UDK 622.271.

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ENVIRONMENTAL ORIENTED IMPERATIVE OF DEVELOPING THE OPENING TECHNOLOGY AND EXCAVATION OF HORIZONTAL FIELDS

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ЕКОЛОГО-ОРІЄНТОВАНИЙ ІМПЕРАТИВ РОЗВИТКУ ТЕХНОЛОГІЇ РОЗКРИТТЯ ТА РОЗРОБКИ ГОРИЗОНТАЛЬНИХ РОДОВИЩ

Purpose. Selection and substantiation of a methodical approach to building an opening technology and developing horizontal and sloping brown coal and manganese layer with capacity of 1.5–10 m, lying in the soft overburden with the full filling out space overburden, improving remediation and reducing costs of transportation of overburden pile.

Methodology. Research tasks are performed by the methods of critical analysis and synthesis of scientific papers and experience of quarries to set goals and formulate opinions; by the analytical method while substantiating parameters of mine workings and piles; as well as by the graphic-analytical method for visual images flowsheet and its parameters.

Findings. The technology of horizontal opening and working fields, based on the allocation of mines to transport overburden and minerals within the quarry field is developed. Flowsheet parameters that provide interaction drop and piling of fronts to accommodate the overburden are grounded. The possibilities are shown offered by technology to fully use of the capacity produced by open pit and reduce transport costs.

Originality. Opening processes of a horizontal bed of minerals are grounded which, unlike the known ones, involve changing the location of temporary trenches, namely their periodic movement with conveyor lines in a quarry that allows completing backfill gob. Analytical dependence of the conveyor trench on the lower tier moldboard angle of slope spreader working platform is established that will allow implementing full accommodation overburden rock ledges to pile tiers.

Practical value. The developed technology takes into account eco-oriented imperative to work out horizontal and sloping brown coal and manganese bed with capacity from 1.5 to 10 m, namely the requirement for its development without the formation of the outer blade and complete filling out space overburden. In practice, the technology will increase the area of land to restore, improve conditions for the mine technical reclamation and accelerate the maturities of the restored lands to agriculture.

Keywords: *a quarry, mining technology, internal piling, mine reclamation, pipeline trench*

Introduction. The well-known technologies of open development of mineral deposits are characterized by a strong negative impact on the environment, especially a large area of waste land that mostly is lost for original usage. At Ordzhonikidze mining and processing plant (Ordzhonikidze DPE) 300 hectares of natural land is on average allocated for each quarry for capital, exit, cutting trenches and the outer pile. Those workings in the mining of horizontal deposits amount to 30 % of the mining lease career sites and distributed to the following: capital trench – from 3.5 to 4.5 %, exit trench – from 8.4 to 8.6 %, cutting trench – from 56.1 to 57 %, outer pile – 31 %. Retirement and backfilling excavation process is an extensive process and requires over 60 mln UAH [1]. The volume of earth surface violations is due to the length of quarry fields. The calculations of the author show that at the length of the field of about 10 km the surface is about 500 ha and its mine technical reclamation, in the absence of sufficient overburden, will greatly be complicated at the stage of quarry repayment.

The degree of recovery of the earth surface is conditioned by the possibility of complete excavation and backfill of the remaining gob overburden and conditions of potentially fertile black soil layer filling and follows the movement of the front strip mining and ledges. The poor quality of the restored land leads to unbalanced use of land resources and unmet needs in land resources of the mining region population. All above mentioned determines the need for eco-oriented imperative for the development of opening technologies and development of horizontal fields without the formation of the outer pile, which should be based on technological approaches to complete filling of openings remaining open to reproduce damaged lands and preserve land resources.

Therefore, the research direction of current concern, which is of scientific and practical importance, involves the search and substantiation of open mining closing technology as the advance of the front of mining operations, which provide favorable conditions for quarry restoration of disturbed lands. The fundamental approach to the selection of such technology should include environmental protection based on ecological imperative as a set of conditions of human life and nature.

