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RESEARCH AND SUBSTANTIATION OF RATIONAL PARAMETERS OF DRILLING AND BLASTING OPERATIONS WHEN USING EMULSIONAL EXPLOSIVES IN UNDERGROUND MINING

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ДОСЛІДЖЕННЯ ТА ОБҐРУНТУВАННЯ РАЦІОНАЛЬНИХ ПАРАМЕТРІВ БУРОПІДРИВНИХ РОБІТ ПРИ ЗАСТОСУВАННІ ЕМУЛЬСІЙНИХ ВИБУХОВИХ РЕЧОВИН НА ПІДЗЕМНИХ ГІРНИЧИХ РОБОТАХ

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ИССЛЕДОВАНИЯ И ОБОСНОВАНИЕ РАЦИОНАЛЬНЫХ ПАРАМЕТРОВ БУРОВЗРЫВНЫХ РАБОТ ПРИ ИСПОЛЬЗОВАНИИ ЭМУЛЬСИОННЫХ ВЗРЫВЧАТЫХ ВЕЩЕСТВ НА ПОДЗЕМНЫХ ГОРНЫХ РАБОТАХ

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Abstract. Purpose. To determine and substantiate the rational parameters of drilling and blasting operations using emulsion explosives such as Ukrainit PP-2B and to develop a methodology for their determination for the effective development of mineral deposits underground mining method.

Methodology. To achieve this goal, a set of modern research methods was used, including an analysis of literature sources, design documentation and the practice of mining iron ore deposits at great depths, theoretical generalization of laboratory and industrial experiments, methods and techniques of technical and economic, graphic-analytical, correlation analysis.

Results. The regularities of the change in the value of least resistance line from the ultimate strength of the ore to uniaxial compression and the diameter of blast holes were established. The obtained regularities made it possible to develop a methodology for calculating the rational parameters of drilling and blasting operations using an emulsion explosive of the Ukrainit PP–2B type in the deep horizons of the Kryvbas mines. Dependences of the technical and economic indicators of the use of the emulsion explosive of the Ukrainit PP–2B type in ore breaking on mining-geological and mining-technical factors were established. On the basis of the established rational parameters of drilling and blasting operations, a variant of the technological scheme for breaking iron ores by using an emulsion explosive of the Ukrainit PP–2B type with loading of ascending fans of deep wells using a self-propelled charging module RTCh–23 was proposed and economically justified.

Originality. Power-law dependences of the least resistance line on the ultimate strength of the ore for uniaxial compression and the diameter of blast holes were established when using an emulsion explosive of the Ukrainit PP-2B type.

Practical value. The method is developed for calculating the parameters of drilling and blasting operations with using an emulsion explosive of the Ukrainit PP-2B type in the deep horizons of the Kryvbas mines. The economically justified version of the technological scheme for breaking off iron ores with using an emulsion explosive of the Ukrainit PP-2B type, which will make it possible to achieve an annual economic effect in the amount of UAH 11.9 million.

Conclusions. It is established that the use of an emulsion explosive of the Ukrainit PP-2B type is a non-alternative direction in the further development of minerals at great depths, which will make it possible to reduce the cost of the technological process of breaking by 21% and reduce the harmful environmental impact on the world by 2,6–3,9 times.

Keywords: drilling and blasting operations, TNT containing explosive, emulsion explosive, least resistance line, well diameter.

Introduction. The development of the Ukrainian economy is largely determined by the efficiency of the mining and metallurgical complex [1].

One of the main processes of mining of ore raw materials is drilling and blasting operations, which significantly affect the completeness of extraction of ore from the bowels of the earth, the quality of the extracted ore mass and its cost [2], as well as the state of the environment and health of miners [3].

Drilling and blasting operations by using deep wells, when mining rich iron ores in the underground Kryvbas and Zaporizhzhia Iron Ore Plant, is one of the main technological processes [4]. Blast hole drilling is carried out by the KBU–80 drilling rig and Simba–H1352 and NKR-100MPa rigs, which drill deep holes with a diameter of 85 to 130 mm [5].

At the underground mines of Kryvbas, during ore breaking, TNT containing explosives is mostly used (91%), whose toxicity and environmental hazard, as well as the high cost and hazard increasingly limits their use [6]. It is known that TNT is not only dangerous to use due to its explosive properties, but it is also toxic and cause up to thirty different diseases in the human body [6]. On the basis of the studies carried out by the KIEBC and KNU employees at the Kryvbas mines, it was found that the gas content in explosives of the Grammonit 79/21 type in terms of conventional carbon monoxide is in the range of 40-80 l/kg [7]. The content of gases in domestic emulsion explosives, such as “Ukrainit” and “ERA”, which do not contain TNT, is, respectively, 20–25 l/kg and 7–21 l/kg [8].

