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Dehydration of no flotation size coal's slimes on the deck of high-frequency screen with multislopes area's working surface

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Summary. The physical model of dehydration of coal slimes is offered on the deck of high-frequency screens as a process of the pulsating forming of inertia visco-plasticmaterial object, in which a coefficient of viscidity is the function of intensity of oscillation excitation.

Key words. Coal, dehydration, physical model, intensity of oscillation excitation.

INTRODUCTION

During the coal slurry dewatering [20, 15, 14, 6, 22], solid phase volumetric concentration is increased due to water removal through the screen mesh. Thus coal slurry structural-mechanical properties [24, 1, 7, 8, 9] are substantially changed. Effective slurry viscosity is subject to the most significant alteration due to its nonlinear dependence on volumetric concentration of solid particles [16, 4, 27].

The processes of muds dehydration in coal's preparation's technology [25, 13, 10, 11, 26, 12] are widely used on high-frequency screens. Quality of products of dehydration to a great extent is determined the parameters of vibration of working surface of screen. However presently the adequate physical models of process absent dehydrations of suspensions' on a vibrating deck surface, allowing making the choice of optimum regime parameters.

In the article the attempt of development of physical model of dehydration's process at motion of stream of suspensions' is done on a vibrating deck at the monotonous decline of liquid phase concentration.

RESEARCH ANALYSIS

Slurry elastic characteristics are resulted from the air bubbles presence. However, during dewatering on the screen sieve accompanied by the layer vibration thickening air bubbles are intensively released through the free layer surface and through its bottom boundary, i.e. through the screen. Thus, slurry layer on the screen may be assumed as a viscoplastic rheological body.

High-concentration slurry is characterized by the spatial structure resistive to stress not exceeding certain τ_c, value designated as shear stress or yield strength [28]. In case that material stress exceeds the yield strength, its structure collapses, and shearing flow occurs, of which rate is proportional to excess shear velocity, i.e., material behaves as a Newtonian fluid at the shear stress τ- τ_c.

RESEARCH OBJECT

It is known [20] that dehydration's process of suspensions' on a vibroscreen it is possible to divide conventional into three stages.

On the first stage, characterized considerable maintenance of liquid phase, there is preliminary dehydration, conditioned mainly hydrostatical pressure layer suspensions', on the second stage the process of dehydration is conditioned the inertia constituent of vibrations, providing tearing away of free moisture from sticespace of layer of material, on the third stage the process of dehydration takes a place due to the vibrocompression of material layer attended with the selection of free moisture from sticespace space layer.

On the first stage an initial suspensions', given on a screen, has an enough low concentration of liquid phase and can be examined as a homogeneous liquid with effective viscidity, exceeding viscidity of liquid phase. For the small concentration of the self-weighted particles of regular shape effective viscidity of suspensions' is calculated on simple formulas [15]. Oscillation influence is elevated by suspensions' viscidity, as amplitudes of particulate matters' vibrations less amplitude of liquid's particles vibrations. Therefore for the case of small concentration of particulate matters selection of liquid phase through openings of deck more effective for an immobile sifting surface. If speed of suspensions' flow on a deck is not very much high, expiration of liquid through openings of deck will be determined the depth of suspensions' stream.

Deformation of viscoplastic material results in occurrence of stress $\tau = \eta\dot{\varepsilon} + \tau_c$, where η is viscosity coefficient, and $\dot{\varepsilon}$ is rate of deformation.

Let us consider a viscous material behavior on the harmonically oscillating horizontal sieve surface under the unseparated conditions.

Let us distinguish unit cross-section bar in the material layer with axis coinciding with the pressure load normal component on the screen side. The bar height is equal to the material layer thickness h and bar mass $m = \rho h$, where ρ is the material density.

Material layer is subject to harmonic exciting force $F \cos \omega t$, where F and ω are the exciting force amplitude and frequency, and t is the time. In addition, during the oscillation layer is subject to inertia forces due to the material density ρ, viscous friction forces and dry friction forces determining the material plastic deformation.