Analysis of the recent research. The problem of ecology-oriented imperative of open mining technology development has been the subject of many scientific papers. Thus, [2] the authors emphasize the need to establish environmental and technological connection between systems of opening and extracting, process equipment and organization of landscape and restoration work. The ecological importance of this relationship is emphasized in terms of impact parameters of quarry working area of its service life and the restoration of disturbed land area.

The issue of open cast mining technologies in terms of their environmental and economic efficiency have been the subject of research by Terekhov E. V. [3], who focused on the features of the traditional methods of field development involving the removal of soil and its subsequent application to the surface of the planned dismantling with a time lag between the land disturbance and its reproduction. This approach significantly complicates the conditions of land acquisition for open development and increases the required plant compensatory payments to landowners. Conditions of achieving economic and environmental objectives of land conservation in the quarry have been analised from which feasibility of initial remediation of ecological functions of man-made land flows as the basis for their multiple use [4]. Galagan T. I. [5] states that the reclamation of disturbed land should be aimed at localisation and neutralization of the land harmful effects (Ordzhonikidze DPE pays compensation of 10–15 thousand UAH/ ha for land alienation).

It is also worth mentioning a horizontal way to develop fields in which on land quarry field reveals the central trench, which is a field divided into two wings (areas) that are worked out along the front overburden works and mining benches [6]. A more complete filling of mined-out space overburden is achieved through the delivery of these rocks in the inner pile using expensive road transport.

From research studies [7, 8] it also follows that better use of quarry worked area, renovation of environmental and aesthetic condition of the landscape are of scientific applied value for the quality of reclaimed land area and their term return to agriculture.

A significant contribution to the prevention of large-scale disturbances of land, which significantly deteriorates the ecological state of land resources in the region, is the results of research stated in the article [9]. It proposes the technological solution that is based on a combination of organizational processes of reclamation and technical mining activities in time, thus decreasing the returning length of land to agricultural use. The otstanding scientist Shapar A. G. argues that the state economy should be based on the principles of minimizing the consumption of natural resources, which will stop the degradation of the environment and affect the harmonious interaction of mankind with nature in the future [10].

Unsolved aspects of the problem. Despite a significant amount of the research on the topic of the article, the results considered do not consider specific technological mining schemes for fully used gob quarry, time estimates of natural drainage of land for the development of deposits and recovery of waste lands. These schemes are not directly focused on the economical use of land resources, which is a condition of ecological-oriented imperative which is reflected in the unconditional implementation of the provisions to minimize the negative impact of mining on the environment. Regarding the legal requirements for the return of wasted land, mining companies do not adhere to the condition providing space and quality of returned land according to their performance during natural drainage in the development field. The problem of reducing delivery cost into the overburden dump by vehicles remains unsolved, and in case of its insufficient capacity – to the external heap having great distance.

Objectives of the article. Taking into account disadvantages of the above mentioned works the authors have formed the purpose of the study, which is to identify environmental-oriented direction of improvement and substantiation of the methodical approach to building technology of uncovering and development of horizontal and sloping brown coal and manganese bed with capacity of 1.5–10 m, lying in soft uncovered rock, which will provide full backfill of quarry and better conditions for remediation and enable lower costs for transporting overburden in the inner pile.

Presentation of the main research. Ecology-oriented imperative concerning production activities of mining companies provides obligatory, imperative, deprived of the choice of planning, organization and practical implementation, internal monitoring and control activities carried out in accordance with the concept of sustainable development aimed at implementing the principle of eco-efficiency by reducing the impact on the environment while increasing profitability. This imperative appears to be necessary to prevent loading costs on the society and take them over, with the background information on the need to use natural resources in solving problems of effective development processes of minerals extraction and processing.

The main reason for high costs of mining companies to protect natural resources is insufficiently developed environmental policies and failure of environmental rules and requirements, restrictions and prohibitions and those that arise in the future, above all, to balance manufacturing with nature, coexistence technosphere and the biosphere for conservation and restoration of the latter. Concerning this direction, the ecology-oriented imperative must be based on technology discovery and development of horizontal mineral deposits. Every year mining companies are paying more for air pollution, wastewater, soil rehabilitation and waste disposal, as mining generally does not provide any reduction in costs for environmental measures or the volume of environmental pollution in mines every year. The main principle of saving, economic usage of natural resources, the maximum possible preservation of the environment results from research and international experience of working fields – a violation of nature and placement of waste production and emissions to minimized area within the immediate area, which is any abandoned quarry.