An effective area of application of emulsion explosives in mines with underground mining is non-watered rocks of medium and below medium strength [9]. At the same time, they are distinguished by very low physical stability and they are considered as “one-day” explosives [9]. This, most likely, can explain the minimum volumes of use of the simplest explosives for breaking rocks with a strength coefficient f = 12–20 points by the scale of prof. MM Protodyakonov, 80-90% of which are watered [9]. The overwhelming majority of emulsion explosives are characterized by low sensitivity to mechanical, thermal and electrical influences, the relative simplicity of the technology for their manufacture on specially designed complexes, many of which can be placed even in underground conditions [10].

The use of emulsion explosives at the “Saint-Lime” Mine (USA) during excavation made it possible to reduce the cost of penetration by 15–20%. The technology of ore breaking with emulsion explosives in combination with non-electric initiation systems at the underground mines of OJSC “Apatit” has proven itself well, where their use has made it possible to significantly reduce the output of oversized material, intensify the production process and increase the technical and economic indicators of ore mining in general [11]. The experience of using granular TNT–free explosives of local preparation at the “Zapolyarny” Mine of the “Norilsk Nickel” OJSC branch is described in sufficient detail [11]. Confirmation of the high efficiency of these explosives, both when driving workings and at a stope, is the almost complete transition of all its mines (“Komsomolsky”, “Taimyrsky” and “Zhovtnevy”) to these explosives with their preparation at underground stationary points [12].

Under the conditions of underground mining, high performance was obtained through the using of emulsion explosive Ukrainit PP–2B (Ukraine), the detonation velocity of which is 5211 m/s at a loading density of 1.27 kg/dm^3, which made it possible to ensure an efficiency factor of 1.2 in relation to explosives of the Grammonite 79/21 type [13]. But there is no unified methodology for determining the rational parameters of drilling and blasting operations when using emulsion explosives of the Ukrainit PP–2B type.

Purpose. The aim of the study is to determine and substantiate the rational parameters of drilling and blasting operations when using emulsion explosives of the Ukrainit PP–2B type and to develop a methodology for their determination for the effective development of mineral deposits by the underground mining method.

To achieve this goal, the following tasks were put in the work:

1. To analyze the methods for determining the parameters of drilling and blasting operations.
2. To develop and substantiate a method for determining the least resistance line when using emulsion explosives of the Ukrainit PP–2B type.
3. To determine the volume of formation of harmful gases from the detonation of granular TNT-containing and emulsion explosives.
4. To select equipment for charging the ascending fans of deep wells of explosive of Ukrainit PP–2B type.
5. To determine the main technical and economic indicators when using granular TNT-containing and emulsion explosives and to compare them.

Methods. There are many methods for determining the parameters of drilling and blasting operations taking into account the energy of the explosion to destroy a certain volume of rocks and their physical and mechanical properties [14], of which the main one, for use in the underground Kryvbas and the “Zaporozhye Iron Ore Plant”, is the method of Yu.P. Kaplenko. This technique separately takes into account the charging density of the explosives and the efficiency factor in comparison with the reference explosives of the Ammonit No. 6ZhV type. Therefore, when using emulsion explosives of the Ukrainit PP–2B type, the generally accepted technique requires clarification.

To develop a methodology for determining the parameters of drilling and blasting operations when using emulsion explosives, as well as a comparative calculation of the volume of drilling deep wells, unit costs for breaking ore and the volume of emission of harmful gases when blasting charges, a cleaning panel in the rock floor was adopted as standard for the conditions of underground Kryvbas 1350–1270 m with the following parameters: panel height $H_к$ = 40 m; panel width $b_р$ = 60 m; the length of the panel in the strike cross (more often the thickness of the ore deposit) $L_с$ = 25 m; dip angle of the ore deposit $\alpha = 55^o$; the ultimate strength of the ore mass for uniaxial compression is taken for a wide range of rich and poor iron ore deposits in Kryvbas within [σ] = 50–200 MPa; volumetric weight of ore in the massif $\gamma_р$ = 3.7 t/m^3. The width of the vertical cutting slot is b_{vsh} = 6 m. Grammonit 79/21 and Ukrainit PP–2B are used as explosives. The diameter of the blast holes is taken in the

range of 85-130 mm. Drilling of wells with diameters of: 85 mm is carried out by the KBU–80 core drilling rig; 89 mm and 102 mm – by the Simba–H1352 self-propelled rotary drilling rig; 105 mm and 130 mm – by the NKR–100MPa impact-rotary machine. The charging of the ascending fans of deep wells is carried out using a self-propelled charging module RTCh–23 [4].

The rationale for the expediency of switching to emulsion explosives in the conditions of the Kryvbas mines was made on the example of the "Yubileyna" Mine of the "Sukha Balka PJSC". For this, the "Nest" deposit was selected in axes 25–31, which is a sheet-like ore body of complex configuration, which lies in the productive strata of the VI ferruginous horizon. The morphology of the ore body is very variable, the ore deposit has inclusions of dense martite hornfels, which is characterized by a thickness of 2 to 6 m and a fortress coefficient from 11–13 to 14–16 points.

