UDC 622.272.4: 622.274.5

Kosenko A.V.
State Higher Educational Institution
«Kryvyi Rih National University»

WAYS OF INCREASING QUALITATIVE AND QUANTITATIVE RECOVERY PERCENTAGES OF ORE IN CONDITIONS OF DEEP HORIZONS OF THE MINES OF KRIVBASS

The scientific article deals with research of technological solutions that allow increasing the completeness of extracted ore recovery and the quality of ore mass. As a result, it has been established that one of the key solutions to this problem is to increase the intensity of the technological process for the ore drawing from the cleaning rooms through the draw hole. Since this will increase the volume of extraction of pure ore by an average of 5-51%, depending on the mining and geological and mining conditions for the development of deposits of natural-rich iron ores at significant depths.

Key words: *natural-rich iron ores, ore loss, dilution, sub-level caving, undercut, clearing room, actual mining, recovery percentages.*

The problem and its connection with the scientific and practical tasks. The reserves of oxidized natural rich iron ores of Kryvbas are characterized by the content of the useful component in them from 46 to 67% and are developed in the depth range 1200-1400 m [1; 2]. These conditions, due to the active manifestation of geomechanical processes, create the need to constantly increase the share of the technology of sub-level caving, which is characterized, in real terms, by significant of ore loss (16-30%) and dilution of ore mass (15-25%) [3]. These indicators with depth constantly deteriorate by 5-8%, which is accompanied by a decrease in the quality of extracted ore mass on average by 3-4% [3]. At the same time, a decrease in the quality of the extracted ore mass leads to the need to expand the scale of ore enrichment and increase the scale of cleaning of ore [4]. Since iron ore is the most important factor in the formation of the country's budget [1]. Therefore, research and improvement of technological solutions to improve the qualitative and quantitative extraction of minerals in the underground Kryvbas is an urgent task and will provide an opportunity to ensure the competitiveness of the national economy.

Research and publications analysis. Based on the analysis of the theory and experience of using the sub-level caving [2; 5–7] it was established that the reserves of further constructive and technological improvement of them based on the use of stationary and portable mine equipment in the conditions of deep mine horizons are practically exhausted. The exploitation of the productive horizons of the Kryvbas mines for the extraction of natural-rich iron ores is accompanied by a low intensity of actual mining, which varies between 1.2-1.8 tons/m^2 per day (average 1.5) [8]. This makes it possible to form undercut only in the range of 8-12% of the volume of the stock pied ore of the panel, provided they are stable for the entire lifetime [2]. And this leads to a significant deterioration in the process of ore drawing [9], since the blasting of rock ore is made in practically a «clamped» medium. Therefore, in order to blasting the ore, it is necessary to form undercut that provide the ore loosening factor within 1.2-1.3 [9]. An increase in the volume of undercut will also increase the amount of heading, which will have a positive effect on the recovery percentages [10; 11].

Calculation of sustainable design parameters for underground mining of natural rich iron ore deposits of Kryvbas is carried out according to the approved NIGRI method [12]. This methodology is based on the integral accounting of the deposit development class, the depth of mining, the ore hardness and the adjacent strata and the lifetime of outcrops. Since the depth and natural strength of the ore-rock massif can`t be influenced by engineering methods, an increase in the volume of the cleaning room (undercut) is possible provided the lifetime of their outcrops is shortened. This is possible due to increased intensification of actual mining.

Foreign experience in the underground mining of mineral deposits indicates that a significant increase

in labor productivity in the technological process of ore drawing and delivery is impossible without the use of self-propelled machinery [13–15]. But large-scale application of self-propelled machinery in the conditions of Kryvbas is contradicted by complex geomechanical conditions [8; 9]. Therefore, an effective way to increase the productivity of the technological process of ore drawing and delivery in this case is the application of the combined method with the help of the «multi-bucket scraper winches 55LS-2S – self-propelled loading and unloading machine TORO 400E» [16; 18]. The productivity of this complex under medium conditions can reach 1200-1400 ton/shift, which ensures the intensity of ore drawing within the limits of 5.5-6.0 tons/m^2 per day [16], and in ideal conditions can reach 10-12 tons/m^2 per day [13].

Formulation of the problem. On the basis of the method of functional characteristics of determining the permissible sizes of structural elements of the underground mining methods of iron ore deposits, it is necessary to investigate the dependence of the value of the parameters of stable outcrops of cleaning room (undercut) spaces depending on mining and geological and mining factors to improve the recovery percentages.