This approach creates conditions for weakening the impact of production processes of field development on the environment as a result of such factors as:

1. The land allotment area for field development is reduced, which allows decreasing the area of natural land to be violated by open mining works.

2. The impact of mining and industrial area, where mining, transportation links and other additional facilities are located, on the agricultural area adjacent to it is reduced.

3. It is possible to arrange direct movement of the entire array of overburden in the inner pile, providing better filling of its from wasted space.

4. The surface area of the piles is increased and conditions of mine technical reclamation are improved.

5. Concentration of mining increases, which improves the operating conditions of the process equipment operation in order to limit the volume of the natural resources.

6. It The rate of disclosure ledges of minerals is reduced due to decrease in the transfer of non-working quarry boards.

Methodical approach substantiation for eco-oriented mining technology building is based on more complete use of residual volume workings quarry, achieved by the following way. A quarry field is divided by the width and worked in two sections, each section (the left and right) on the wing in half-trenches and on the surface of the upper tier blade interacting spreaders are placed as well as transportation links that follow the movement of the front of mining operations on the wings move, and the vacant flank of half-trenches are backfilled (Fig. 1).

Overburden upper ledge is transported in the inner pile in each area separately, for this there are transverse conveyors jacks and height variator in half-trenches. There is a trench recess in the middle of quarry fields, which equips the temporary conveyor rally, connecting with the surface extractive ledge quarry by placing transport communications to deliver minerals to the surface.

The proposed mining technology involves mining operations in the way shown in Fig. 1 and in sections A–A and B–B. The method is implemented by the following way. Upper opening ledge 1 is worked out at transport system by a rotary excavator 2 using belt conveyors 3 transporting overburden in the inner pile.

These rocks are transported firstly along the front overburden operations, and then along the flank trenches 4 to the quarry surface where alternately using cantilever spreaders 14 and 15 form the top tier pile. The lower ledge drop 5 is worked out at the developing transport and piling system by a rotary excavator 6 and breed in the lower tier pile 8 by a spreader 7. Along with these works exposed ore layer is mined, to remove the minerals 9 dragline 10 is used. The main conveyor 11 is loaded by using minerals hopper mounted on the roof of the ore layer beside a conveyor.