An ore deposit with a thickness of 25 m and a dip angle of 52–57°, which is represented by martites with an average fortress coefficient of 7 points. The specific gravity of the ore is 3.7 t/m^3, the Fe content is 61.4%. The enclosing rocks of the recumbent side are hornfelses with a fortress of 9–11 points, medium fracturing, medium and below medium stability. The host rocks of the hanging wall are represented by martite hornfelses with a hardness factor of 6–8 points of low stability and high fracturing. The specific gravity of the enclosing side rocks is 2.7 t/m^3, and the average *Fe* content in them is 32.8%. Development of the block is carried out on the floor of 1350–1270 m.

Geometrical parameters of the block and its constituent elements: floor height – 80 m, sublevel height – 40 m; the length of the treatment block along the strike – 60 m; rear sight width – 10 m; the width of the compensation chamber is 20 m, the length of the compensation chamber is 25 m, the height of the compensation chamber from the horizon of the outlet funnels is 8 m.

Ukrainit PP–2B and Grammonit 79/21 were used as explosives in the calculations. For drilling vertical fans of deep wells, a deep drilling machine NKR–100MPa was adopted. The charging of the ascending fans of deep wells with emulsion explosives is carried out using a self-propelled charging module RTCh–23 [4], granular TNT containing explosives – MTZ–3.

Results. Calculations were made of the LPS value when using the emulsion explosive of the Ukrainit PP–2B type, on the basis of which the graphs of the LPS dependence on the borehole diameter and the ultimate strength of the ore mass for uniaxial compression were built (Fig. 1).

Having carried out an approximation by Microsoft Excel 2010, the dependences of the LPS on the borehole diameter were obtained for various ultimate strength of the ore for uniaxial compression, which are generally expressed in power-law form

$$W = a \cdot d_{wd}{}^{b}, m, \quad (1)$$

where a і b – numerical values that have specific values; d_{wd} – well diameter, m.

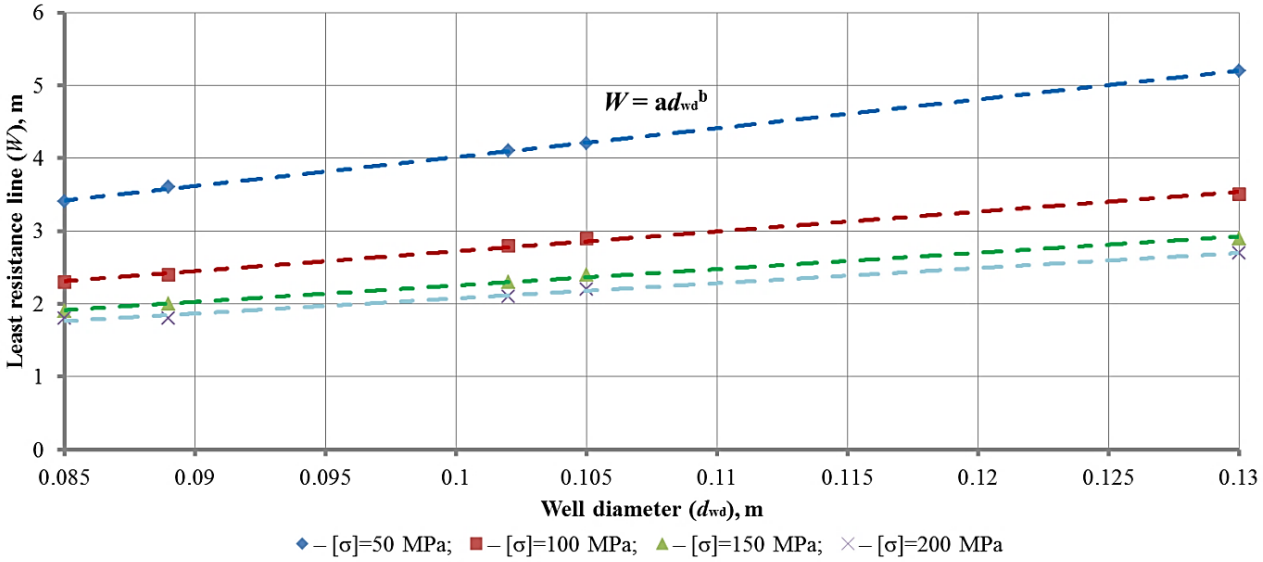

Figure 1 – Graphs of the dependence of the least resistance line on the borehole diameter and the ultimate strength of the ore mass for uniaxial compression when using explosives of the Ukrainit PP–2B type

Each of these values varies depending on the ultimate strength of the ore for uniaxial compression [σ] according to the following laws:

$$a = 147{,}5 \cdot [\sigma]^{-0.335}, \tag{2}$$

$$b = 0{,}0006 \cdot [\sigma] + 0{,}96, \tag{3}$$

where [σ] – ultimate strength of the ore for uniaxial compression, MPa.