Presentation of the main material and results. The object of the study is the deposit of the iron ore deposit of Krivbass, represented by a plate-like ore body with a hardness coefficient of 4-6 on the scale of Professor M. M. Protodyakonov, with a thickness of 15-40 m and a pith angle of 35-65°. The adjacent strata of the hanging wall are represented by quartzites with a hardness coefficient of ≥8, and the bottom layer – by killas with a hardness coefficient of ≥ 4. The geological stress field is geostatic. The height of the sub-level is 40 m, and the length of the panel along the strike of the ore deposit is 25-35 m. It is conditionally assumed that the actual mining is carried out by one cleaning panel for the entire thickness of the ore deposit. During development, a caving zone of collapse from the abandoned workings. The shape of the caving zone of collapse is determined by the depth of mining operations, the thickness and pith angle of incidence of the ore body, the nature of collapse and displacement of the rocks of the hanging wall: without lagging or lagging behind the clearing horizon; with the transition to a closed zone. Mining is conducted at depths of 1200-1400 m by a resource-saving combined system of sub-level caving with blasting and combined mechanized delivery [13].

Based on the technique [12], a calculation program was developed in the software package Exel 10 of the operating system Windows 8 (figure 1).

With the help of the developed program, the possible relative volumes of the primary treatment areas were established by the condition of maximum stability of outcrops of the cleaning room (undercut) and the capabilities of the delivery vehicles. Based on the calculations carried out using the graph-analytical method, graphs of the dependence of the relative vol-

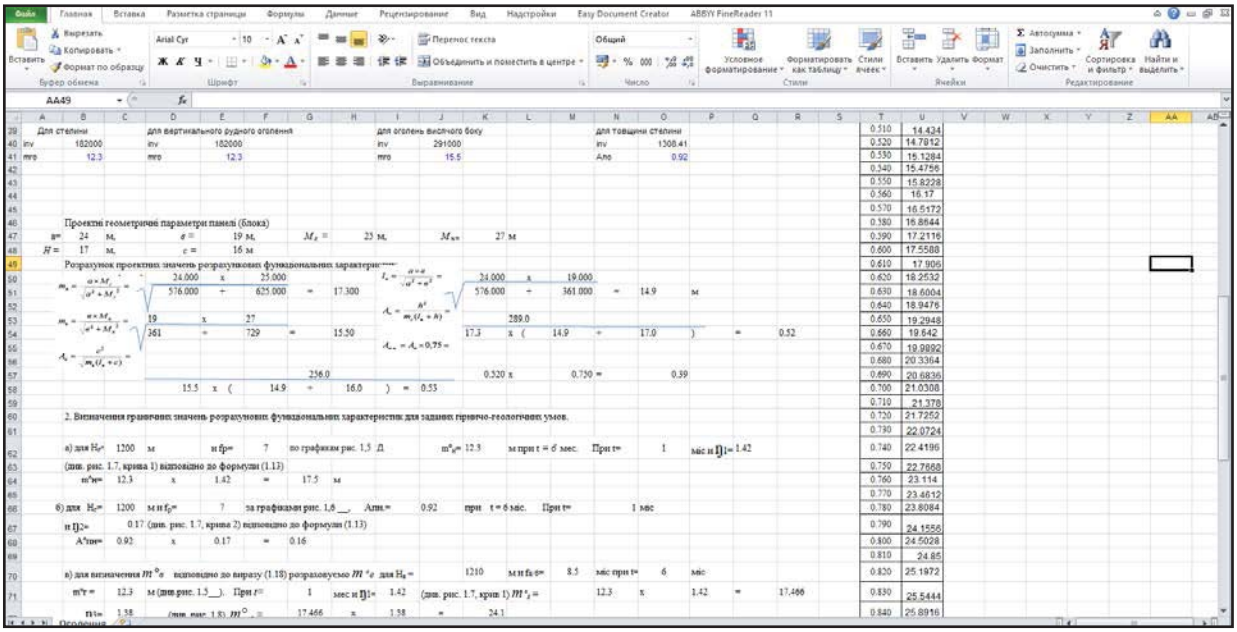

Fig. 1. Fragment of the developed program for calculating the parameters of stable outcrops of structural elements of sub-level caving

ume of the purification cleaning room (undercut) on the thickness of the ore deposit (width of the panel in the cross of the strike) for different intensity of the technological process of ore drawing and delivery of the ore mass, different classes of reservoir development, ore at a different depth of mining (figure 2, figure 3).