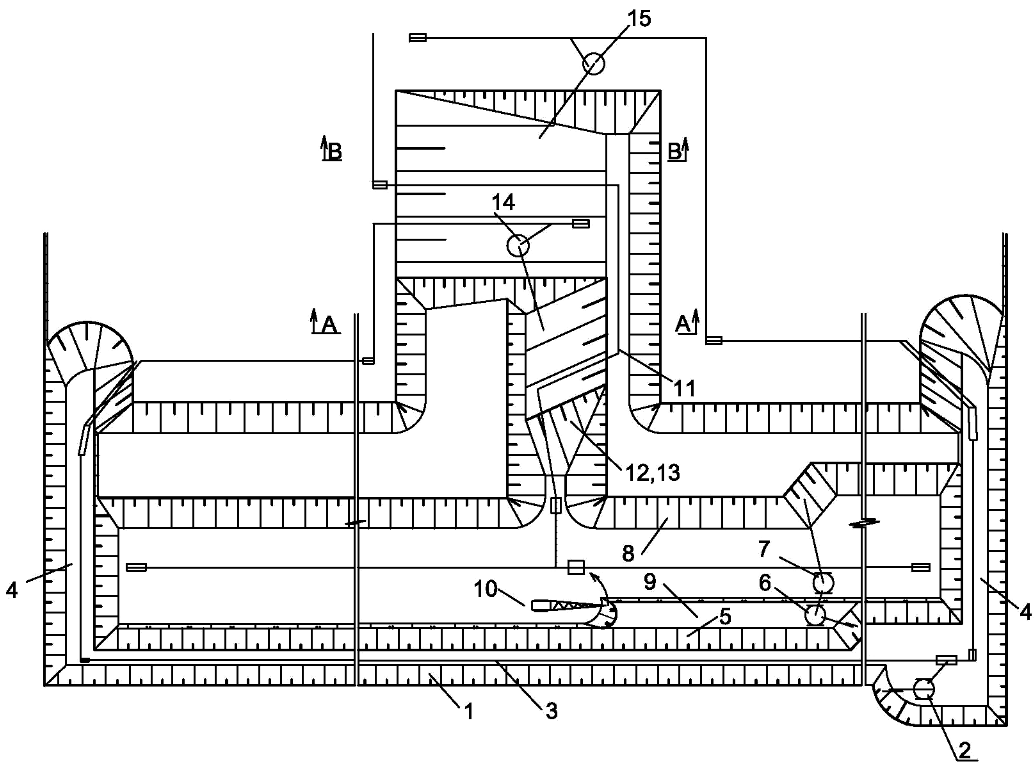

Fig. 1. Mining process flow sheet with the proposed method of horizontal development field

Then extracted minerals are moved to the surface of a quarry. To make it, the main conveyor is placed in trench passage at joined inclined and horizontal platforms 12 and 13 in the middle of the ledge to the surface mining quarry along the first front work producing ledges, and on crossing the upper slopes tier two internal pile sites. Piling of the upper layer of inside pile is carried out by spreaders 14 and 15.

The availability of these new technological elements allows using the internal space fully to accommodate the piling of overburden while developing horizontal ore bed. This allows starting preparation for mine technical piled land reclamation earlier. In addition, the rock transporting cost in the inner pile, and minerals – to the surface of a quarry reduces significantly.

The basic design parameters of the proposed mining technologies are defined. The parameters of open ledges for given rock mass are determined by work dimensions of technological equipment, in turn, parameters of pile ledges should provide placing of stripping ledges, and this placing can be regulated due to the height of pile tiers. Let us consider this approach. The amount of overburden (m^3) on the bottom ledge to disclose the ore layer on one passage is equal to the extracting

$$L_{l.o} = L_{l.o} \cdot A_o \cdot H_{l.o},$$

where $L_{l.o}$, $H_{l.o}$ are the length of the front on the lower ledge and its height, m accordingly; A_o is the width of opening passage, m.

Taking into account the placement of overburden in volume $V_{l.o}$ alternatively in two parts (the left and right sides of the conveyor driving) and loosening rock coefficient K_o, the amount of each stacking lower tier sections in one passage is determined by the expression

$$V_{l.p} = V_{l.o} \cdot K_o/2.$$

Herewith the length (m) of each section of the lower tier due to internal pile is defined by the width of a quarry field and accepted technological scheme of ore layer processing. In this case, the height (m) of a pile tier, based on the central location of outgoing trench is associated with the parameters of pile working scheme as follows

$$L_{l.p} = \frac{V_{l.p}}{A \cdot H_{l.p}} - 0{,}5m,$$

where $V_{l.p}$, $H_{l.p}$ are respectively the volume area of the lower tier of the inside pile, m^3, and its height, m; A is the width of pile passage, m; m is the width of the trench bottom conveyor arrangement for communication and passage of vehicles, m (according to width of a working platform that provides the location of transport equipment m = 50–60 m).

The height of the lower tier pile $H_{l.p}$ should satisfy the condition, taking into account the volume of the conveyor trench height of the stage, which is not filled on the basis of (1–3)

$$L_{l.o} \cdot A_o \cdot H_{l.o} \cdot K_o = A \cdot H_{l.p} \cdot L_{l.p} - (m + \text{ctg}\,\alpha\, H_{l.p}) \cdot H_{l.p}, \quad (1)$$

where α is the angle of the slope conveyor trench board, which formed a temporary passage, degree.