The screen surface vibration normal component results in layer deformation and facilitates its dewatering, while the tangent component provides layer vibratory displacement. Therefore, when taking account of vibration normal component only, we assume that layer inertia force will be $m\ddot{y} = \rho h\ddot{y}$, where y is layer vertical displacement, $y = \varepsilon h$.

Viscous friction force in the material layer is equal to $\eta\dot{y}$, where $\dot{y} = h\dot{\varepsilon}$ is the layer vertical displacement velocity.

Dry friction force $\vec{R}$ is constant in magnitude and is directed oppositely to displacement velocity $\vec{R} = -R\dot{y}/|\dot{y}|$, where R is constant depending on the friction coefficient and cohesive force. If force $\vec{R}$ is resulted from the stress exerted upon the lateral surface of the square bar, then $R = 4h\tau_c$. Assuming the permanent plastic deformation during the layer vibration thickening, we will represent dry friction force as $R(\operatorname{sgn}\dot{y} + 1)/2$ [17,18], where:

$$\operatorname{sgn} = \dot{y}\begin{cases} 1 & at\ \dot{y} > 0, \\ -1 & at\ \dot{y} < 0. \end{cases}$$

Thus, layer plastic deformation occurs, if screen displacement velocity is directed upward, and the stress in layer exceeds ultimate shear stress τ_c. If screen velocity is directed downward, then dry friction force is equal to zero, and layer moves as an inertia body.

Fig.1 shows dynamic computational diagram of the inertia viscoplastic body being subject to harmonic exciting force.

The equation for layer motion on the vibrating surface takes the following form based on the assumed dynamic design:

$$m\ddot{y} + \eta\dot{y} + 2h\tau_c\left(\operatorname{sgn}\dot{y} + 1\right) = F\cos\varpi t. \qquad (1)$$

Layer height varies slowly at the final dewatering process stage, so that $dh / dt << 1$.

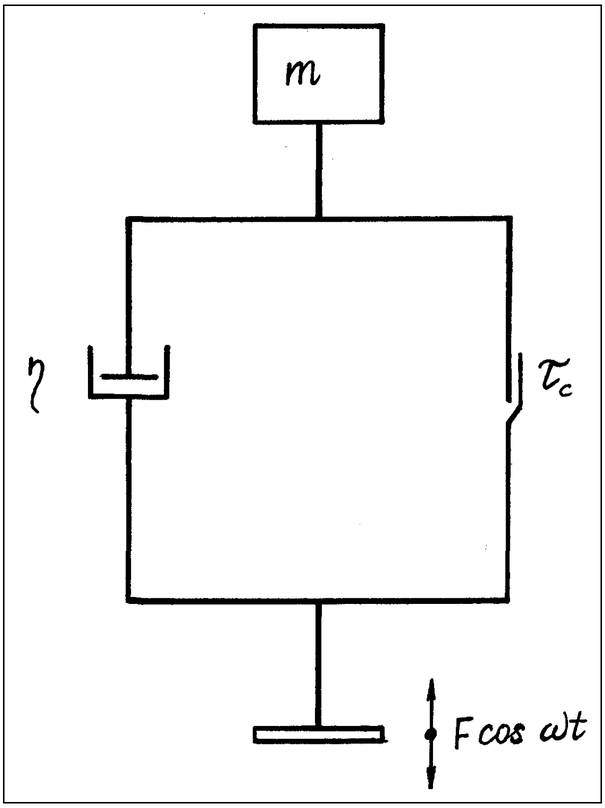

Fig.1. Dynamic computational diagram of the inertia viscoplastic material on the vibrating surface

The equation (1) includes nonlinearity due to the function sgn $\dot{y}$. Such type equations are solved with the use of methods of step-by-step integrating or methods based on the motion equation linearization [2].

