UDC 622.272:622.611

Kosenko A.V.
State institution of higher education
"Kryvyi Rih National University"

INCREASE OF EFFICIENCY OF TECHNOLOGICAL PROCESS OF ORE DRAWING AND DELIVERY OF ORE MASS AT DEVELOPMENT OF DEPOSITS OF NATURAL-RICH IRON ORES ON LARGE DEPTHS

The scientific article gives an investigation of technological solutions for intensity the ore drawing, which will improve the completeness of extraction of freed ore and the quality of ore mass. As a result, it has been established that one of the key solutions to this problem is the use of a combined method for the delivery of ore and ore mass with the help of the "multi-bucket scraper winches – self-propelled loading and unloading machine" complex. Since the application of this complex is most adapted to the complex geomechanical conditions of the deep horizons of the Kryvbas mines. Research and technological solutions for decreasing the amount of localization of ore mass hanging in the draw-points upto 1,4–2,2% are presented, which will allow increasing the operational productivity of the scraper winch up to 600–700 tons/shift. And it will also make it possible to increase the intensity of the technological process of ore drawing from 1,5 to 5,5–6,2 tons/m2 per day and the extraction of clean ore to 10,5%.

Key words: *deep horizons, intensification of mining operations, recovery percentages, natural-rich iron ores, self-propelled loading and unloading machinery, combined ore delivery method.*

The problem and its connection with the scientific and practical tasks. To date, the development of natural deposits of rich iron ore in underground mines Kryvbas made at a depth of 1200–1400 m under significant influence of gravitational stress fields with different options sublevel caving method characterized by low rates of ore extraction and design complexity, with increasing depth reduces the competitiveness of underground mining enterprises [1]. Under these conditions, the reserves for further design and technological upgrade sewage extraction technology based on the use of obsolete fixed and hand-held equipment is almost exhausted [1–4].

Research and publications analysis. Analysis of the current domestic and foreign experience, scientific works and project materials prove that at the moment the main problem of mining natural rich iron ore is the intensification of its production and the introduction of advanced methods of production using modern mechanization of all production processes [1–8]. Since it is proved that the intensification of extraction long-hole stoping improve the competitiveness of the mining enterprises of Kryvyi Rih iron ore basin. But the large-scale introduction of the self-propelled machines hinder sophisticated geomechanical conditions of deep horizons of mines Kryvbas, especially in the process of delivery of ore mass since the release of the ore through the crosscut, located at the base of draw-ball of production level, it is extremely difficult to keep the workings of cross-sectional area of 12–14 m^2 during their lifetime while ensuring maximum quality and quantity of ore extraction [9]. This raises the question of changing the design of the production level.

To solve this problem, developed a combined method of delivery of ore from the discharge openings to the system of capital ore passes, through scrapers on the horizon, the primary delivery and Load-Haul-Dump on the horizon secondary delivery, which is the most adapted to the complex geomechanical conditions of deep horizons of mines Kryvbas [10].

The disadvantages of this method of delivery is that the combination of vehicle the roof load-delivery cross drift and foot wall roadway complicated ventilation openings initial delivery. As a result, scrapers driver installation is in a niche that is not ventilated. As well as the formation of ore mass invasion foot wall roadway small volume, which reduces the use of self-propelled vehicles for change if the process simple scrapers installation. But still the main drawback of this technological scheme is to ensure the performance of a scraper winch within 200 tons/shift [4]. Since there is a significant loss in performance due to the localization of hangs, which is an average of 15%