The value $H_{l.p}$ is defined by solving the quadratic equation relative to $H_{l.p}$ by formula

$$\text{ctg}\,\alpha H_{l.p}^2 - (A \cdot L_{l.p} - m) H_{l.p} + L_{l.o} \cdot A_o \cdot H_{l.o} \cdot K_o = 0; \quad (2)$$

$$H_{l.p} = \frac{(A \cdot L_{l.p} - m) \pm \sqrt{(A \cdot L_{l.p} - m)^2 - 4\,\text{ctg} \cdot L_{l.o} \cdot A_o \cdot H_{l.o} \cdot K_o}}{2\,\text{ctg}\,\alpha}. \quad (3)$$

According to (3) the height of the lower tier of the inner pile is defined depending on the length of the front work and the height of drop ledge according to the conditions of manganese mining quarries of Ordzhonikidze DPE. It is defined that for placement of rock ledge in the lower drop pile height of the lower tier should be 18–34 m (Fig. 2). The graph analysis in Fig. 2 shows that the height of the lower tier pile to place ledge drop increases proportionally to increase of its height and decreases with increasing length of the front pile operations. However, the second option does not affect significantly because with the increasing length of the front lowering the pile tier at the same time there reduces the share volume of conveyor trench in the amount of overburden passage that should be placed in the floor of pile. That is, the height of pile tier increases with the increasing height ledge overburden regardless of the length of the front and overburden and pile workings. The height (m) of upper tier of inner pile $H_{t.p}$ is defined similarly, which provides the placement in it the upper opened ledge. Extracted rocks are filled a pile in the same way as in the lower tier, by two plots.

In the area on the left (Fig. 3), primarily rock in volume $V_{p.l}$ is placed in the top tier, and in volume $V_{p.tr.l}$ – in the zone forming conveyor passage quarry in the middle of the field. For this purpose a spreader moves on its previously created passages of a sloping platform in length l connected with the quarry surfaces of the lower tier pile, where the conveyor line for recovery of extracted minerals to the surface is situated.

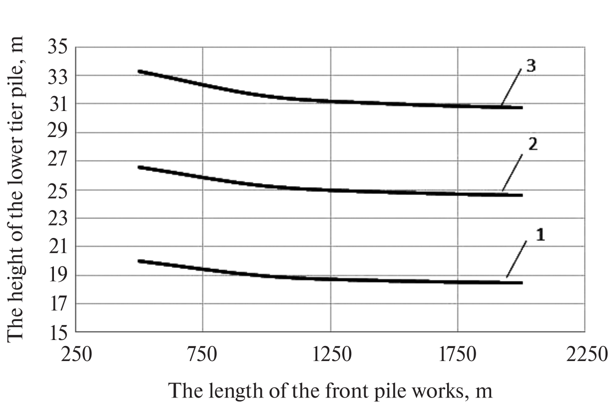

Fig. 2. Dependence of the lower tier height of inner pile on the front length of pile working:

1, 2, 3 – accordingly, at the height of the ledge drop of 15, 20 and 25 m

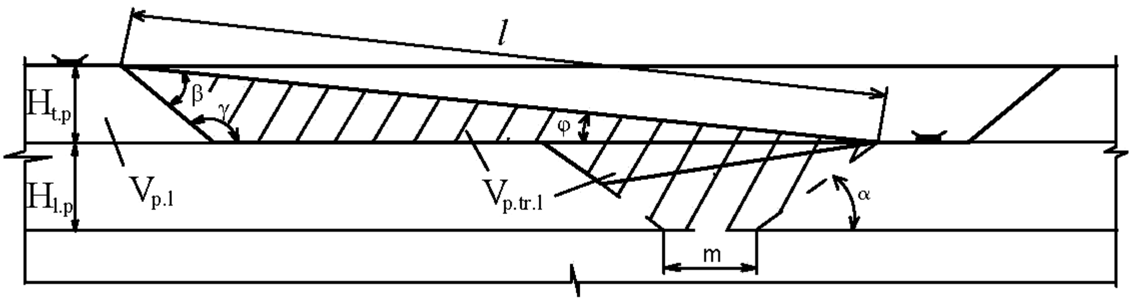

Fig. 3. Crosscut of the inner pile in place of temporary conveyor driving (section A–A in Fig. 1)

In addition, a spreader partially fills the rock conveyor trench width at the bottom, forming its board downhill slope for the location conveyor driving.