In order to reduce equation (1) to the linear form we will use the power balance method [19, 3, 21, 5, 23] whereby nonlinear dry friction force can be replaced with the energy equivalent linear force $b_o\dot{y}$, for which coefficient b_o is determined based on the condition of equality of the works done by both forces over the oscillation period [24], i.e.:

$$\int_0^T \tau_c \operatorname{sgn}\dot{y}\cdot\dot{y}\cdot dt = \int_0^T b_o\dot{y}^2 dt. \qquad (2)$$

We cam assume for a first approximation that oscillatory process is harmonic in the steady conditions.

One can see from the equation (1) that nonlinear friction force presents at the positive velocity values only, and function sgn $\dot{y}$ takes on values 0 and 1. Therefore expected oscillatory law for the layer displacement velocity will be:

$$\dot{y} = -a\varpi\sin\varpi t, \qquad (3)$$

where: a is the layer oscillation amplitude.

Insertion of expression (2) into (3) results as follows:

$$\int_0^T b_o\dot{y}^2 dt = b_o a^2\varpi\int_0^{2\pi}\sin^2\psi d\psi = b_o\pi a^2\varpi, \qquad (4)$$

where: $\psi = \omega t$.

Let us calculate an integral on the left part of (2) for the nonlinear resistance force:

$$\int_0^T \tau_c\dot{y}\operatorname{sgn}\dot{y}\cdot dt = -\tau_c a\int_0^{2\pi}\sin\psi\operatorname{sgn}\dot{y}\cdot d\psi = 4\tau_c a. \qquad (5)$$

Equating results of calculations of (4) and (5) allows determination of equivalent friction coefficient:

$$b_o = \frac{4}{\pi a\varpi}\tau_c.$$

Once the coefficient b_o is determined, the problem reduces to investigation of the equivalent linear dynamic system where the dry friction force is as follows:

$$2h\tau_c\left(\operatorname{sgn}\dot{y}+1\right)\approx 2h\tau_c\left(b\dot{y}+1\right),$$

where: b = 4/πaω.

In case of the system with the non-elastic resistance, oscillatory motions lag behind the exciting force. Therefore, if oscillatory motions follow the low $y = a\cos\omega t$ as a first approximation, then law of variation of exciting force can be on written as $F\cos(\omega t + \varphi)$, where φ is phase angle. Then the motion of the linearized dynamic system will be described by equation:

$$m\ddot{y}+\left(\eta+2bh\tau_c\right)\dot{y}+2h\tau_c=F\cos\left(\varpi t+\phi\right). \quad (6)$$

At the moments of maximum system departure from the equilibrium point when $\cos\omega t = 1$:

$$F\cos\phi=2h\tau_c-ma\varpi^2,$$

and at the moment of equilibrium point passage $\cos\omega t = 0$ and:

$$F\sin\phi=\left(\eta+2bh\tau_c\right)a\varpi-2h\tau_c.$$

After the last equalities squaring and addition, we will obtain following expression associating the exciting force value and system oscillation amplitude:

$$F^2=\left(2h\tau_c-ma\varpi^2\right)^2+\left(Ba\varpi-2h\tau_c\right)^2, \quad (11)$$

where: B = η + 2bhτ$_c$.

Thus oscillation phase is as follows:

$$\phi=arccos\frac{2h\tau_c-ma\varpi^2}{F}.$$

Equation (6) is linear with respect to $\dot{y}$, and its solution is known:

$$\dot{y}=\ell^{-\frac{B}{m}t}\left\{\int\left[\frac{F}{m}\cos\left(\varpi t+\phi\right)-\frac{2h\tau_c}{m}\right]\ell^{\frac{B}{m}t}dt+C_o\right\},$$

where: C_o is the initial value. Solving this integral at the initial condition:

$$\dot{y}=0 \text{ given } t = 0,$$

we obtain:

$$\dot{y}=\frac{2h\tau_c}{B}\left(\ell^{-\frac{B}{m}t}-1\right)+\frac{Fm}{B^2+m^2\varpi^2}\times$$
$$\times[\frac{B}{m}\cos\left(\varpi t+\phi\right)+\varpi\sin\left(\varpi t+\phi\right)-$$
$$-\left(\frac{B}{m}\cos\phi+\varpi\sin\phi\right)\ell^{-\frac{B}{m}t}]. \quad (11)$$