By substituting equation (2) and (3) into equation (1), we obtain an analytical expression according to which the LNS value is determined when using emulsion explosive of the Ukrainit PP–2B type

$$W = 147{,}5 \cdot [\sigma]^{-0{,}335} \cdot d_{wd}^{\,0{,}0006 \cdot [\sigma] + 0{,}96}, \, m,$$

the deterministic coefficient is $R^2 = 0{,}97$.

The next step was to determine dependence of volume of drilling deep wells on their diameter (Fig. 2), specific costs for ore breaking (Fig. 3) and the amount of harmful substances generated by detonating charges (Fig. 4) from the ultimate strength of the ore mass for uniaxial compression at the use of various types of explosives.

As can be seen from the given graphs of dependence (Fig. 2), the volume of deep well drilling is in power-law dependence on the diameter of the well and when using explosives like Ukrainit PP–2B is 21% lower than when using VR type Grammonit 79/21.

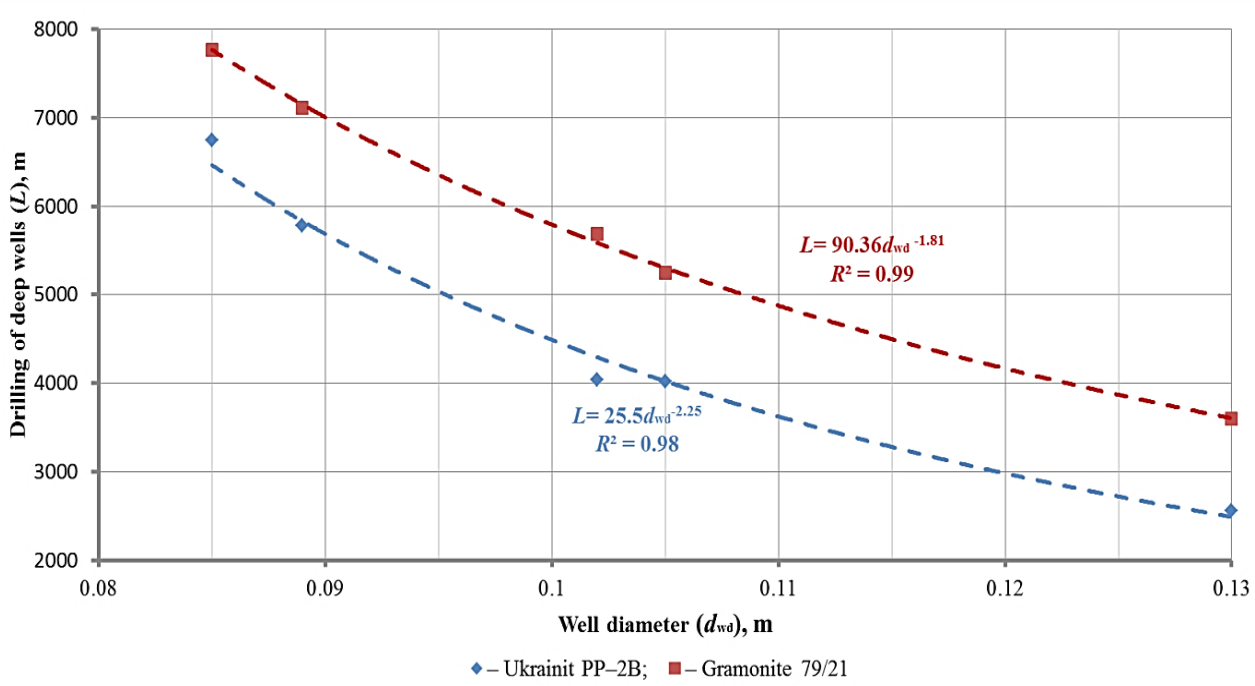

Figure 2 – Graphs of the dependence of the volume of drilling of deep wells on their diameter