The amount of overburden (m^3) of the upper ledge is the product of its parameters

$$V_{t.o} = L_{t.o} \cdot A_o \cdot H_{t.o},$$

where $L_{t.o}$, $H_{t.o}$ are the length of the front of the upper ledge and its height, m, accordingly. Based on the above mentioned information the rock volume drop top ledge $V_{t.o}$ with regard to their dissolution K_o is equal to the sum of volumes of the upper tier of two pile sites $V_{p.l}$, $V_{p.p}$, and in the conveyor trench $V_{p.tr.l}$, $V_{p.tr.p}$.

According to Fig. 3

$$V_{p.l} = A \cdot H_{t.p} \cdot (0.5L_{t.p} - l\sin\varphi - 0.5m),$$

where $H_{t.p}$, $L_{t.p}$ are accordingly the height and length of the internal pile front on the top floor, m; l, φ are accordingly the length of the inclined platform for a spreader location, m, and the angle of the slope, degree.

The volume of overburden required to form an inclined platform for placing a spreader that fills overburden conveyor trench (Fig. 3) is given by

$$V_{p.tr.l} = A \cdot \Big((H_{h.l})^2 \cdot \mathrm{ctg}\,\alpha + H_{h.l} \cdot m + \frac{(H_{t.p})^2 \cdot \sin\beta \cdot \sin\gamma}{2\sin\alpha^2 \cdot \sin\varphi} \Big), \quad (4)$$

where β is the angle between the slope of the trench board conveyor and inclined platform location of a spreader, degree; φ is the angle between the surface and inclined platform pile; γ is the angle of repose board conveyor trench degrees.

Similarly, the amount of rock backfill of the trench on the conveyor section to the right is set by the (4), but the size of the height of the lower tier $H_{h.l}$ is substituted by height value $H_{t.p}$ of the upper tier.

The overburden volume is put in the volume $V_{p.tr.p}$ at the beginning in the area of minerals transportation to the surface of a career on the area to the right, piling sloping platform on the width of passage, and then – in the area of forming the upper tier dinner pipe with the following piping of moldboard passage in volume $V_{p.p}$ (Fig. 4). The volume of overburden $V_{p.p}$ to form the upper tier of the inner pipe at the site will be conditioned by the temporary conveyor parameters slots in the lower tier pipe by the formula

$$V_{p.p} = A \cdot H_{t.p} \cdot (0.5L_{t.p} - 1.5m - \mathrm{ctg}\,\alpha\, H_{t.p}).$$

Due to the volume of excavation for location of conveyor passages that are covered with rock ledge drop top, the height of the upper tier pile must suit the equation

$$L_{t.o} \cdot A_o \cdot H_{t.o} \cdot K_o = A \cdot H_{t.o} \cdot L_{t.p} - (m + \mathrm{ctg}\,\alpha\, H_{l.p})H_{l.p}. \quad (5)$$

It is received the formula for calculating of the upper tier pile height based on the (5) after mathematical transform and simplifies

$$H_{t.p} = \frac{H_{t.o} \cdot A \cdot L_{t.o} \cdot K_o + H_{l.p} \cdot m + (H_{l.p})^2\, \mathrm{ctg}\,\alpha}{A \cdot L_{t.p}}. \quad (6)$$

It follows from the (6) that the height of the upper tier will increase by increasing the height of the lower tier and will decrease with decreasing ratio of the upper ledge to drop down the length of the upper tier pile.

Regarding the above mentioned working conditions in the horizontal ore seam of the manganese quarries in Ordzhonikidze DPE, the height of the upper tier pile for location of drop-ledge by height 15, 20, 25 m should be from 18.1 to 31.4 m. The volume of the trench conveyor for lifting the ore extracted at the top tier pile depends on