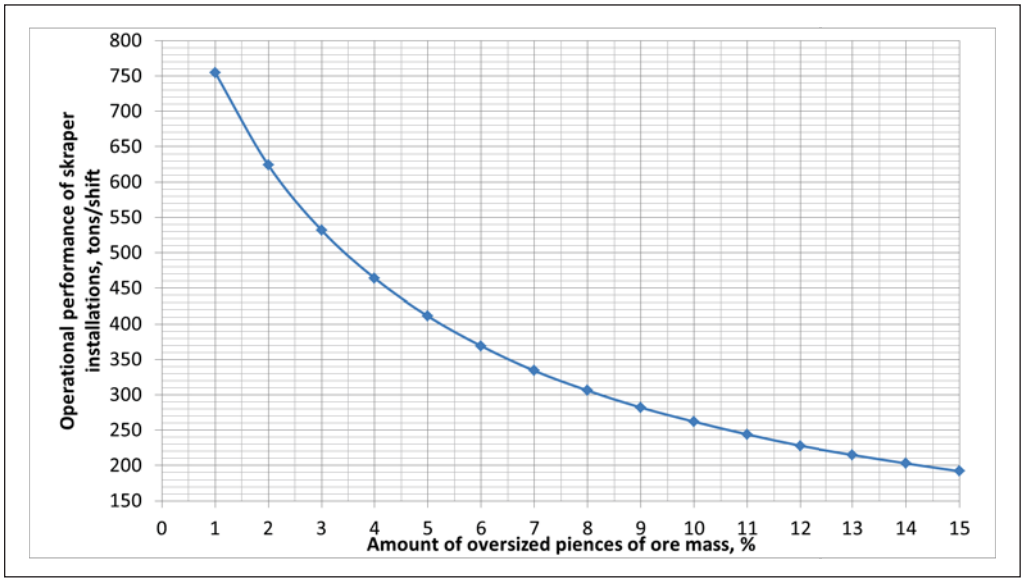

Fig. 1. Dependence variable operating performance scraper installations from the exit of oversized pieces of ore mass (%)

[11].Which mainly arise from the exit of oversized pieces of ore or waste rock [11;12].

Formulation of the problem. To improve the combined method of ore mass delivery by increasing the productivity of the scraper winch. To do this, it is necessary to find the possibility of reducing the average length of ore mass delivery and reducing the amount of localization of hangings in the draw-points.

Presentation of the main material and results. To reduce the average length of ore delivery to 6 m, the use of a multi-bucket scraper winch is suggested [13]. But still the main task is to reduce the number of out-of-gauge pieces of ore and waste rock. Thus, according to the formula given in [4], the operating capacity of the scraper winch 55LS-2S was calculated, with a tail scraper with a volume of 1,2 m^3, depending on the exit of the oversized pieces (Figure 1).

Thus, it can be seen from Figure 1 that an exception to the maximum value of the exit of oversized pieces will ensure an increase in the productivity of a scraper winch by 2–4 times.

The first step in the solution of the problem is to replace the draw-points with a diameter of 1.5 m to the niches or ore drawing with the size of 2x2 m. This will reduce the number of localization of hangings by 2,0–2,5 times. But the most effective way to reduce the output of oversized pieces is to improve drilling and blasting operations.

During the study found that the quality of the blasted rock mass depends on such factors: the influence of gravitational and tectonic stress fields, which leads to a deterioration of the situation and mine technical causes an increase in consumption of explosives in the breaking of using known short-delay blasting circuits; the nature of stratification of rocks, which affects the speed of propagation of elastic waves, under the influence of which the medium is deformed and destroyed; of the means of drilling of blast holes, parameters and methods of blasting.

On the basis of investigations carried out to solve the problems of regulating the quality of crushing rock explosion resource it was developed technological scheme of the process of breaking the ore excavation units in the array embodiments of sublevel caving in difficult geological and mining conditions of deep horizons of mines complex, including: select the direction of the main group of holes, taking into account the regularities of formation stress fields in the zone horizons stopping, their changes and zoning arrays excavation units and structural elements of the system in the process of development of mining operations; reducing the seismic effect of breaking the bottom of the complex workings of excavation units due to account of the orientation of sets of wells with respect to the bottoms of the excavation units; improving the quality of ore crushing due to the choice of the optimal length of blast holes and applied geotechnics; selection of management sets the direction of blast holes and blasting parameters taking into account the anisotropy of the ore massif.