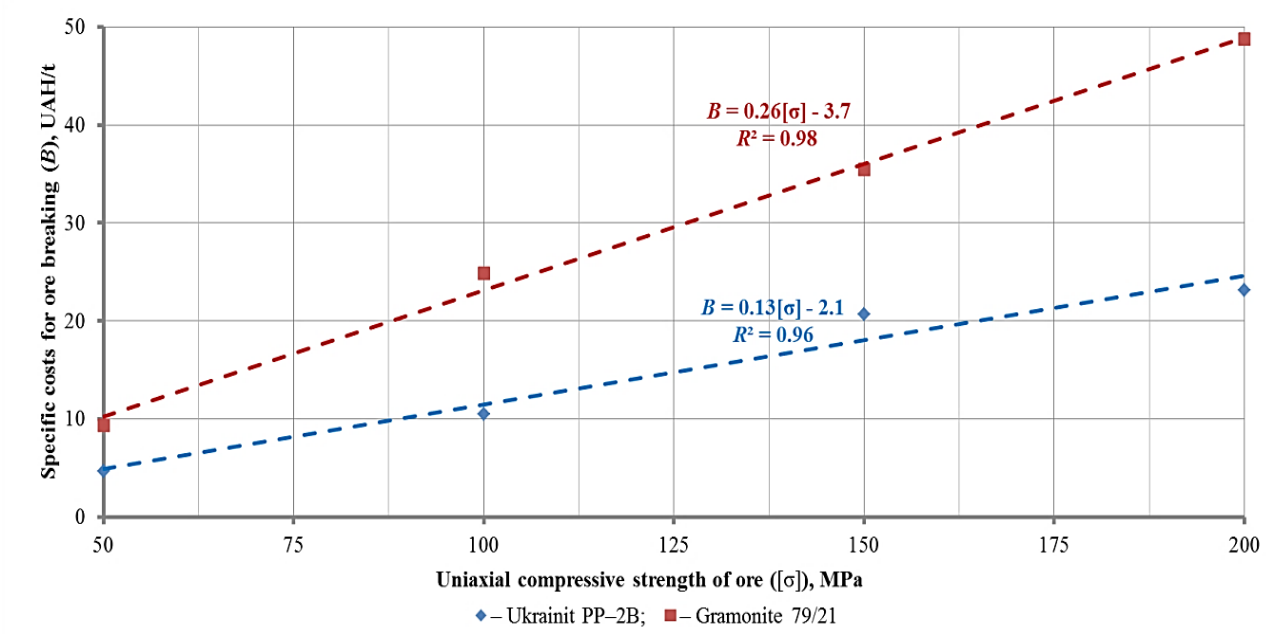

Figure 3 – Graphs of the dependence of the unit costs for breaking 1 ton of ore on the ultimate strength of the ore for uniaxial compression

As can be seen from the given graphs of dependence (Fig. 3), that the unit costs for ore breaking is linearly dependent on the ultimate strength of the ore for uniaxial compression and when breaking 1 ton of ore with using explosives of the Ukrainit PP–2B type is 1.7–2.4 times lower than when using explosives of the Grammonite 79/21 type.

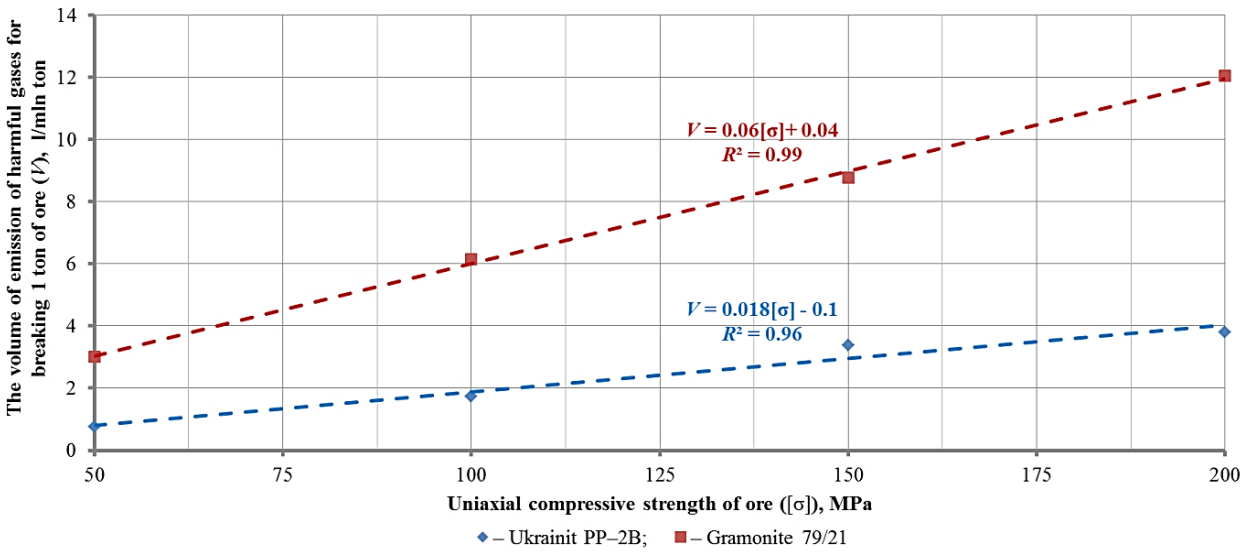

Figure 4 – Graphs of the dependence of the volumes of emission of harmful gases during blasting of explosives on the ultimate strength of the ore for uniaxial compression

As can be seen from the given graphs of dependence (Fig. 4), the volume of emission of harmful gases is linearly dependent on the ultimate strength of the ore for uniaxial compression, and when breaking 1 ton of ore with using explosives of the Ukrainit PP–2B type, is 2.6–3 9 times lower than when using explosives of the Grammonite 79/21 type.

To substantiate the feasibility of switching to emulsion explosives of the Ukrainit PP–2B type in the conditions of the Kryvbas mines, technological schemes of ore breaking when using various types of explosives are given below (Fig. 5 and 6).