From Figure 2 and 3 it can be seen that:

1) for class I mining presented below ores medium strong ($f = 4$), and stability in the depth range of 1200-1400 m (see Figure 2 a and Figure 3 a), the specific volume cleaning room (undercut) of the spaces may increase in 7.3- 49.5%;

2) for class II mining deposits presented below ores medium strong ($f = 4$), and stability in the range of 1200-1400 meters depth (see Figure 2 b and Figure 3 b), the specific volume cleaning room (undercut) of the spaces may increase in 5-51%;

3) for class I mining presented ores medium strength ($f = 6$) and stability in a depth range of 1200-1400 m (see Figure 2 c and Figure 3 c), the specific volume cleaning room (undercut) of the spaces may increase in 7.0-15.8%

4) for class II mining deposits represented ores medium strength ($f = 6$) and stability in the range of 1200-1400 meters depth (see Figure 2 d and Figure 3 d),

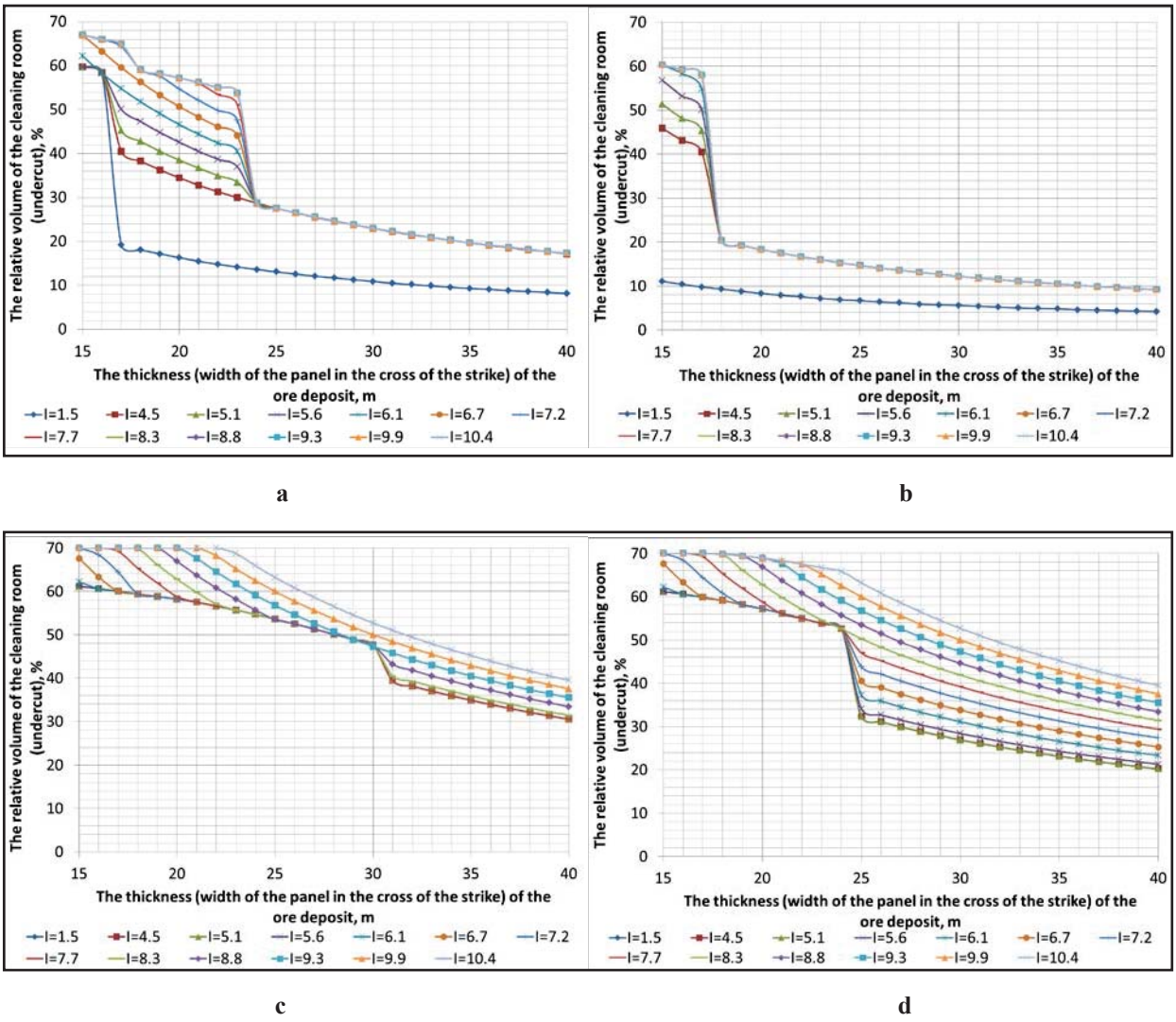

Fig. 2. Graphs of the dependence of the relative volume of the cleaning room (undercut) chamber on the thickness (width of the panel in the cross of the strike) of the ore deposit for the various intensity of the technological process of ore drawing and delivery of ore during the actual mining at a depth of 1200 m: a – I class of development of natural-rich deposits iron ore with a hardness coefficient of 4; b – II class development of the deposit of natural-rich iron ore with a hardness coefficient of 4; c – I class of development of a deposit of natural-rich iron ore with a hardness coefficient of 6; d – II class of development of a deposit of naturally-rich iron ore with a hardness coefficient of 6; 1,5-10,4 – intensity of conducting works on ore delivery, tons/m² per day