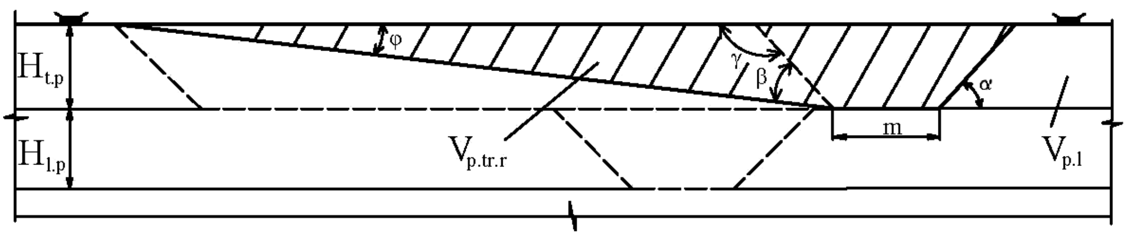

Fig. 4. Crosscut of the inner pile in place of temporary conveyor driving (section B–B in Fig. 1)

the length *l* of the working platform of a spreader (Fig. 4), and the length depends on the slope of the area. By calculating the width of moldboard passage from 50 to 60 m the change in slope from 4 to 8 degrees leads to changes in the volume of the trench from 250,000 to 500,000 m^3 (Fig. 5).

In general, the technology has the following positive aspects, namely, reducing the cost of delivery of overburden produced in the area of a quarry, and minerals – on the surface due to the replacement of road transportation by cheaper conveyor transportation, complete backfilling of moldboard volume and subsequent alignment of a moldboard surface because the location of the assembly line in the middle of a quarry field requires the allocation of land area on the surface of a pile and does not require expensive building of roads on soft surface of piles with loosened rocks. The parameters of technological schemes that provide interaction of expanding and piling facilities for placement of overburden were calculated.

Conclusions.

1. Purposeful ecology-oriented imperative of technology development of opening and development of horizontal fields leads to implementation in the quarries of technological mining schemes that will provide improved performance of mining with the limitation of negative impact on the environment.

2. New technology of testing and disclosure of horizontal fields that does not require mining outside the quarry field is developed, and it means that it helps reduce land resources overworking on the field significantly. Complete filling out of the area based on the offered technology provides favorable conditions for the working volume and quality of natural lands disturbed.

3. The main parameters of the developed technological scheme, which determine the placement of overburden in the inner piles, are height and length of the front dump operations. Analytical connections were determined and the quantification of these parameters was given considering placing conveyor trench.

4. The proposed technology of opening and extraction of the ore layer has limited application conditions (overburden thickness from 50 to 60 m, which are removed by two benches). It is necessary to continue the development of the technology adopted by way of placing rocks in the quarry area of embedded area for overburden thickness from 70 to 80 m and more.

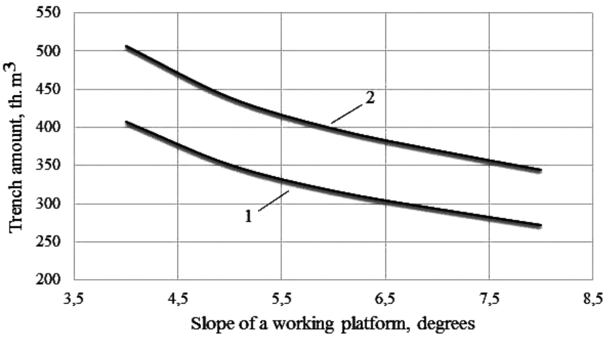

Fig. 5. The graph of the conveyor trench amount on the lower tier moldboard angle of slope of a working platform of a spreader:

1, 2 – width of passage 50 and 60 m, respectively

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Мета. Вибір та обґрунтування методичного підходу до побудови технології розкриття й розробки горизонтальних і похилих марганцеворудних та буровугільних пластів потужністю 1,5–10 м, що залягають у м'яких розкривних породах за умови повної засипки виробленого простору розкривними породами, поліпшення умов рекультиваційних робіт і зниження витрат на транспортування розкривних порід у відвал.

Методика. Завдання дослідження виконані за допомогою методів критичного аналізу й узагальнення результатів наукових праць, досвіду роботи кар'єрів – для постановки задач і формулювання

висновків; аналітичного — при обґрунтуванні параметрів гірничих виробок і відвалів; графоаналітичного — для наочного зображення технологічної схеми та її параметрів.

