Practical implications. Reasonable improvements in the design of water-lowering wells during rotary drilling with backwashing for obtaining optimal hydrogeological parameters. The optimal parameters of the water lowering wells and the required decrease in the groundwater level depending on the statistical level in the wells are established, which indicate that the total flow rate of the water lowering wells has a dynamic nature and ranges from 4 m to 7 m., And the specific flow rate - from 0.62 m. To 13.64 m. Recommendations for implementation are given in accordance with the feasibility study.

Keywords: *flow rate, dewatering wells, process parameters, pumping out, open pit*

УДК 622.271.3

© О.П. Стрілець, Г.Д. Пчолкін, М.Р. Мекшун

ОСОБЛИВОСТІ ФОРМУВАННЯ ТЕХНОГЕННИХ РОДОВИЩ ВАПНЯКУ

© O. Strilets, G. Pchelkin, M. Mekshun

FEATURES OF FORMATION OF TECHNOGENIC LIMESTONE DEPOSITS

The purpose of the work is to create and use patterns of segregation in the formation of man-made deposits (tier of dumps, storage of finished products in the form of a cone) with the help of the basic laws of theoretical mechanics.

Research methods. For decision-making methods of analysis of the patterns of segregation of rocks during the formation of tiers of dumps were used. Statistical analysis was applied in generating random numbers. Natural studies on models with the transfer of results to existing mining in the conditions of the Dokuchaevsk flux-dolomite company.

The results. Segregation laws become important in the formation of man-made deposits. The theoretical basis of the physical mechanism of the phenomenon of segregation of the rock mass in the formation of dumps and the storage of minerals or finished products in the embankments allow to take into account the initial distribution of the fractional composition of the rock mass, which has important practical application in the development of man-made deposits or shipments of finished products to the customer.

Scientific novelty. Modeling the segregation of the rock mass allows predicting the quality of the segregation effect on a sloping surface, which depends on the fractional composition of the rock, the slope angle and the height of the cone of the dump. The dependence of the segregation effect on the height of unloading on the sloping surface of fractions of rubble 0 - 5 mm (20%) and 5 - 15 mm is established. The character of the distribution of middle size pieces in height of the cone of the embankment and around its axis is shown.

The practical significance. The adequacy of the mathematical model considered in this paper has been experimentally proved, which will allow us to apply the results of studies in the formation of man-made deposits with subsequent development. It has been established that for storage conditions of fraction 5-15 mm with a natural moisture and content of nonconstituent components of 20 %, the optimum height of the cone of the stockpile is 20 m, which ensures the required quality of rubble at the basis of the cone and the appropriate parameters for the finished product loading by EKG-5A excavator. The height of the stockpile with high humidity should be raised to 25 m.

Key words: *segregation, technogenic deposits, mining industry, fraction, excavator*

Introduction. A mining process is accompanied the accumulation of large amounts of industrial wastes, the breach of the Earth's surface and the other negative ecological problems. At present over 7 billion of cub.m. of overburden rock are only accumulated in the dumps of mining enterprises of Ukraine, about 190 thousand ha of lands are disturbed by mining works.

Passing to resource-saving technologies of extraction and processing of minerals is possible, in the first place, due to the complex use of raw material, by the increase of product output of the unit involved in resource development.

Considerable part of wastes, that occurs at extraction and dressing of minerals often presents passing minerals. Similar technogenic deposits of minerals are the additional source of raw materials for different industries of national economy. However, the perspective of development of similar deposits largely depends on knowledge of distributing features of useful component in technogenic formation.

Separation processes in the bulk material of the rock mass, as a result of technological influence and natural phenomenon is segregation, largely determines the perspective of technogenic deposit.

In practice of mining production the special value has an effect of segregation, which shows up at pouring out dead rock dumps, forming of ore storages of the different functional setting both in quarries and on the industrial site mining and processing enterprises, at pouring out of dams and dikes, in the body of technogenic mineral deposits, at downhole hydraulic output of minerals.

The effect of segregation is widely used in practice of ore-dressing of ferrous and non-ferrous metals. The segregation also occurs in a gaseous and liquid environment, that is used in the processes of dressing of minerals, in chemical industry.

Basic conformity to law of segregation is distinctly looked over at the visual analysis of surface of slopes of dumps: a concentration of shallow factions in the upper part of slopes, large factions – in the lower part of them. The separation process of the rock mass according to its size during the formation of piles depends on many factors: its physical and mechanical properties, geometric parameters of surface dumping slope, the granulometric composition of the rock and its form of separate; grain-size distribution of rock and form of its separate pieces piling parameters – performance dumping, the rate of discharge.

It is determined that during the spontaneous segregation of rock mass in the dumps and transshipment areas are prerequisites for their selective mining, taking into account the granulometric composition of the rock mass accumulated in the different layers of the embankment to a height of the pile.

In a number of deposits, the steady statistical regularity is exposed: the qualitative indices of shallow factions of mineral raw material considerably differ from the proper descriptions in large classes. Separation of technogenic mineral deposits on grain-size and material distributions, as a result of migration of useful components on between pore spaces of composing species and segregation of solid components of pulp, naturally leads to the formation of nuclei – the original «ore bodies», which coincides with the bulk minerals lost from enrichment.

However, for the decision of wide circle of engineering, technological and ecological tasks it is necessary to know conformities to law of change of grain-size distribution, porosity, coefficient of filtration, bulk density of rocks and other qualitative indices of the entire volume of bulk body.

Problem statement. Thus, theoretical basis for physical mechanism of the phenomenon the segregation of the rock mass at pouring out of dumps and ore storage taking into account initial grain-size distribution and warehousing technology it is necessary to consider an actual scientific task, having important practical application. To know the laws of segregation acquires an important practical value also for that reason, that a number of deposits found steady statistical dependence on qualitative indices from the class size piece of rock.

The **purpose** of work is to establish and use of the conformities to law of segregation in the formation of technogenic man-made object (tier of dump, storage of the prepared products in the cone-type form) with the help of the fundamental laws of theoretical mechanics. It was to: a mathematical model, firstly, to the fullest extent we take into account the characteristics of rock (grain size, connectivity elements among themselves, a factor of "flakiness"), secondly – the opportunity to implement features of the formation technology of man-made object.

