. The basic dimensionless parameters for assessing the efficiency of compaction concrete.

5. The main parameters of working process of a vibrating device enabling to formulate the algorithm and method of engineering calculation of vibrating device.

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Анотація. *В статті запропоновано метод інженерного розрахунку вібраційного пристрою для формування горизонтальних поверхонь на основі розгляду взаємодії оброблюваної бетонної суміші з реалізацією безлічі робочих параметрів робочого органу.*

Ключові слова: ***метод, розрахунок, параметри, вібрація***

Аннотация. *В статье предложен метод инженерного расчета вибрационного устройства для формирования горизонтальных поверхностей на основе рассмотрения взаимодействия обрабатываемой бетонной смеси с реализацией множества рабочих параметров рабочего органа.*

Ключевые слова: ***метод, расчет, параметры, вибрация***