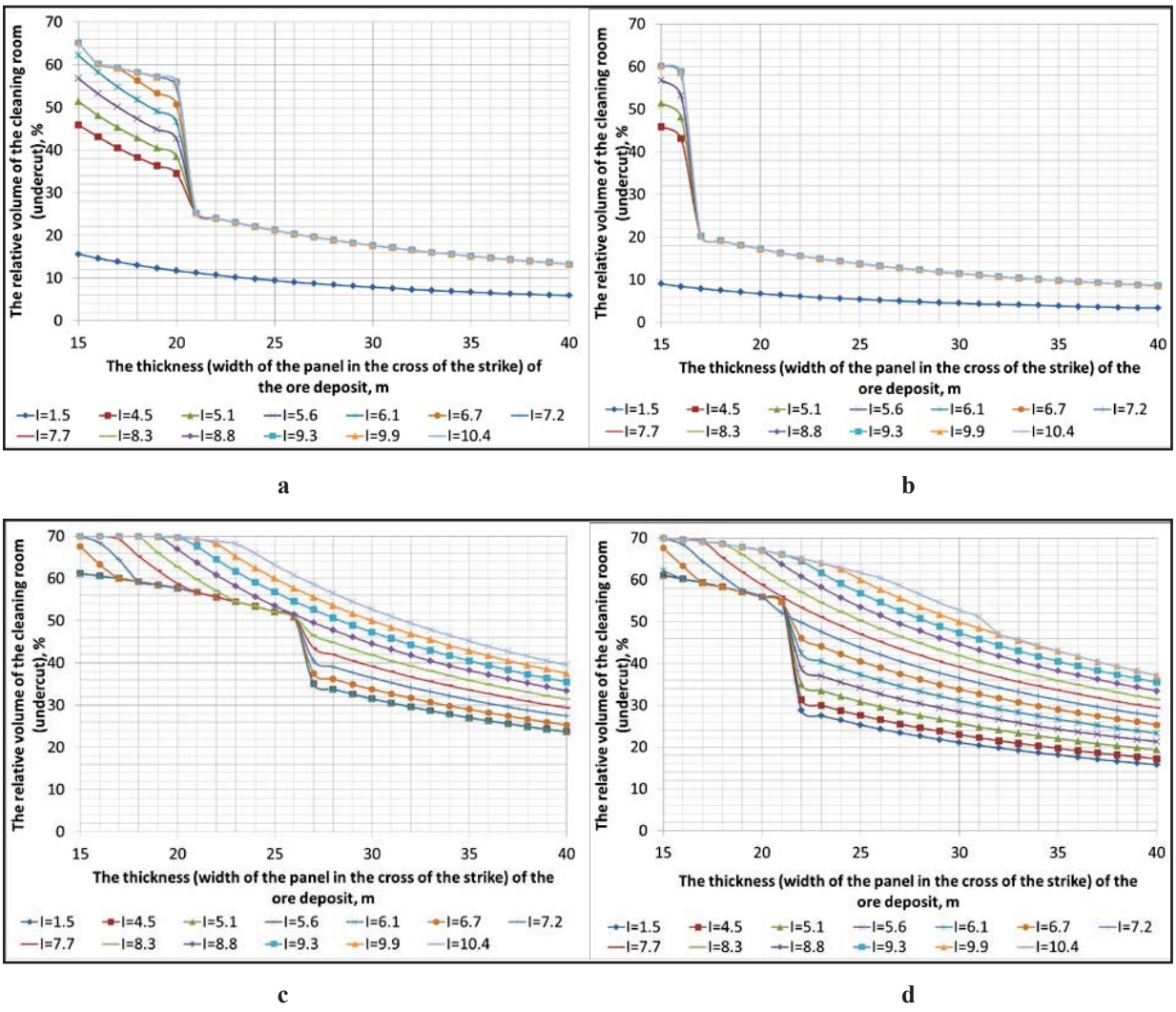

Fig. 3. Graphs of the dependence of the relative volume of the cleaning room (undercut) chamber on the thickness (width of the panel in the cross of the strike) of the ore deposit for the various intensity of the technological process of ore drawing and delivery of ore during the actual mining at a depth of 1400 m: a – I class of development of natural-rich deposits iron ore with a hardness coefficient of 4; b – II class development of the deposit of natural-rich iron ore with a hardness coefficient of 4; c – I class of development of a deposit of natural-rich iron ore with a hardness coefficient of 6; d – II class of development of a deposit of naturally-rich iron ore with a hardness coefficient of 6; 1,5-10,4 – intensity of conducting works on ore delivery, tons/m^2 per day

the specific volume cleaning room (undercut) of the spaces may increase in 8.8-21.3%.

Conclusions. During research, it was found that one way of a significant increase in the volume of space in stable undercut unstable metallic arrays, lying in complex geotechnical conditions, is to intensify the process of ore drawing and delivery of the ore mass.

Thus, when mining deposits of natural-rich iron ores with a hardness coefficient of 4-6 on the scale of Professor M. M. Protodyakonov, average and below average stability and with a thickness of 15-40 m, which are concentrated in the depth range 1200-1400 m, it becomes possible to create stable outcrops of sewage cameras with a volume of up to 70% of the main stock of the cleaning panel. And, as a consequence, it will allow to increase the volume of extraction of pure ore by 5-51%, depending on mining and geological and mining conditions of development.

References:

1. Рациональная разработка и обогащение железорудного сырья Криворожского бассейна / Ю.Г. Вилкул, С.А. Сторчак, В.И. Яременко, Н.К. Кравцов. Качество минерального сырья. 2011. С. 20.