The main material. The first part of this problem is solved by setting this kind of interaction that take into account the essential components (1, 2): gravity ~ R_3; friction at the interaction between the pieces themselves and the surface, as well as the influence of the environment (in our case, the air friction) which in turn ~ R_2.

$$\begin{aligned} f_x &= f_{x1} + dt \cdot x_1 \cdot r_{э1} - G_2 \cdot G_1 \cdot (v_{X1} - v_{X2}) + \sigma, \\ f_z &= f_{z1} + dt \cdot z_1 \cdot r_{э1} - G_2 \cdot G_1 \cdot (v_{z1} - v_{z2}) + \sigma. \end{aligned} \quad (1)$$

$$\begin{aligned} f_x &= f_{x1} - G \cdot v_{x1} \cdot R^2, \\ f_z &= f_{z1} - g \cdot m + B \cdot \exp\left(-\frac{z_1}{b}\right) \cdot R^2 - G \cdot v_{z1} \cdot R^2. \end{aligned} \quad (2)$$

where G_1, G_2 are parameters, characterizing a friction between interactive objects 1 and 2 (particle – particle, particle – surface), *s* – an additional term takes into account the friction of the air.

The model assumed that the land filling of bulk material (throw particles – pieces of various sizes) and the interaction between the particles is in accordance with the normal distribution law – the Gauss's law (3);

$$P(r) = C \exp\left[-\frac{(r - R_0)^2}{2c^2}\right] \quad (3)$$

where *C*, *c* – normalization coefficients determining how the dynamics of interaction and the average (effective) radius of the pieces.

The interaction between the particles occurs at the effective radius (Fig. 1). On the effective radius of interaction imposed additional requirements:

– First, it must satisfy an expression:

$$r_э = C\exp\left[\frac{1-\dfrac{r\cdot r'}{R_0\cdot R_0'}}{c}\right], \tag{4}$$

where *r, r,* – radius-vector, defined by the expression

$$r = abs(\Delta x + i\cdot\Delta z);$$

– Second, the "reasonable" to limit the interaction space around the individual i-th piece, including the purpose of taking into account the factor of "flakiness" – *λ*,

$$r_{эij} \le \lambda\left|R_i + R_j\right| \tag{5}$$

An array of speeds and the provisions of the pieces is organized with the release of the tangential and normal components (6);

$$v_x = v_{xo} + dt\cdot fx/m \qquad v_z = v_z + dt\cdot fz/m$$
$$x = x_0 + dt\cdot v_x \qquad z = z_0 + dt\cdot v_z \tag{6}$$

The second component of the program specifies: the volume of the rock mass as the total number of throw-in, the width of the discharge device performance unloader as the frequency of a throw, dump height, parameters and angle of the surface on which unloaded the rock mass.As an additional limit is assumed that the interaction of a piece with the base embankment, its movement stops quickly, that is friction on the surface of the base is sufficiently large.

The developed program allows you to specify not only the desired particle size and characteristics of the discharge (Fig. 1, 2), but also change, to a certain extent, the nature of the interaction between system elements (pieces of rock), the nature of the boundary conditions, the qualitative indices of the various fractions (Fig. 2 b, c). The last is extremely important to consider, when spontaneous segregation of rock mass in the dumps and transshipment areas are prerequisites for their selective mining, taking into account the granulometric composition of the rock mass accumulated in the different layers of the embankment to a height of the pile.

From this follows that the formation of the cone man-made mound rock mass segregation is occurred, which leads to the formation of internal area – the nucleus in the form of an obelisk with a predominance of the percentage content of small fractions. A similar pattern of distribution of minerals in technogenic deposits has been installed in hydraulic reclamation conglomerate in the form of a truncated cone. At the same time within the cone the nucleus in the form of an obelisk is formed.

In the following program, we use the linear dependence of the density *ρ* of the particle radius *R* of the form: $\rho \sim (1 - A\ (R - R_0)/R_0)$. In this case the particle mass $m \sim R_3$.

Generating random numbers and statistical analysis was carried out using MATLAB.

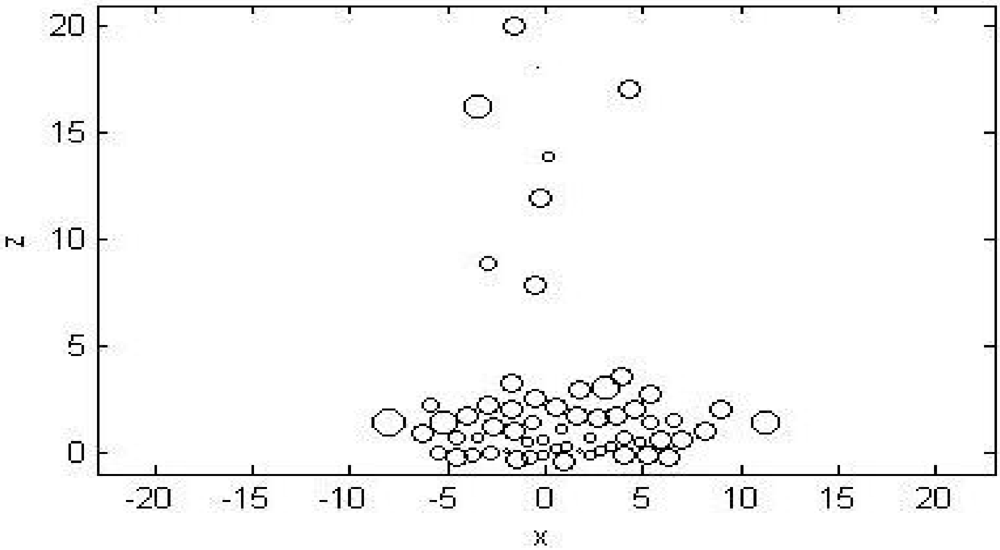

Fig. 1. Emptying three-granular material on a horizontal surface (frame animation)