Thus, these recommendations will allow to reduce the output of oversized pieces to 1,4–2,2% and thereby increase the productivity of the scraper winch to 600–700 t/shift (Figure 1).

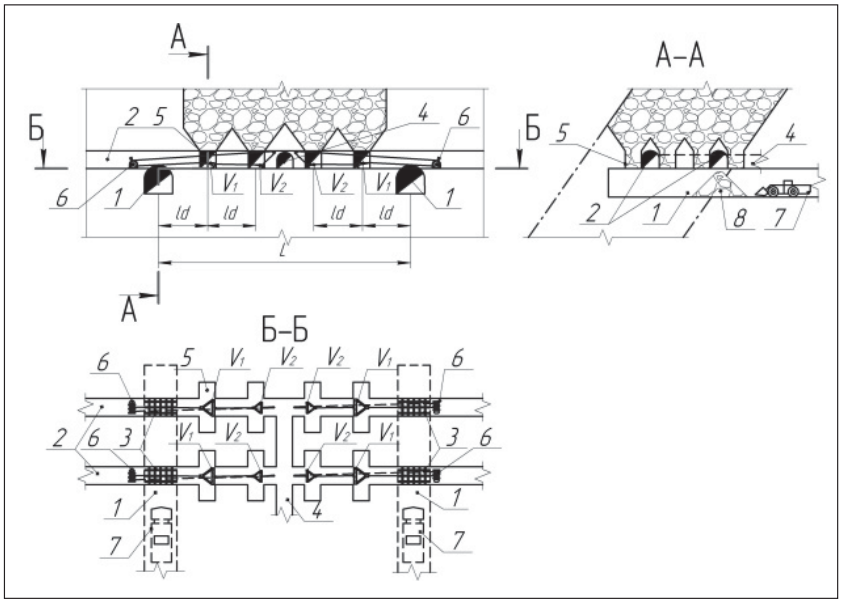

Fig. 2. Scheme of the combined method of delivery of ore mass "multi-bucket scraper winches – self-propelled loading and unloading machine"

The conducted researches and formulated recommendations made it possible to develop a fundamentally new design of the combined method of ore mass delivery (Figure 2).

To ensure the operation of the scheme shipping ore mass, the level is divided into several sublevel approximately equal height at which and foot wall roadway with the bottom layer cutting load-delivery cross drift 1. Over the load-delivery cross drifts 1 cutting roadway 2 of horizon primary delivery, combining their roof and foot wall, respectively. In the field of combining these workings is set grating 3. Pairs form a 4–6 discharge niches 5 that have a size of 2×2 m in the roadway 2 of horizon primary delivery. Will increase conditioned piece of 600 mm. The roadway 2 of horizon primary delivery in the central part combine with each other using ventilation cross drift 4 connecting system of mining ventilation drifts collective-collector.

Production and delivery of ore mass within the cleaning panels made after vidbiyky ore mass of discharge niches 5 to roadway 2. Ore delivered multibowl scraper settings 6, on both sides of the ventilation cross drift 4, their intersection with loading and load-delivery cross drift 1 where it grating by 3 grid unloaded. On the soles of cargo load-delivery cross drift 1, thus formed bulk ore mass 8, the amount of which can reach the order of 90 tons. The automated high-performance production of ore ensured that each quantity scrapers scraper setting 6 corresponds to the number of pairs of exhaust openings 5 of which held output, volume scrapers (V), starting with the tail, twice the previous volume ($V_1 = 2V_2$). The distance between the scrapers same and the distance between adjacent discharge niches (*ld*) and center loading and load-delivery cross drift 1. This combination of discharge niches and scrapers setting will ensure uniform ore output equal doses of each outlet and help eliminate the social factor subject planogram production. Thus the average length delivery reduced to the distance between the discharge niches, which is 6 m, depending on the parameters of sustainability ore array and intensity of cleaning processes remove. As a result, productivity scraper installation is provided in the range of 600 to 700 tons/shift, causing the intensity of working panels in a range of 5,5–6,2 tons/m^2 per day. Depending on the distance (*ld*) and the number of pairs discharge niches through the wall roadway on the horizon, the primary delivery, distance between loading and load-delivery cross drifts *L* will fluctuate within 30–35 m. The secondary self-propelled load-delivery machines 7, carried out on load-delivery cross drifts 1 to include discharge directly into vehicles or major ore pass.