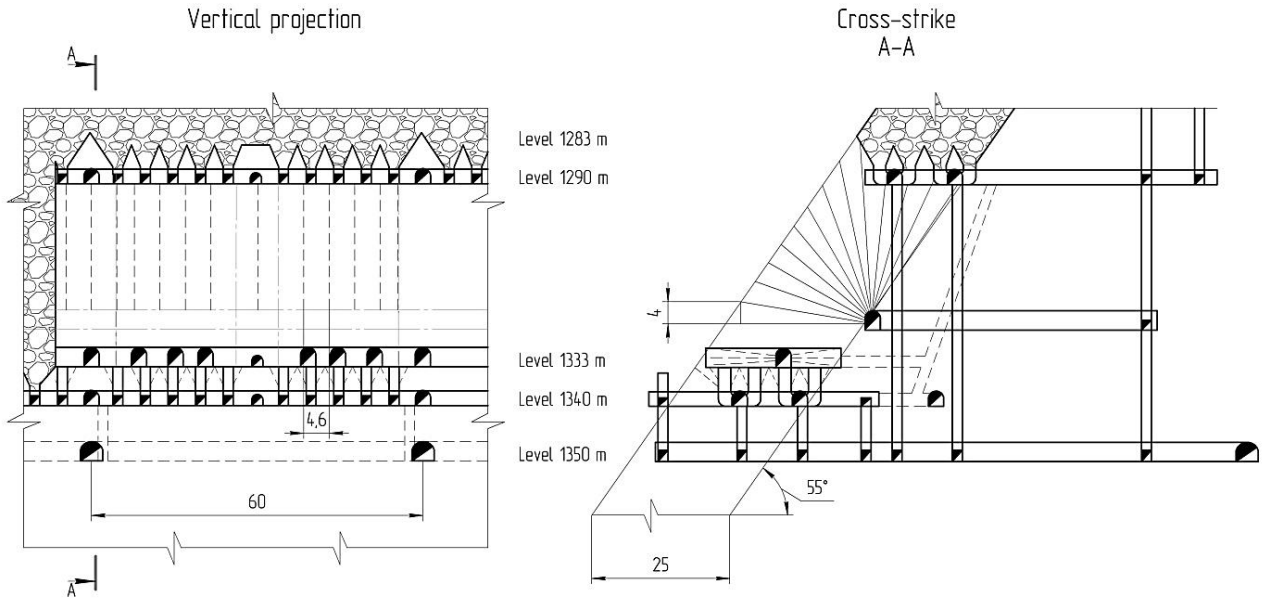

Figure 5 – Scheme of breaking the ore massif by vertical fans of deep wells with using explosives of the Grammonite 79/21 type

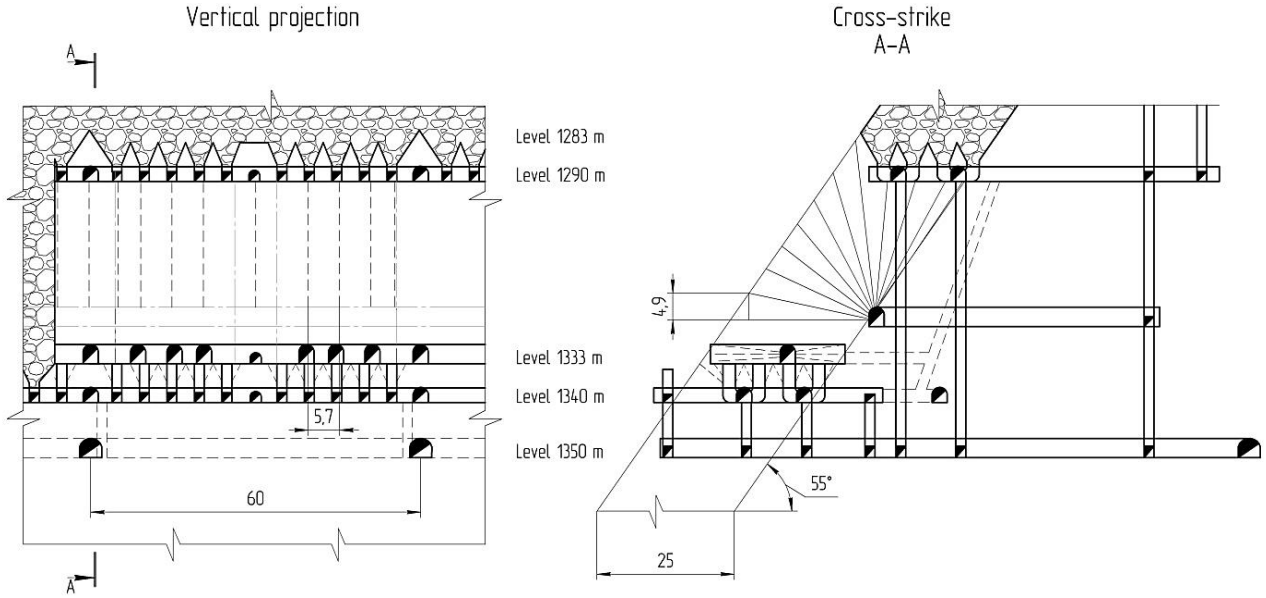

Figure 6 – Scheme of breaking the ore massif with vertical fans of deep wells with using explosives Ukrainit PP–2B type

The results of the calculations of drilling and blasting operations when using explosives of the Grammonit 79/21 and Ukrainit PP–2B types are presented in table 1.