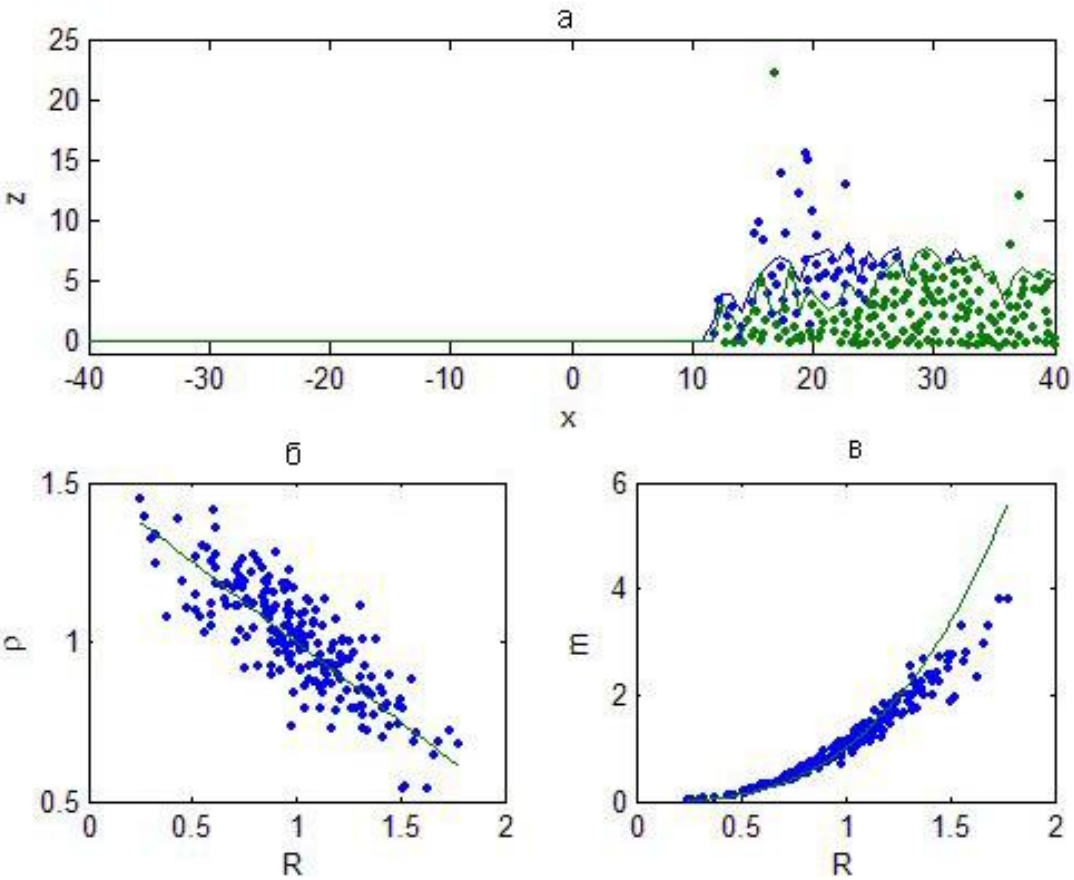

Fig. 2. The result of processing N = 500 face-off: a – the process of formation of the layered structure tier blade, b – defined by the relationship between the density of particles – ρ and radius – R; c – the resulting relationship between the mass-m-R and the radius of the particle

An analysis of the results as can be seen that the lower layer of the embankment there is an accumulation of large fraction, and the top of the pile accumulated fines. This is confirmed by statistics of the distribution of particles on the mean radius. When sufficient numbers of repetitions of this process produced a smooth curve

(Fig. 3.) Characterizing the distribution of medium-range "piece" rock pile height (embankment). In the case of aggravation of the fine fraction (qualitative indicator for the fine fraction), we observe a small fraction approximation to the base of the pile.

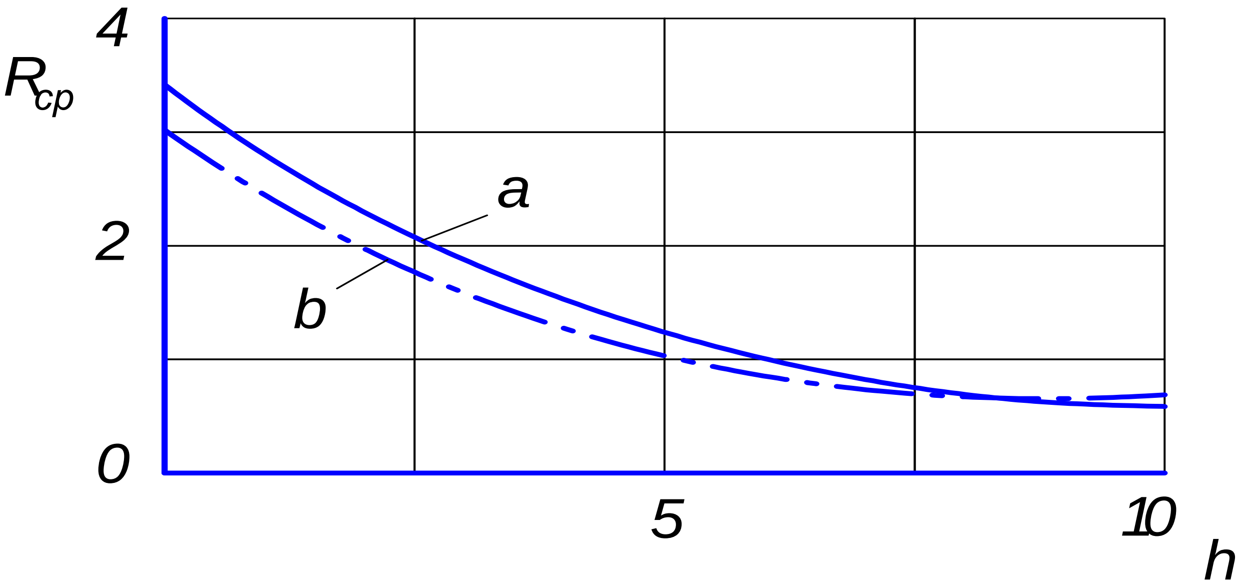

Fig. 3. The nature of the distribution of medium-range pieces of "rock pile height:
a – the distribution curve for the case of equal densities of different pieces,
b – distribution of the light weighting of small fractions.

Features of the redistribution of factions within the cross-sectional bulk of the object should be considered in the process of averaging the ore mass on granulometric composition the stock. If there is a certain dependence of the percentage content of useful component of the average size of the piece, it will require a change in technology for loading and unloading at stockpiles, quality control system, the choice of technology for processing the tailings and mining.

Features of the redistribution of factions within the cross-sectional bulk of the object should be considered in the process of averaging the ore mass on granulometric composition the stock. Since the observed dependence of the percentage content of useful component of the average size of the piece, it requires a technology for loading and unloading at stockpiles, quality control system, the choice of technology for processing the tailings and mining.

So for flux enterprises characteristic is the presence of large amounts of waste recycling to 25 % and more. The main part consists of waste fractions 0 – 15 mm, 0 – 20 mm and in some cases up to 40 mm and more. Laying waste processing by using the rotational-link conveyor or bulldozing in conjunction with road transport.

Project waste disposal for the various factories of flux enterprise provides a model structure of dumping, i.e., the first at an angle of 12° slept part of the blade tilted to elevation 60 m, after which the height of the stage remains unchanged. Depending on the technology of forming stage blade is shaped and conventional border between the layers with a predominant content of a particular class size.

The use of peripheral unloading dump trucks as well as the areal unloading followed by pushing the rock bulldozer down the slope forms a smooth transition fuzzy border *Δh* ≥ 10 m between layers of fine fraction – 1, medium – 2 large and – 3, which do not allow the subsequent selective disassembly transition regions 1-2 and 2-3 technogenic deposits (Fig.4 a).