Airing horizon secondary delivery propelled loading and delivery machines, depending on the capacity of ore deposits can be made using forced local ventilation fans, or using the ventilation openings in the bottom layer of or put rocks in which it is placed. Airing horizon primary winches delivery unit 6 made clear jet of air that comes from the roadway 2 on each side panel cleaning and removal of exhaust air through the ventilation crosses 4.

This ore drawing method excludes the impact of social factors in the performance of planogram ore

drawing, through the use of multi-bucket scraper winch. Since the distance between adjacent scraper winch buckets equal to the distance between the pairs of draw-points from which the ore drawing.

The use of multi-bucket scraper winches allows the ore drawing all the draw-points along the length of the primary mine working uniform dose delivery («linearly alternating with a uniform dose of ore drawing») that improves the quantitative and qualitative of ore extraction. Because based on laboratory studies conducted for the terms of the range of tilt angles of one of the side walls panel stope of ore deposits within 35–65° and height of the layer of ore collapsed draw-points, which in scale modeling is 40 m, it was found that "linearly alternating with a uniform dose of ore drawing" reduces the ore to 10,5% in fact pure ore extraction, depending on the angle and height of the ore deposit ore collapsed layer, as compared to a uniformly consistent ore-release mode.

Conclusions. The research helped to establish optimal parameters of the technological process of ore drawing and delivery of ore mass within the panel, which will allow to provide its high-intensity of ore drawing in the range of 5,5–6,2 tons/m^2 per day. This indicator of intensity is ensured by the productivity of the scraper winch at the level of 600–700 tons/shift, on the horizon of the primary delivery along the line of scraper drift, provided that the oversized pieces of the ore mass are released in the range of 1,4–2,2%. The performance of the TORO 400E self-propelled loading and unloading machine, within an average delivery length of 90–110 m, ranges from 1200–1400 tons/shift, which allows one machine to service two scraper covers in two loading crosscuts that are located along the contour of the cleaning panel . The distance between the capitalore passes will be, on average, 330 m, with an average thickness of the ore deposit of 20–30 m. The combination of the roof of the loading and unloading crosscut and the soles of the scraper drift can increase the amount of invasion of the ore mass on its sole, as a result of increasing its height, which will increase the coefficient the use of a self-propelled loading and unloading machine in time for a change, in case of possible technological downtime of one of the scraper units. On the horizon of the primary scraper delivery, through-air ventilation of fresh air jets of scraper drift, which will ensure high-quality sanitary and hygienic working conditions of the driver of the scraper winch.

References:

1. Ступнік М.І., Калініченко О.В., Калініченко В.О. Техніко-економічне обґрунтування доцільності застосування самохідної техніки на шахтах Кривбасу. Науковий вісник Національного гірничого університету. 2012. № 5 (131). С. 39–42.

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

3. 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. 100–104.

4. 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. 141–146.

5. BrownE. T. BlockCavingGeomechanics. Queensland, 2002. 515 p.

6. Chitombo G.P. Cave mining – 16 years after Laubscher's 1994 paper Cave mining – state of the art: Proceedings of the second International Seminar on Block and Sublevel Caving (Caving 2010), (Perth, Australia, 20–22 April 2010). Perth: Centre for Geomechanics, 2010. P. 45–61.

7. 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.

8. Пояснительная записка к проекту № 40 от 21 ноября 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. В.И. Ленина. Кривой Рог. 2011.

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: ООД«Бял ГРАД-БГ», 2016. Том 11. С. 25–31.

10. 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. 20–25.