Результати. Розроблена технологія розкриття та відпрацювання горизонтального родовища, що ґрунтується на розміщенні гірничих виробок для транспортування розкривних порід і корисної копалини всередині кар'єрного поля. Обґрунтовані параметри технологічної схеми, що забезпечують взаємодію розкривного та відвального фронтів роботи для розміщення розкривних порід. Наведені можливості запропонованої технології щодо повного використання ємності виробленого простору кар'єру й скорочення транспортних витрат.

Наукова новизна. Обґрунтовані технологічні процеси розкриття горизонтального пласту корисної копалини, що, на відміну від відомих, передбачають змінювання місця розташування тимчасових траншей, а саме їх періодичне переміщення разом з конвеєрними лініями всередині кар'єру. Це дозволяє здійснити повну засипку виробленого простору. Встановлені аналітичні залежності обсягу конвеєрної траншеї на нижньому відвальному ярусі від кута ухилу робочої площадки відвалоутворювача, що дозволить здійснити повне розміщення порід розкривних уступів у відвальних ярусах.

Практична значимість. Розроблена технологія враховує еколого-орієнтований імператив до відпрацювання горизонтальних і похилих марганцеворудних та буровугільних пластів потужністю 1,5–10 м, а саме вимогу щодо його розробки без утворення зовнішнього відвалу та повної засипки виробленого простору розкривними породами. На практиці запропонована технологія дозволить збільшити площу земель для відновлення, поліпшити умови для гірничотехнічної рекультивації, а також прискорити строки повернення відновлених земель до сільського господарства.

Ключові слова: *кар'єр, технологія гірничих робіт, внутрішнє відвалоутворення, гірничотехнічна рекультивація, конвеєрна траншея*

Цель. Выбор и обоснование методического подхода к созданию технологии вскрытия и разработки горизонтальных и наклонных марганцеворудных и буроугольных пластов мощностью 1,5–10 м, залегающих в мягких вскрышных породах при полной засыпке выработанного пространства вскрышными породами, улучшение условий рекультивационных работ и снижение расходов на транспортировку вскрышных пород в отвал.

Методика. Задачи исследования выполнены с помощью методов критического анализа и обобщения результатов научных трудов, опыта работы карьеров — для постановки задач и формулирования выводов; аналитического — при обосновании параметров горных выработок и отвалов; графоаналитического — для наглядного изображения технологической схемы и ее параметров.

Результаты. Разработана технология вскрытия и отработки горизонтального месторождения, которая основывается на размещении горных выработок для транспортировки вскрышных пород и полезного ископаемого внутри карьерного поля. Обоснованы параметры технологической схемы, обеспечивающие взаимодействие вскрышного и отвального фронтов работы для размещения вскрышных пород. Приведены возможности предлагаемой технологии при полном использовании емкости выработанного пространства карьера и сокращении транспортных расходов.

Научная новизна. Обоснованы технологические процессы вскрытия горизонтального пласта полезного ископаемого, которые, в отличие от известных, предусматривают изменение места расположения временных траншей, а именно их периодическое перемещение вместе с конвейерными линиями внутри карьера. Это позволяет осуществить полную засыпку выработанного пространства. Установлены аналитические зависимости объема конвейерной траншеи на нижнем отвальном ярусе от угла наклона рабочей площадки отвалообразователя, что позволит осуществить полное размещение вскрышных пород в отвальных ярусах.

Практическая значимость. Разработанная технология учитывает эколого-ориентированный императив в разработке горизонтальных и наклонных марганцеворудных и буроугольных пластов мощностью 1,5–10 м, а именно, требование их разработки без образования внешнего отвала и полной засыпки выработанного пространства вскрышными породами. На практике предложенная технология позволит увеличить площадь земель для восстановления, улучшит условия для горнотехнической рекультивации, а также ускорит сроки возврата восстановленных земель сельскому хозяйству.

Ключевые слова: *карьер, технология горных работ, внутреннее отвалообразование, горнотехническая рекультивация, конвейерная траншея*

Рекомендовано до публікації докт. техн. наук М. С. Четвериком. Дата надходження рукопису 18.04.16.