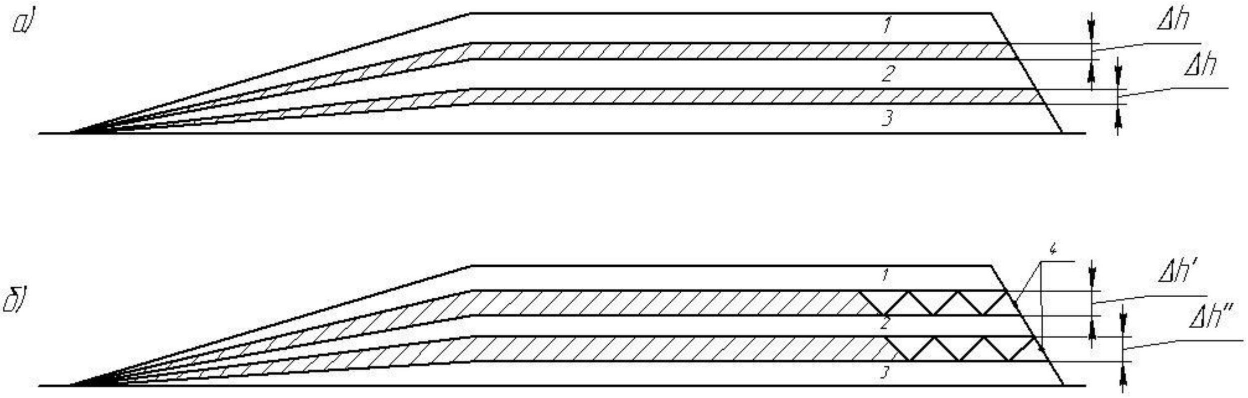

Fig. 4. Layered structure of the tailings pile fluxes: a – dumping the use of road transport, b – dumping using rotary-link belts

In the case of piling the filling conveyor body dump is consistent dumping conical bodies in which segregation is the separation of the above scheme, i.e., with the formation of the central obelisk containing predominantly small fractions (Fig. 5).

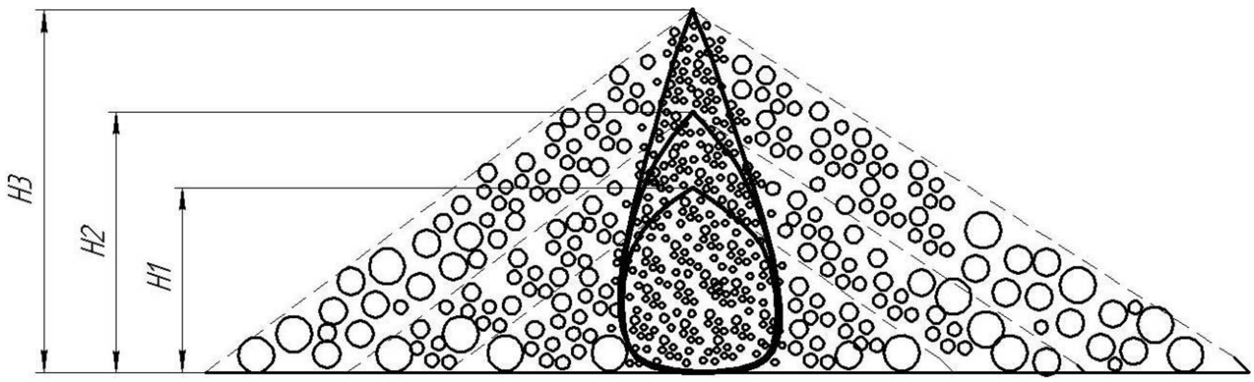

Fig.5. Phased formation of the cone and the nucleus through the segregation redistribution granulometric composition of rocks

Through successive stages of spatial modeling dumping gravel fraction 0-15 mm on an incline through the console spreader with departure console l = 10 m and given the established patterns of segregation, we obtain complex isosurface, which delimit the three characteristic layers (Fig. 6).. Thickness of the layer 1 is determined from the condition of content fraction 0 – 5mm 80 % and amounts to an h = 7.1 m, layer 2 with 50 % of the content of the entire volume fraction 0 – 5 mm h_2 = 27.4 m and layer 3 containing less than 20 % of this faction, has the power of h_3 = 20.5 m.

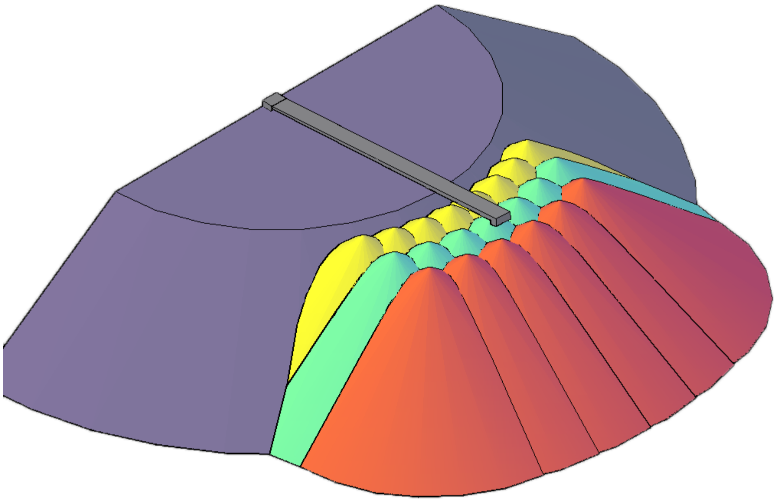

Fig. 6. Volumetric model blade formed coherent dumping cones rotary-link conveyor

As a result of this technology, piling the interface between layers 1-2 and 2-3 has a wavy shape (Fig. 4 b and 7), with a ridge height $\Delta h' \approx 4,7$ m, $\Delta h'' \approx 2,7$ m. The distance between the ridges corresponds to the emission moldboard console l = 10 m. In this case, provided the opportunity to accurately determine the location and parameters of volume (Fig. 8). For their selective extraction. The defining parameters are: the initial size distribution of gravel (for the duration of dumping dump taken 60 % fraction of 0 – 5 mm, 40 % fraction of 5-15 mm) radius moldboard console from the upper edge l = 10 m with a step reinstallation 10 m between tops of neighboring cones.