The solution (11) describes the layer velocity variation with account for the transient process in the initial time period. The expression (11) can be rewritten for the steady-state process $t \to \infty$ as follows:

$$\dot{y}=\frac{Fm}{B^2+m^2\varpi^2}\left[\frac{B}{m}\cos\left(\varpi t+\phi\right)+\varpi\sin\left(\varpi t+\phi\right)\right]-$$
$$-\frac{2h\tau_c}{B}.$$

Integration of expression (11) at the initial condition $y = h_o$ at $t = 0$ results in determination of the vibrating layer displacement:

$$y=h_o-\frac{2h\tau_c}{B}\left[t-\frac{m}{B}\left(1-\ell^{-\frac{B}{m}t}\right)\right]+$$
$$+\frac{Fm}{B^2+m^2\varpi^2}\times[\frac{B}{m\varpi}\sin\left(\varpi t+\phi\right)-\cos\left(\varpi t+\phi\right)+$$
$$+\left(\cos\phi+\frac{m\varpi}{B}\sin\phi\right)\ell^{-\frac{B}{m}t}-\frac{B^2+m^2\varpi^2}{m\varpi B}\sin\phi.$$

In steady-state process $(t \to \infty)$:

$$y = h_o - \frac{2h\tau_c}{B}t + \frac{Fm}{B^2 + m^2\varpi^2} \times$$
$$\times \left[\frac{B}{m\varpi}\sin(\varpi t + \phi) - \cos(\varpi t + \phi) - \frac{B^2 + m^2\varpi^2}{m\varpi B}\sin\phi \right].$$

The solution describes material layer surface displacement at the oscillatory shear flow and includes evolutionary:

$$y_1 = h_o - \frac{2h\tau_c}{B}t - \frac{F}{\varpi B}\sin\phi$$

and oscillatory:

$$y_2 = \frac{Fm}{B^2 + m^2\varpi^2}\left[\frac{B}{m\varpi}\sin(\varpi t + \phi) - \cos(\varpi t + \phi) \right]$$

components. The layer vibration thickening process takes place without its mass variation at the constant resistance. It is reasonable that the layer thickening is only possible when the stress in material exceeds shear stress τ_c.

Evolutionary component of thickening rate under the steady-state conditions $dy/dt = -2h\tau_c/B$. Here the layer height h *is* present as a parameter.

Concentrated slurry viscosity coefficient depends on the vibration parameters as follows:

$$\eta = \eta_o + \frac{k}{a\varpi^3},$$

where: k is the constant coefficient, and η_o is the residual viscosity coefficient due to the oscillatory thixotropic destruction of dispersion medium.

Then the rate of material layer thickening on the vibrating screen:

$$\frac{dy}{dt} \approx -\frac{2h\tau_c}{\eta_o + \frac{k}{a\varpi^3} + \frac{8h\tau_c}{\pi a\varpi}}.$$

Parameters τ_c, η_o and k included in this formula are subject to the experimental determination.

Fig. 2 shows plots of layer thickening rate against working surface vibration amplitude and frequency. Exemplary material parameters for the layer of h = 0.1 m are assumed as follows [12,13]: τ_c = 10 N/m^2, $\eta_o = 10^3$ M·s/m^2, $k = 10^6$ N/m·s^2 .

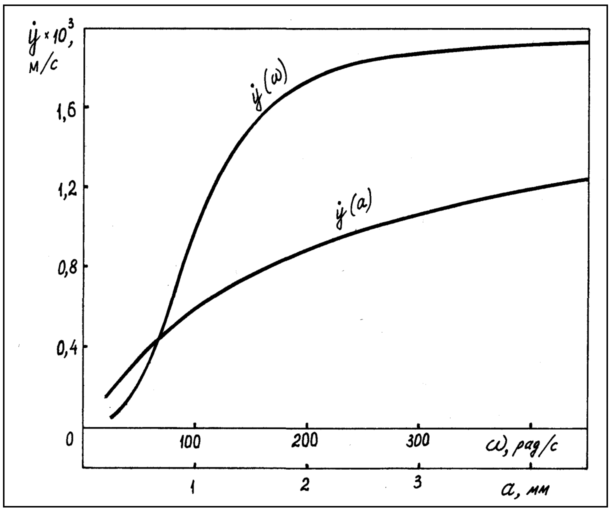

Fig. 2. Viscoplastic material vibration thickening rate vs. working surface vibration amplitude and frequency:

$\dot{y}(v)$ *при* a=1 mm,

$\dot{y}(a)$ *при* $v = 75$ *рад/с.*

RESULTS OF RESEARCH

On the first stage there is a translation of coal suspensions' in highly concentrated due to the upcast of free-drying.

On the second stage the translation of highly concentrated suspensions' is carried out in viscoplastic material due to the delete of external moisture.

Beginning of the third stage corresponds the state of the water saturated system of particulate matters, at which regular contacts have particles with each other. On this stage the process of dehydration is already determined the vibrocompression' process of particles of hard phase and delete of the liquid freed from interparticle space through a deck.

It is known that its rheological properties change during the vibration of the structured suspensions'. It is experimentally set [3] that deformation of mixture (or its speed) at unchanging as compared to static middle tension is increased in

$\left[1+\alpha\left(A\omega^2/g\right)\right]\psi\left(Ti\right)$ one times, where A and ω accordingly, amplitude and frequency of vibrations, $\psi\left(Ti\right)$ it is a function of specific thixotropic, depending on granule compositions and circulating in unit in default of vibration, g it is an acceleration of gravity, α it is a constant.

Between the modes of vibration and viscidity of highly concentrated suspensions many authors were engaged in the decision of problem of establishing a connection [14]. Semiempiric formulas, including the different criteria of intensity of vibration, are got as a result. The most reliable are consider the criterion of intensity and dependence of viscidity from the mode of vibration, where is viscidity of the fully blasted structure. Thus, quality of dehydration on this stage substantially depends on the parameters of vibration of dehydrating surface.

It is set [6] that the compression of dispersible environment is determined in size accelerations of the vibrations put to it. Thus, the optimum value of acceleration depends on physic-mechanical properties of environment. The compression of environment takes a place because of decline of forces of friction between particles due to the action of inertia forces and gravities.

It is experimentally set [6] that at influence of vibration with the optimum for a compression acceleration of particle of environment with a high-slay and largenesses can walk up a surface layer. This phenomenon is explained the difference of values of optimum accelerations for the particles of different largeness and closeness in the process of vibrocompression.

It is known also, that at more high-frequencies a maximal compression is arrived at less amplitudes. However with the increase of frequency the degree of maximal compression goes down. Growth of amplitude of vibrations only to the known limit is instrumental in the increase of closeness. The certain most usefully frequency of vibrations, cooperated achievement of maximal compression, corresponds every value of amplitude.

The results of researches of influence of duration of process of vibrocompression rotined on the degree of compression [6], that the process of compression flowed unevenly with decreasing speed: more intensively in initial moment, and then speed of compression diminishes. Such unevenness is explained that as far as the compression of environment the area of surfaces of contact between particles is increased, what efficiency of influence of vibration goes down because of.

On the third stage dehydration of suspensions is carried out in two stages [22]: overstowage of particles of hard phase and their rapprochement.

On the stage of overstowage under the action of vibration there is destruction and alteration of unsteady casual structure of particles which under the action of gravity aim to occupy the most advantageous power position.

Reason of destruction of the structured system of dispersible particles is relative inertia displacement of particles of hard phase of different closeness and size.

This relocation bias the more than anymore mass of particle, higher acceleration of vibrations, anymore difference of closenesses of particle and environment, than less than viscidity of the system. At the end of the stage of overstowage the system acquires a steady structure.

On the stage of rapprochement of substantial change of structure of particles does not take a place. The compression of mixture is carried out as a result of rapprochement of particles, their moving apart and relative changes, that is conditioned not only vibroinfluence but also redistribution on volume of liquid phase. Time of the second stage considerably anymore duration first. On this stage at relative displacement of particles there is «wringing» out of liquid phase from the pores of mixture.