2. Тарасютин В.М., Косенко А.В. Ресурсосберегающие технологии очистной выемки богатых железных руд на глубоких горизонтах шахт. Вісник КНУ: збірник наукових праць. 2017. Вип. 44. С. 85.

3. Калініченко В.О., Косенко А.В., Хівренко О.Я. Дослідження показників вилучення руди на основі фізичного моделювання її випуску для умов глибоких горизонтів шахт Кривбасу. Качество минерального сырья. 2017. Т.1. С. 143.

4. Олейник Т. А. Современные тенденции развития технологий обогащения гематитовых руд в Украине. Збагачення корисних копалин. 2014. Вип. 56(97). С. 37.

5. Кудрявцев М.И., Басов А.М. Пути совершенствования технологи подземной разработки богатых руд Кривбасса. Вісник КНУ: збірник наукових праць. 2010. Вип. 26. С. 23.

6. Проект № 148-20-11 нарезных и очистных работ в блоке 140-147 оси гор. 1220 м в п/эт. гор. 1265/1190 м зал. «Основная» п.ш. «Большевик» (с применением самоходного оборудования) // ПАО «Кривбассжелезорудком» шахта «Октябрьская». Кривой Рог. 2011.

7. Пояснительная записка к проекту №40 / от 21.11.2011 г./ нарезных и очистных работ в экспериментально-промышленном блоке 93-102 оси гор. 1350-1275 м по залежи «102-5» 6-го простирания 1,2 р.т. с применением самоходной техники // ПАО «Кривбассжелезорудком» шахта им. Ленина В.И. Кривой Рог. 2011.

8. Підвищення ефективності технологічного процесу випуску і доставки руди на базі використання самохідної навантажувально-доставочної техніки / М.І. Ступнік, В.О. Калініченко, В.М. Тарасютін [та ін.]. Вісник КНУ: збірник наукових праць. 2016. Вип. 41. С. 141.

9. Косенко А.В., Мурашкін А.В. Дослідження та удосконалення технологічного процесу випуску і доставки руди на базі використання самохідної навантажувально-доставочної техніки // «Бъдеещите изследования – 2016» : материали за XII международна научна практична конференция (Болгария, София, 15-22 февруари 2016). София: «Бял ГРАД-БГ» ООД. 2016. Том 11. С. 25.