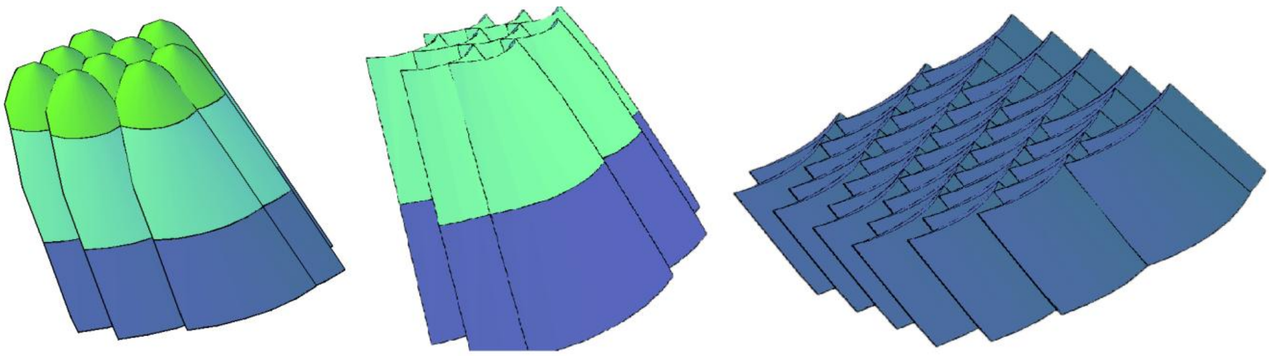

Fig. 7. Isosurface separates layers with different content of fractions 0 – 5 mm

Because in terms of transition layer has a certain order, and the layer thickness does not exceed 4.7 m, the efficiency of its mining will depend on the applicable excavation and transportation equipment and remoteness of receiving the item. Since the development of a second and the third layer has an important role proximity of railway path or loading point for the shipment of commodity products, and for 2-layer arrangement of the site screening.

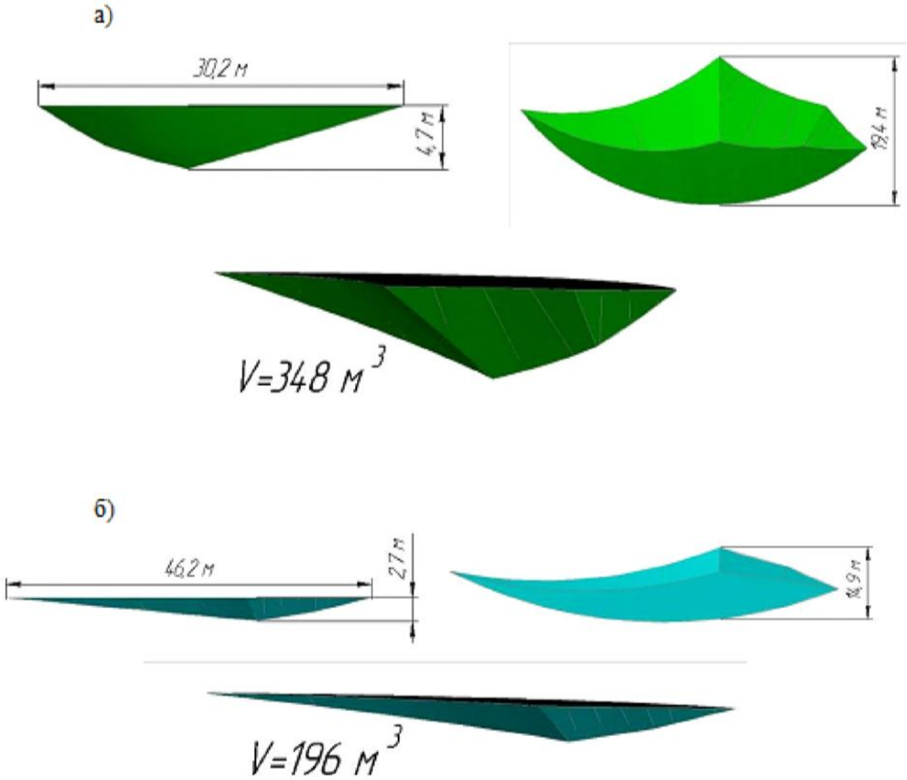

Fig. 8. Volume element of the transition layer for the selective mining a) top b) bottom layers

Given the parameters of dumps for waste recycling flux (area ranging from 25.0 ha to 37.7 ha, with an average height tiers – 60 m), it seems appropriate use shovel loaders, both as excavation and transportation equipment (transportation of rocks up to 250 m) and as a purely of extraction-loading equipment in conjunction with dump trucks, for example, BelAZ-75481 (42 t).

Testing of the results was made on the basis of JSC "Dokuchaevsk flux-dolomite company" So for the time of operation of JSC "DFDC" has accumulated more than 100 million m 3 of tailings limestone and dolomite, which, because of the small grain size of 0 – 15 mm long were not in demand as a commercial product. In recent years, the time due to increasing demand for backfill material used in the development of iron ore (mainly mining companies Krivoy Rog Basin), special interest group 0 – 5 mm, which, among other positive characteristics and has cementing properties. On the other hand construction companies ready to be used for construction (mainly for concrete production) fraction of 5 – 15 mm, with a minimum content of other factions.

With the purpose of processing tailings created a technological line sequential screening of the rock mass for the two types of commercial products – crushed stone fractions 0 – 5 mm for laying of the area mined and crushed stone for construction fraction of 5 – 15 mm.

An analysis of the results obtained for the case of a conical object (Fig.5.) shows that for each horizontal section (layer) of the embankment grading redistributed appropriately – dependence of the contents of large fraction relative to the axis of the cone has a polynomial form (7), which confirms and distribution statistics particles of mean radius (Fig. 9).

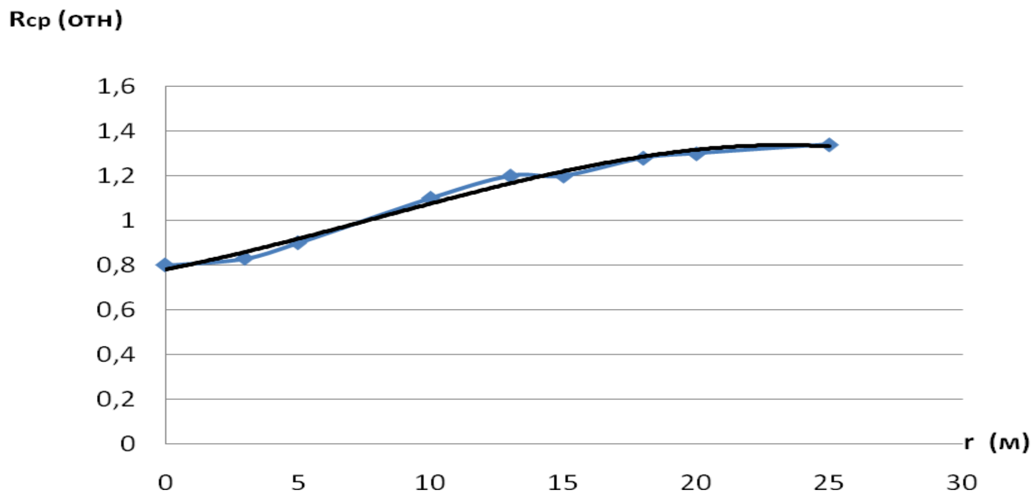

Fig. 9. The nature of distribution medium piece of rock about the axis of the cone (on the horizon foundation embankment)

$$R_s = Ar^3 - Br^2 + Cr + d \qquad (7)$$

where the coefficients *A*, *B* and *C* are proportional to the normalization factor $\gamma = (R_0 \times H)/(R_{Wed} \times h)$ and, accordingly, the density of a piece of ρ, the coefficient of internal friction of granular material and the factor "flakiness" λ, *d* – a constant corresponding to the proportion of the smallest fraction.