On the final stage of dehydration formation of the thixotropic structured system, formed as a result of coagulative co-operations is possible. As a result of action of effect of the oscillation work-hardening of structure formation of the new work-hardened contacts is possible, that results in formation of hard dispersible structure.

On the basis of the expounded pictures of process of dehydration the simplified dynamic model layer suspensions on the working surface of vibroscreen can be interpreted visco-plastical rheological body with the added mass, to equal mass of bar of single section the height of which is equal to the height of layer of dry material, and a closeness is equal to the closeness of suspensions. As a result of action of vibration there is a limit of fluidity of material $\sigma_o \to 0$, and tension in a plastic element proportionally deformations: $\sigma_n = k_{\text{п}}\varepsilon_{\text{п}}$, where $k_{\text{п}}$ is a coefficient of plasticity, and $\varepsilon_{\text{п}}$ is deformation of plastic element. In addition, suppose that the height of layer of water-free material is equal to h_m, and then tension in a plastic element on the stage of compression of layer proportional to $(h_1 - h)/(h_1 - h_m)$, that is to say resistance a flowage changes from zero to $k_{\text{п}}$.

We suppose that a height of layer of the dehydrated material $h = h(t)$ is a slowly changing parameter, remaining unchanging during one period of vibrations of working surface. Then equalization of motion of layer of the dehydrated material on the sieve of crash under the action of the pulsating loading $F_o \sin\omega t$, proper the i-period of vibrations, it will be:

$$\rho h(t)\,\ddot{y} + K\dot{y} + \frac{h(t)}{h(t) - h_m}k_{\text{п}}y = F_o\sin\omega t. \tag{12}$$

where: ρ is a closeness of the dehydrated material, K it is a coefficient of viscid resistance, F_o and ω accordingly, amplitude of revolting force and frequency of the forced vibrations of working surface of screen.

Because layers deformation is irreversible and developing only in the direction of decline, during the semiperiod of vibrations a layer moves as a solid by mass, and during the second semiperiod as inertia visco-plastical Bingham's body in accordance with equalization (12).

The decision of equalization (12) is searched in a kind:

$$y = A_i\sin\omega t + B_i\cos\omega t. \tag{13}$$

After the substitution of expression (13) in equalization (12) expression (13) can be presented in a kind:

$$A_i = F_o\frac{\dfrac{h_1 - h_i}{h_1 - h_m}k_{\text{п}} - \rho h_i\omega^2}{\left(\dfrac{h_1 - h_i}{h_1 - h_m}k_{\text{п}} - \rho h_i\omega^2\right)^2 + K^2\omega^2},$$

$$B_i = \frac{F_oK\omega}{\left(\dfrac{h_1 - h_i}{h_1 - h_m}k_{\text{п}} - \rho h_i\omega^2\right)^2 + K^2\omega^2}.$$

$$y = a_i\sin(\omega t + \varphi_i),$$

where:

$$a_i = \sqrt{A_i^2 + B_i^2} =$$

$$= F_o\left[\left(\frac{h_1 - h_i}{h_1 - h_m}k_{\text{п}} - \rho h_i\omega^2\right)^2 + K^2\omega^2\right]^{-\frac{1}{2}},$$

$$\varphi_i = arctq(B/A) = arctq\frac{K\omega}{\rho h_i\omega^2 - \dfrac{h_1 - h_i}{h_1 - h_m}}.$$

Thus, the vibrations of surface of layer of the dehydrated material take a place with frequency of the forced vibrations, and the change of phase in the i-period of vibrations is equal φ_i and depends on a layers height.

There is a height of layer of the dehydrated material $h = h_1$ in initial moment of compression . Thus a flowage is equal to the zero and motion of material is characterized inertia and viscous resistances. As far as diminishing of height of layer arise up and plastic resistances increase further. The algorithm of calculation of changing height of layer consists of the following.