10. Письменный С.В. Отработка сложноструктурных залежей богатых руд камерними системами разработки. Гірничий Вісник: науково-технічний збірник. 2014. Вип. 97. С. 3.

11. Трубецкой К.Н. Проблемы геотехнолгических процессов комплексного освоения суперкрупных рудных месторождений / под. ред. К.Н. Трубецкого, Д.Р. Каплунова. Москва: ИПКОН, 2005. 248 с.

12. Бабец Є.К., Сиротюк С.В., Царіковський В.В. Визначення та контроль допустимих розмірів конструктивних елементів систем розробки залізних руд. Київ: Мінпромполітики, 2010. 121 с.

13. Тарасютин В.М., Косенко А.В. Разработка рациональных вариантов ресурсосберегающей технологии очистной выемки залежей богатых железных руд шахт с использованием самоходного горного оборудования // «Modern European science – 2015»: materials of the XI international scientific and practical conference (England, Sheffild, June 30 – July 7, 2015). Sheffild: SCIENCE AND EDUCATION LTD, 2015. Volume 11. С. 69.

14. Дослідження та удосконалення технології відпрацювання покладів з застосуванням самохідної доставочної техніки / В.О. Калініченко, Н.Ю. Швагер, С.М. Чухарев [та ін.]. Гірничий Вісник: науково-технічний збірник. 2015. Вип. 99. С. 100.

15. Комбінований спосіб доставки руди при відпрацюванні потужних рудних покладів / Д.Ф. Зенюк, В.М. Тарасютін, О.Я. Хівренко, М.Б. Федько. Вісник КНУ: збірник наукових праць. 2012. № 29. С. 20.

16. Косенко А.В. Комбинированный способ доставки рудной массы – перспективы дальнейшего развития подземных рудников Кривбасса. Наука и образование сегодня. 2018. № 3(26). С. 21.

17. Kosenko A.V. Improving the efficiency of production process and shipping ore on the basis of the use of self-propelled load-delivery machines technology // «Science in 2018»: proceedings of XIV International scientific conference (USA, Morrisville, Jan 26 2018). Morrisville, 2018. P. 6.

18. Kosenko A.V. Definition and justification of rational parameters of technological schemes of delivery ore mass in the process of development of natural-rich iron ore of Krivbass // «Scientific research in 2018»: proceedings of XV International scientific conference of students and young scientists (Kramatorsk, Feb 9th 2018). Vinnytsya, 2018. P. 85-89.

ПУТИ ПОВЫШЕНИЯ КАЧЕСТВЕННЫХ И КОЛИЧЕСТВЕННЫХ ПОКАЗАТЕЛЕЙ ИЗВЛЕЧЕНИЯ РУДЫ В УСЛОВИЯХ ГЛУБОКИХ ГОРИЗОНТОВ ШАХТ КРИВБАССА

В статье производится исследование технологических решений, позволяющих повысить полноту извлечения отбитой руды и качество рудной массы. Вследствие чего установлено, что одним из ключевых решений этой проблемы является повышение интенсивности технологического процесса выпуска руды и рудной массы из очистных пространств через выработки выпуска. Так как это позволит увеличить объём извлечения чистой руды в среднем на 5-51% в зависимости от горно-геологических и горнотехнических условий разработки залежей природно-богатых железных руд на значительных глубинах.

Ключевые слова: *природно-богатые железные руды, потери руды, разубоживание, подэтажное обрушение, компенсационная камера, очистное пространство, очистные работы, показатели извлечения.*

ШЛЯХИ ПІДВИЩЕННЯ ЯКІСНИХ І КІЛЬКІСНИХ ПОКАЗНИКІВ ВИЛУЧЕННЯ РУДИ В УМОВАХ ГЛИБОКИХ ГОРИЗОНТІВ ШАХТ КРИВБАСУ

У статті проводитися дослідження технологічних рішень, що дозволяють підвищити повноту вилучення відбитої руди і якість рудної маси. Внаслідок чого встановлено, що одним із ключових рішень цієї проблеми є підвищення інтенсивності технологічного процесу випуску руди і рудної маси з очисних просторів через виробки випуску. Оскільки це дозволить збільшити обсяг вилучення чистої руди в середньому на 5-51% у залежності від гірничо-геологічних і гірничотехнічних умов розробки покладів природно-багатих залізних руд на значних глибинах.

Ключові слова: *природно-багаті і залізні руди, втрати руди, засмічення руди, підповерхове обвалення, компенсаційна камера, очисний простір, очисні роботи, показники вилучення.*