11. Кудрявцев М.И., Гайдуков В.С. К вопросу о путях снижения выхода негабаритных фракций обрушенной руды при подземной разработке богатых руд Кривбасса. Сталий розвиток гірничо-металургійної

промисловості: матеріали Міжнародної науково-технічної конференції (Україна, Кривий Ріг, 25–28 травня 2011 р.). Кривий Ріг: КТУ, 2011. С. 25–26.

12. Письменный С.В. Отработка сложноструктурных залежей богатых руд камерными системами разработки. Гірничий вісник: науково-технічний збірник. 2014. Вип. 97. С. 3–6.

13. Комбінований спосіб доставки рудної маси при підземній розробці крутоспадних потужних рудних покладів: пат. 105304. Україна: МПК E21C 41/00. u 2015 09471; заявл. 01.10.2015; опубл. 10.03.2016. Бюл. № 5.

ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ ТЕХНОЛОГІЧНОГО ПРОЦЕСУ ВИПУСКУ І ДОСТАВКИ РУДНОЇ МАСИ В ПРОЦЕСІ РОЗРОБКИ ПОКЛАДІВ ПРИРОДНО-БАГАТИХ ЗАЛІЗНИХ РУД НА ЗНАЧНИХ ГЛИБИНАХ

У статті наведено дослідження технологічних рішень щодо підвищення інтенсивності випуску руди, які дозволять покращити повноту вилучення відбитої руди й якість рудної маси. Встановлено, що одним із ключових рішень цієї проблеми є застосування комбінованого способу доставки руди і рудної маси за допомогою комплексу «багатоковшеві скреперні лебідки – самохідна навантажувально-доставочна машина». Тому що застосування даного комплексу найбільш адаптоване до складних геомеханічних умов глибоких горизонтів шахт Кривбасу. Наведено дослідження і технологічні рішення щодо зменшення кількості локалізації зависань рудної маси в дучках до 1,4–2,2%, що дозволить підвищити експлуатаційну продуктивність скреперної лебідки до 600–700 т/зміну. А також сприятиме підвищенню інтенсивності технологічного процесу випуску руди з 1,5 до 5,5–6,2 т/м² на добу, а отже, вилученню чистої руди до 10,5%.

Ключові слова: *глибокі горизонти, інтенсифікація гірничих робіт, показники вилучення, природно-багаті залізні руди, самохідна навантажувально-доставочна техніка, комбінований спосіб доставки руди.*

ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ ТЕХНОЛОГИЧЕСКОГО ПРОЦЕССА ВЫПУСКА И ДОСТАВКИ РУДНОЙ МАССЫ ПРИ РАЗРАБОТКЕ ЗАЛЕЖЕЙ ПРИРОДНО-БОГАТЫХ ЖЕЛЕЗНЫХ РУД НА БОЛЬШИХ ГЛУБИНАХ

В статье приведено исследование технологических решений по повышению интенсивности выпуска руды, что позволит увеличить полноту извлечения отбитой руды и качество рудной массы. Установлено, что одним из ключевых решений этой проблемы является применение комбинированного способа доставки руды и рудной массы с помощью комплекса «многоковшовые скреперные лебёдки – самоходная погрузочно-доставочная машина». Так как применение данного комплекса наиболее адаптировано к сложным геомеханическим условиям глубоких горизонтов шахт Кривбасса. Приведены исследования и технологические решения по уменьшению количества локализации зависаний рудной массы в дучках до 1,4–2,2%, что позволит повысить эксплуатационную производительность скреперной лебёдки до 600–700 т/смену. А так же даст возможность увеличить интенсивность технологического процесса выпуска руды с 1,5 до 5,5–6,2 т/м² в сутки и, в результате, извлечение чистой руды до 10,5%.

Ключевые слова: *глубокие горизонты, интенсификация горных работ, показатели извлечения, природно-богатые железные руды, самоходная погрузочно-доставочная техника, комбинированный способ доставки руды.*