We suppose $h = h_1$ and on formulas (12) calculate coefficients A_i and B_i. Then on a formula (12) determined a_1 – amplitude of vibrations in the direction of diminishing h for the first period of vibrations of process of compression.

Then, for first period of vibrations the change of materials layer height will make $\Delta h_1 = F_o / \left(\rho h_1 \omega^2\right) - a_1$. At the beginning of the second period $(i = 2)$ of vibrations $h_2 = h_1 - \Delta h_1$. Repeating calculations will define $\Delta h_2 = a_1 - a_2$, $h_3 = h_2 - \Delta h_2$ et cetera. Iteration process continued to achievement of time $t = i / 2\pi\omega$, equal time of unloading of water-free material from the deck of screen. For example, at frequency of unbalance screens billow rotation of 150 radian/sec, to middle speed of materials portage at dehydration 0,1 m/sec and to length of deck area on which the process of vibrocompression is provided actually, equal 2 m, and iteration count will be 3000.

CONCLUSIONS

1. These data enable length calculation for screen dewatering surface devices, where the first device is designed for the material dewatering with the prevailing use of hydraulic principles, while the second one is designed for dewatering due to the laws of inertial mixtures mechanics.

2. Thus, on the basis of presentation of dehydration process of suspensions on a vibroscreen, as a process of pulsating deformation of inertia viscoplastic body, a dynamic model, answering equalization (12) in which a coefficient of viscidity is the function of intensity of oscillation influence, is offered $A\omega^2 / g$.

REFERENCES

1. **Averin G.A., 2008.:** Coal content prediction in technogenic deposits, Ugol Ukrainyi, № 4, 42-44. (in Russian).
2. **Blekhman I.I., Dzhanelidze G.Y., 1964.:** Oscillatory displacement, Moscow, “Nauka”. (in Russian).
3. **Bronstein I.N., Semendyaev K.A., 1986.:** Reference book on mathematics for engineers and students of technical college, Moscow, “Nauka”. (in Russian).
4. **Dominika Katarzyna Szponder, Kazimierz Trybalski, 2011.:** Fly ash in agriculture - modern applications of coal combustion by-products, TEKA. Commision of motorization and energetics in agriculture, Lublin University of Technology, Volodymyr Dahl East-Ukrainian National University in Lugansk, 11, 373-385.
5. **Fomenko T.G., Kondratenko A.F., 1977.:** Flotation tailings and properties thereof, Moscow, “Nedra”. (in Russian).
6. **Goncharevich I.F., 1981.:** Theory of vibration technique and technology Moscow, Science, 320. (in Russian).
7. **Grachev O. V., Pozhydaev V. F., 2000.:** Conditions of mathematical description of the coal ash fractions distribution, Visnyk SNU, №9, Ch.1. (31), 99-105. (in Russian).
8. **Grachev O.V., 2012.:** Enrichability curves analysis of several coals mixture, TEKA. Commision of motorization and energetics in agriculture, Lublin University of Technology, Volodymyr Dahl East-Ukrainian National University in Lugansk, 2012, Vol. 12, No 4, 64 70.
9. **Grachev O.V., Pozhidaev V.F., Ul'shin V.A., 2005.:** The process control system of coal batch preparation for optimal separation on arbitrary criterion, Enrichment of minerals, Scientific and technical collection NGU, Dnepropetrovsk, Vip. 22(63), 158-165. (in Russian).
10. **Grachev O. V., 2003.:** Efficiency of increasing the stability of quality of coal concentrates, Visnik SNU im. V. Dalja, № 4 (62), 126-129. (in Russian).
11. **Grachev O. V., Pozhidaev V. F., Tarasenko S.A., 2007.:** Informational model of a coal preparation plant schema, Enrichment of minerals, Scientific and technical collection NGU, Dnepropetrovsk, Vip. 29(70) – 30(71), 216-218. (in Russian).