Established as a result of modeling the relationship between the average size of a piece of rock for the selected horizontal layer on the position of this layer relative to the base and the height of the cone (rock pile) allows to predict the quality of the segregation effect on an inclined surface for the original product. Further processing of the calculated and experimental results confirms the adequacy of the obtained mathematical model that convincingly shown in Fig. 10.

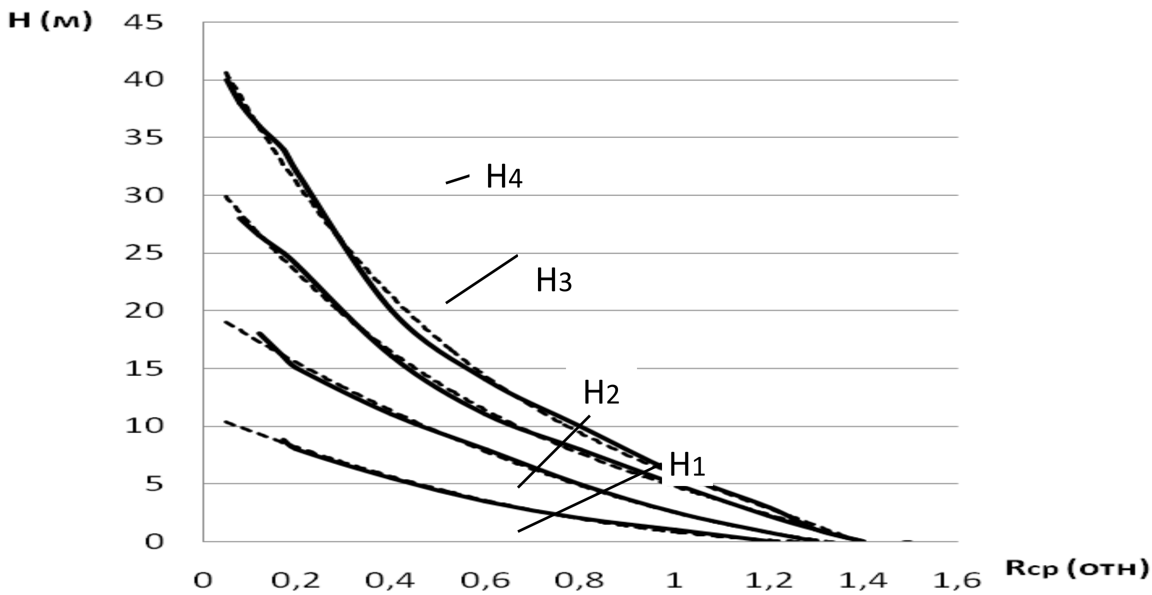

Fig. 10. Dependence of the segregation effect on the height of discharge on an inclined surface fraction of 0-5mm (20%) and gravel fraction 5-15 mm (80%) for *R p* = 0.85 mm. Solid line – experimental data for H_1 = 10 m, H_2 = 20 m, H_3 = 30 m and H_4 = 40 m, dashed line – calculated data for the model

For storage conditions of rubble fraction of 5 – 15 mm from the natural moisture content and 20 % of the contents of sub-standard components, the optimum height of the cone can be considered the height of 20 m, which provides the required quality of the gravel at the base of the cone, and the optimal parameters for the face of shipping products excavator EKG-5A (Fig. 11). dumping in case of source material with high humidity dumping height should be increased to 25 m. This will, improve treatment of major pieces of trapped silt particles by increasing the time shaking the motion of particles along the slope.

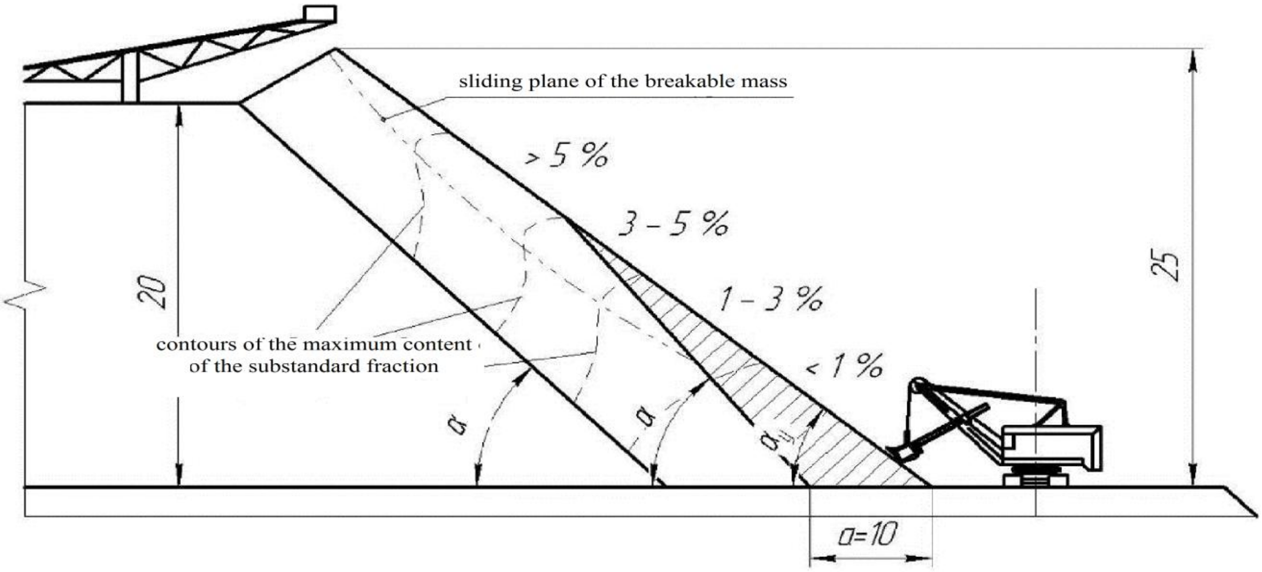

Fig. 11. Scheme mining conditioned area (fraction 5-15mm) from the surface of the cone blade

Regarding the ratio of maximum height of the ledge at the *N* and the maximum height of digging $h_{dig.max}$ shovel should be pointed out that according to in the development of blasted rock by power shovel height of the H_y shall not exceed the maximum height of one and a half digging shovel $h_{dig.max}$. Only when blasting operations on coal mining is permitted height of the 30 m, and in some cases, with the permission of authorities State mine technical inspection, up to 40 m.