Table 1 – Main technical and economic indicators for ore recovery schemes

Name	Ore breaking scheme with using the explosive			
	Grammonit 79/21		Ukrainit PP-2B	
	Number	Total cost, UAH	Number	Total cost, UAH
Ore reserve in the panel, t	200725	–	200725	–
Total length of wells, m	4346	–	3162	–
Ore output from 1 m of the borehole when breaking the main stock of the panel, t/m	46.2	–	63.5	–
Number of shifts for drilling wells, shifts	19	–	14	–
Labor intensity of well drilling, people/shift	19	15832.7	14	11666.2
Labor intensity of work on loading wells, people/shift	22	18332.6	13	10832.9
Specific explosive consumption, kg/t	0.14	1178015	0.102	521676.3
Specific consumption of electric detonators, pcs/t	0.002	8398.3	0.00145	6088.8
Specific consumption of detonating cord, m/t	0.0541	107506.3	0.0394	78294.79
Specific compressed air consumption, m^3/t	3.68	125573.6	2.67	91109.08
Unit costs for depreciation of drilling equipment, UAH/t	–	6653.93	–	4902.89
Specific consumption of drill bits, pcs/t	0.00037	658031.6	0.00027	480185.18
Specific consumption of drill steel, kg /t	0.001	0.78	0.00072	0.56
Unit costs for other materials and equipment, UAH/t	12.12	2432787.0	11.91	2390634.8
Total costs for ore breaking, UAH	–	4551132.0	–	3595391.4
Cost of ore breaking, UAH/t	**–**	**22.67**	**–**	**17.91**
Economic efficiency, %			21	

Conclusions.

1. The method has been developed for calculating the parameters of drilling and blasting operations when using emulsion explosives of the Ukrainit PP–2B type in the conditions of deep horizons of Kryvbas mines.

2. Dependences of technical and economic indicators of the use of emulsion explosives of the Ukrainit PP–2B type in ore breaking on mining-geological and mining-technical factors are established.

3. The proposed and substantiated, on the basis of technical and economic calculations, variant of technological scheme for breaking rich iron ores of Kryvbas using emulsion explosives of the Ukrainit PP–2B type and charging ascending fans of deep wells with using a self-propelled charging module RTCh-23, which is used in practical conditions will allow: to reduce the cost of breaking out by 4.77 UAH; increase economic efficiency by 21%; to increase labor productivity in the technological process of breaking by 1.4 times; to reduce the volume of deep well drilling by 20%; to reduce the volume of formation of harmful gases 2.6–3.9 times – in comparison with the scheme of stripping using explosives of the Grammonite 79/21 type.

4. The annual economic effect from the implementation of the emulsion explosive of Ukrainit PP–2B type in the conditions of the "Yubileyna" Mine of ZAO "Sukha Balka" is expected in amount of UAH 11.9 million.

REFERENCES

1. Kosenko, A.V. (2021), "Improvement of sub-level caving mining methods during high-grade iron ore mining", *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu,* 1, 19–25. https://doi.org/10.33271/nvngu/2021-1/019

2. Kosenko, A.V. (2019), "A promising direction for further development of high-grade iron ores at great depths", *Physical and technical problems of mining,* 21, 160–172. https://doi.org/10.37101/ftpgp21.01.010

3. Khomenko, O., Kononenko, M., Myronova, I. (2017), Ecological and technological aspects of iron-ore underground mining, *Mining Of Mineral Deposits,* 11(2), 59–67. https://doi.org/10.15407/mining11.02.059

4. Kovalenko, I.L., Stupnik, N.I., Korolenko , M.K. et al. (2016), Features of the technology of formation of borehole charges with emulsion explosives Ukrainit in underground conditions, *Bulletin of the Kryvyi Rih National University,* 41, 3–6.

5. Zubko, S.A., Kononenko, M.N. (2007), "Substantiation of rational parameters of the technology of drilling and blasting operations in the extraction of iron ores by the underground method", Materialy mizhnarodnoy naukovo-praktychnoi konferentsii "Shkola pidzemnoi rozrobky" [School of Underground Mining: Materials of the International Scientific and Practical Conference], Dnipro, Ukraine, 17-22 Sept, 2007, pp. 302–306.

6. Guang, Wang Xu (1994), *Emulsion explosives*. Metallurgical Industry Press, Beijing, China.

7. Gurin, A.A., Ratushny V.M., Gurin Yu.A. et al. (2006), "The main explosive characteristics of water-ibishofite-filled grammonite 79/21", *Development of ore deposits,* no.90, pp. 246–248.

8. Kuprin, V.P. (2012), *Rozrobka i vprovadzhennya emulsiynykh vybukhovykh rechovyn na karerakh Ukrainy* [Development and implementation of emulsion explosives in quarries of Ukrain], UDKHTU SHEI, Dnipropetrovsk, Ukraine.