12. **Grachev O. V., PozhidaevV. F., 2010.:** Analytical method for calculating the separation results for quality control of products of enrichment, Enrichment of minerals, Scientific and technical collection NGU, Dnepropetrovsk, Vip. 41(82) – 42(83), 244-250. (in Russian)
13. **Kolmogorov A.N., 1941.:** About the logarithmic normal distribution of particle sizes at crushing, DAN SSSR, Novaja Serija, Moscow, T.31, №2, 99-101. (in Russian).
14. **Kunnos G.Ya.,1967.:** Vibration technology of concrete, Leningrad: Stroyizdat, 168. (in Russian).
15. **Landau l.D. 1988.:** Hydrodynamics, Moscow, Science,736. (in Russian).
16. **Oleg Lehtsier, Vitaly Ulshin, Oleg Kilymnik, Alexey Pismenskiy, 2012.:** Determination the dynamic parameters of the controlled technological processes of coal preparation by using the semi graphical method, TEKA. Commision of motorization and energetics in agriculture, Lublin University of Technology, Volodymyr Dahl East-Ukrainian National University in Lugansk, Vol. 12, №4, 117-121.
17. **Palmov V.A., 1976:** Elastic-plastic body oscillation, Moscow, “Nauka”. (in Russian)
18. **Panovko Y.G., 1976.:** Fundamentals of the applied oscillation and impact theory, Leningrad, “Mashinostroenie”. (in Russian).
19. **Panovko Y.G., 1971.:** Introduction to the mechanical oscillation theory, Moscow, “Nauka”. (in Russian).
20. **Polulyakh A.D., 2013.:** Change of structurally mechanical properties of coal muds in the process of dehydration on the deck of screen, Mineral dressing: Sciences technical volume, Vol. 52(93), 96-106. (in Russian).
21. **Rudenko I.F., 1971.:** Product forming with the use of vibroforming equipment, Moscow, “Stroyizdat”. (in Russian).
22. **Savinov O.A., 1986.:** The vibration technique of compression and forming of concrete mixtures, Leningrad, Stroyizdat, 280. (in Russian).
23. **Tihonov O.N., 1985.:** Automation of enrichment plants production processes, Moscow, Nedra, 272. (in Russian).
24. **Tihonov O.N., 1973.:** Introduction to the dynamics of enrichment technology mass transfer processes, Leningrad, Nedra, 239. (in Russian).
25. **Vitaly Pozhidayev, Oleg Grachyov, 2010.:** The analytical problem solution of finding the several coals mix characteristics, TEKA. Commision of motorization and energetics in agriculture, Lublin University of Technology, Volodymyr Dahl East-Ukrainian National University in Lugansk, OL PAN, 10B, P. 105-113.
26. **Vitaly Ulshin, Oleg Grachyov, 2010.:** The analytical solution method of the ordinary coals optimum batching problem, TEKA. Commision of motorization and energetics in agriculture, Lublin University of Technology, Volodymyr Dahl East-Ukrainian National University in Lugansk, OL PAN, 10B, 266-274.
27. **Vitaliy Danich, Svitlana Shevchenko, 2012.:** Models of the dynamics of the information-management architectures of the coal industry enterprises, TEKA. Commision of motorization and energetics in agriculture, Lublin University of Technology, Volodymyr Dahl East-Ukrainian National University in Lugansk, Vol. 12, №4, 31-35.
28. **Wilkinson U.L., 1964.:** Non-Newtonian fluids, Moscow, “Mir”. (in Russian).

ОБЕЗВОЖИВАНИЕ УГОЛЬНОГО ШЛАМА НА СИТЕ ВЫСОКОЧАСТОТНОГО ВИБРАЦИОННОГО ГРОХОТА С РАЗНОНАКЛОННЫМИ УЧАСТКАМИ РАБОЧЕЙ ПОВЕРХНОСТИ

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Аннотация. Предложена физическая модель обезвоживания угольных шламов на высокочастотных вибрационных грохотах как процесс пульсирующего формирования вязко-пластичного материала, в котором коэффициент вязкости является функцией интенсивности возбуждения колебаний.

Ключевые слова: уголь, обезвоживание, физическая модель, интенсивность возбуждения колебаний.