The nature of the collapse of rock determines the degree of safety in excavation works and the possible placement of equipment in the slaughter.

Studies of the blasted rock collapse in a number of typical coal, ore, flux and the granite quarries of the USSR showed that the maximum height of excavating the face is determined by the following factors: 1) the properties of the blasted mass (loosening coefficient k_p, lumpiness d_{Wed}, presence of clay inclusions), 2) the nature and parameters of the process of collapse rocks in underworking face (volume, frequency and duration of the collapse, the depth of the collapse of rocks on the bottom of the ledge, etc.) 3) Working size excavator ($R_{dig.max}$, $h_{dig.max}$). This allowed for the seizure well crushing ($d_{Wed} \leq 20$ cm), prone to collapse (K_p = 1,35 – 1,5) in the absence of individual sites and slaborazryhlennyh clay inclusions (in volume over 5-6%) with a maximum height equal to the face 2,2 – 2,7 maximum height of digging shovel.

Because the waste is processed enrichment plants JSC «DFDK», JSC «Novotroitskoe Mining Factory», JSC « Komsomolsk Mining Factory» and other companies flux extraction virtually no major weak formation, the inclusion of clay (less than 5 %), while the average size of a piece of $d_{av} \leq 20$ cm and average rate of loosening of the $k_p \geq 1,3$ a rock mass corresponds to the properties of the granular material. So, this rock mass is prone to collapse with little underworking slaughtering and collapse occur very often in small portions (over).

In selecting the permissible height of the face (Fig. 14) and connected with the bulk-bulk (approximately uniform connectedness) rocks the main source parameter is the maximum depth of the collapse hit rocks on the bottom of the ledge L_o (m), which is limited to a radius excavator digging horizon install $R_{kon.y}$ (8).

$$L_o \leq R_{кoп.y} - 0{,}5 l_x - l_б - l_П, \tag{8}$$

where l_x – the length of the excavator, m; l_b – safety strip (the distance between the edge of collapse rockslide and caterpillar excavator), m; $l_П$ – the length of a gently sloping plot trajectory of the bucket of the excavator, m

The band size security l_b is aligned with rock d_{av} and the magnitude of the required clearance between the rotating part of the excavator and the collapse of the l_b' at the time of the turn to unload. For species with small, medium and large-scale lumpiness value of l_b can be taken respectively 1, 2 and 3 m.

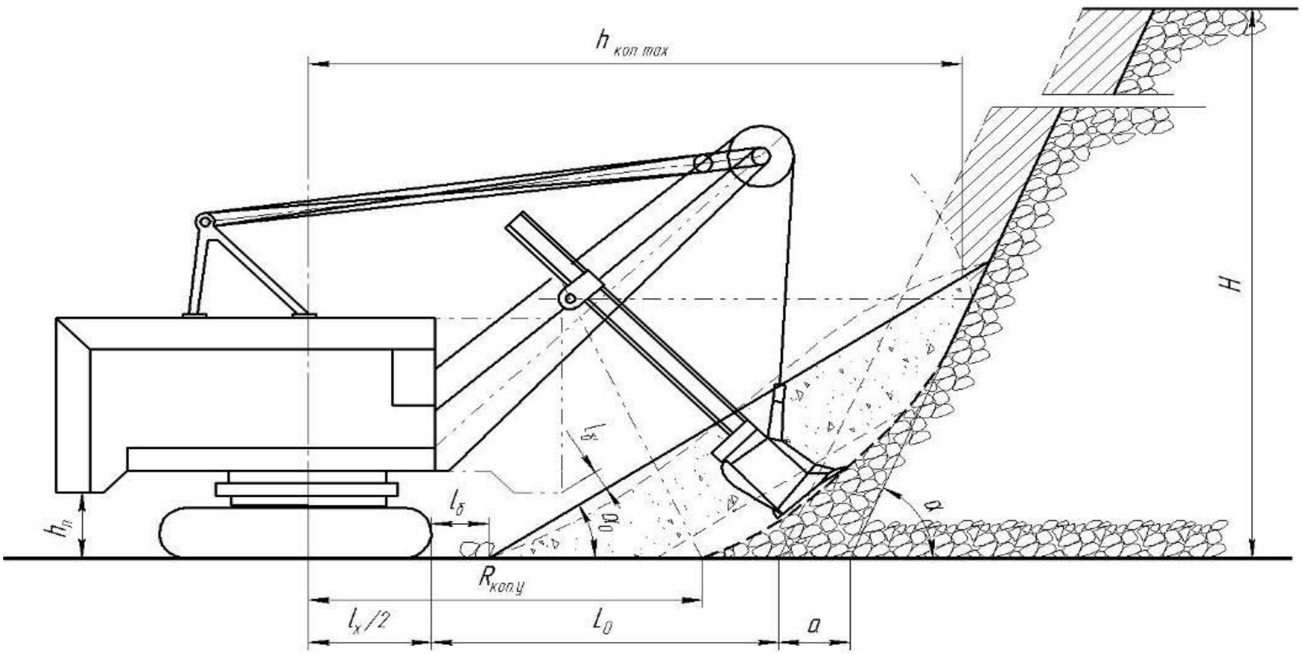

Fig. 12. Scheme to determine the relationship of power showel and cutting parameters

The value of L_{omax}, defined by the expression (8) for mining excavators EKG-5A, ECG-8I and EKG-12,5, presented in Table.

Table

The value of $L_{0\ max}$ for dredges

Power-shovel	h_{max}, m	R, m	l_x, m	l_n, m	$L_{0\ max}$ (м) for lump		
					shallow (d_{cp}= 10-20 cm)	middle (d_{cp}= 20-40 cm)	large (d_{cp}= 40-60 cm)
EKG-5A	11,2	5,6	6,0	3,0	7,6	6,6	5,6
EKG-8I	12,5	11,3	7,8	4,0	10,4	9,4	8,4
EKG-12,5	15,2	14,3	9,6	5,0	13,5	12,5	11,5

Studies conducted by Yu.I. Belyakov and V.M. Vladimirov determine the maximum height of excavation faces for the various properties of blasted mass for the three types of dredges.

Conclusions. Based on the foregoing, we conclude that given the height of the stack, H = 20-25m, of which the alternate will be selected aggregates of varying quality, can be considered valid.

As the shipment fraction of 5 – 15 mm on the L_{0max} = 7,5 m upsets the "cap" of the cone is arbitrary or forced through attachment (pig), contains 73 % or more fraction of 0 – 5 mm, followed by shipping it to produce backfill work. Formed the surface is ready to continue the segregation of rubble.

Thus, it should be noted that our approach to solving problems and modeling of the segregation of the rock mass can predict the quality of the segregation effect on an inclined surface depends on the fractional composition of the rock, the angle of inclination and height of cone mounds. Experimentally proved the adequacy of the mathematical model under consideration in the process.

Перелік посилань

1. O. Strilets, G. Pchelkin (2018). Using of segregation for development of technogenic deposits with the purpose of upgrading of products *Збірник наукових праць Національного гірничого університету*. № 53., С. 87-93. http://nbuv.gov.ua/UJRN/znpngu_2018_53_11
2. Вилкул, Ю.Г., Слободянюк, В.К., Аралкин, А.С. (2007). Моделирование и исследование гравитационной сегрегации скальной горной массы в процессе отвалообразования с применением методов планирования экспериментов. Разработка рудных месторождений, (91), 3 – 9.
3. Пономарев, А.В., Пчолкин, Г.Д. (2008). Обоснование эффективности безвзрывной выемки известняков и доломитов экскаваторами непрерывного действия с режущими рабочими органами на флюсовых карьерах Украины. Металлургическая и горнорудная промышленность, (1), 118 – 121.
4. Гальянов, А.В., Лаптев, Ю.В. (1998). Исследование эффекта сегрегации при отсыпке рудных перегрузочных складов. Изв. УГГГА. Серия: Горное дело, (7), 62 – 67.
5. Гольянов, А.В., Лаптев, Ю.В., Ковалев, М.Н. (1997). Закономерности сегрегации при складировании скальных пород и руд на карьерах ОАО «Комбинат магнезит». Екатеринбург: ИГД УрО РАН.
6. Пчолкин, Г.Д. (2009). О математическом моделировании процесса сегрегации горной массы при формировании конусообразного объекта. Металлургическая и горнорудная промышленность, (1), 96 – 101.

АНОТАЦІЯ

Метою роботи є створення і використання закономірностей сегрегації в формуванні техногенного родовища (ярус відвалу, зберігання готової продукції в формі конусу) за допомогою основних законів теоретичної механіки.

Методи дослідження. Для прийняття рішень були використані методи аналізу закономірностей сегрегації гірничих порід при формуванні ярусів відвалів. Застосовано статистичний аналіз при генерації випадкових чисел. Натурні дослідження на моделях з перенесенням результатів на існуючі гірничі виробки в умовах Докучаєвського флюсо-доломітного комбінату.

Результати. Закони сегрегації набувають важливого практичного значення в формуванні техногенного родовища. Теоретичні основи фізичного механізму явища сегрегації гірської маси при формуванні відвалів та зберіганні корисних копалин або готової продукції в насипах дозволяють врахувати початковий розподіл фракційного складу гірничої маси, що має важливе практичне застосування при розробці техногенних родовищ або відвантаженні готової продукції замовнику.

Наукова новизна. Моделювання сегрегації гірничої маси дозволяє прогнозувати якість ефекту сегрегації на похилій поверхні, яка залежить від фракційного складу породи, кута нахилу і висоти конуса відвалу. Встановлена залежність ефекта сегрегації від висоти розвантаження на похилій поверхні фракцій щебеню 0 – 5 мм (20 %) і 5 – 15 мм. Відображено характер розподілу кусків середньої крупності по висоті конуса насипу і навколо його вісі.

Практичне значення. Експериментально доведено адекватність математичної моделі розглянутої в цій роботі, що дозволить застосовувати результати долсліджень при формуванні техногенних родовищ з подальшою їх розробкою. Встановлено, що для умов зберігання щебеню фракції 5 – 15 мм із природньою вологістю та вмістом некондиційних компонентів 20 % оптимальна висота конуса відвалу складає 20 м, що забезпечує необхідну якість щебеню в основі конуса і доцільні праразметри для відвантаження готової продукції екскаватором ЕКГ-5А. Висота насипу із підвищеною вологістю має бути збільшена до 25 м.

Ключові слова: *сегрегація, техногенні родовища, гірнича промисловість, фракція, екскаватор*

АННОТАЦИЯ

Целью работы является создание и использование закономерностей сегрегации в формировании техногенного месторождения (ярус отвала, хранения готовой продукции в форме конуса) с помощью основных законов теоретической механики.

Методы исследования. Для принятия решений были использованы методы анализа закономерностей сегрегации горных пород при формировании ярусов отвалов. Применен статистический анализ при генерации случайных чисел. Натурные исследования на моделях с переносом результатов на существующие горные выработки в условиях Докучаевского флюсодоломитного комбината.

Результаты. Законы сегрегации приобретают важное практическое значение в формировании техногенного месторождения. Теоретические основы физического механизма явления сегрегации горной массы при формировании отвалов и хранении полезных ископаемых или готовой продукции в насыпях позволяют учитывать начальное распределение фракционного состава горной массы, что имеет важное практическое применение при разработке техногенных месторождений или отгрузке готовой продукции заказчику.

Научная новизна. Моделирование сегрегации горной массы позволяет прогнозировать качество эффекта сегрегации на наклонной поверхности в зависимости от фракционного состава породы, угла наклона и высоты конуса отвала. Установлена зависимость эффекта сегрегации от высоты разгрузки на наклонной поверхности фракций щебня 0 – 5 мм (20%) и 5 – 15 мм. Отражен характер распределения кусков средней крупности по высоте конуса насыпи и вокруг его оси.

Практическое значение. Экспериментально доказана адекватность математической модели, рассматриваемой в этой работе, что позволит применять результаты исследований при формировании техногенных месторождений с последующей их разработкой. Установлено, что для условий хранения щебня фракции 5 - 15 мм с естественной влажностью и содержанием некондиционных компонентов 20% оптимальная высота конуса отвала составляет 20 м, что обеспечивает необходимое качество щебня в основании конуса и целесообразные прараметры для отгрузки готовой продукции экскаватором ЭКГ-5А . Высота насыпи с повышенной влажностью должна быть увеличена до 25 м.

Ключевые слова: сегрегация, техногенные месторождения, горная промышленность, фракция, экскаватор.