9. Kolganov, E.V., Sosnin, V.A. (2009), *Emulsionnye promyshlennye vzryvchatye veshchestva* [Emulsion industrial explosives], GosNII "Crystal", Dzerzhinsk, Russia.

10. Kononenko, M.M., Khomenko, O.Ye., Kovalenko, I.L. and Savchenko, M.V. (2021), "Control of density and velocity of emulsion explosives detonation for ore breaking", *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytet, no.* 2, pp. 69–75. https://doi.org/10.33271/nvngu/2021-2/069

11. Baron, V.L., Kantor, V.H. (1989*), Tekhnika i tekhnologiya vzryvnykh rabot v SShA* [Blasting technique and technology in the USA], Nedra, Moscow, Russia.

12. Zakalinsky, B.M. (2011), "Prospects for explosive destruction of rock mass are the basis of progress in mining in Russia", *Bulletin of the Russian Academy of Natural Sciences,* no. 4, pp. 24–28.

13. Ishchenko, N.I., Monakov, V.F. and Koltunov, O.V. (2012), "Emulsion explosives – practical experience", *Newsletter of the Ukrainian Union of Explosive Engineers,* no. 2, pp.2–6.

14. Stupnik, M., Kalinichenko, V., Rymarchuk, B. et al. (2018), “Improvement of the method of drilling and blasting operations at the use ofexplosive substance "Ukrainite" in underground mining works”, *Technology audit and production reserves,* no. 6/1(44), pp. 29–35. https://doi.org/10.15587/2312-8372.2018.152055

СПИСОК ЛІТЕРАТУРИ

1. Kosenko A.V. Improvement of sub-level caving mining methods during high-grade iron ore mining . Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu. 2021. № 1. P. 19–25. https://doi.org/10.33271/nvngu/2021-1/019

2. Косенко А.В. Перспективний напрямок подальшої розробки багатих залізних руд на великих глибинах. Физико-технические проблемы горного производства. 2019. Вип. 21. С. 160–172. https://doi.org/10.37101/ftpgp21.01.010

3. Khomenko O., Kononenko M., Myronova I. Ecological and technological aspects of iron-ore underground mining. Mining Of Mineral Deposits. 2017. 11(2). P. 59–67. https://doi.org/10.15407/mining11.02.059

4. Особенности технологии формирования скважинных зарядов эмульсионными ВВ Украинит в подземных условиях. / Коваленко И.Л. и др. / Вісник Криворізького національного університету. 2016. Вип. 41. С. 3–6.

5. Зубко С.А., Кононенко М.Н. Обоснование рациональных параметров технологии буровзрывных работ при добычи железных руд подземным способом / Школа підземної розробки: матеріали міжнар. наук.-практ. конф., м. Дніпро, 17–22 вересня. 2007 р. Дніпро, 2007. С. 302–306.

6. Guang Wang Xu. Emulsion explosives. Beijing: Metallurgical Industry Press, 1994. 388 p.

7. Основные взрывные характеристики водо- и бишофитонаполненного граммонита 79/21 / Гурин А.А и др. / *Разработка рудных месторождений.* 2006. Вып. 90. С. 246–248.

8. Купрін В.П. Розробка і впровадження емульсійних вибухових речовин на кар’єрах України. Дніпропетровськ: ДВНЗ УДХТУ, 2012. 243 с.

9. Колганов, Е.В., Соснин В.А. Эмульсионные промышленные взрывчатые вещества. Дзержинск.: ГосНИИ «Кристалл», 2009. 592 с.

10. Kononenko M.M., Khomenko O. Ye., Kovalenko I.L., Savchenko M.V. Control of density and velocity of emulsion explosives detonation for ore breaking / Naukovyi Visnyk Natsionalnoho Hirnychoho Universytet. 2021. № 2. С. 69–75. https://doi.org/10.33271/nvngu/2021-2/069

11. Барон В.Л., Кантор В. Х. Техника и технология взрывных работ в США. М.: Недра, 1989. 376 с.

12. Закалинский В. М. Перспективы взрывного разрушения массивов горных пород – основа прогресса в горном деле России / Вестник Российской академии естественных наук. 2011. № 4. С. 24–28.

13. Ищенко Н.И. Монаков В.Ф., Колтунов О.В. Эмульсионные взрывчатые вещества – опыт практического применения / Информационный бюлетень украинского союза инженеров-взрывников. 2012. №2. С. 2–6.

14. Improvement of the method of drilling and blasting operations at the use ofexplosive substance «Ukrainite» in underground mining works. / Stupnik M. et al. / Technology audit and production reserves. 2018. № 6/1(44). P. 29–35. https://doi.org/10.15587/2312-8372.2018.152055.

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Анотація. Мета. Визначити та обґрунтувати раціональні параметри буропідривних робіт при застосуванні емульсійної вибухової речовини типу Україніт ПП–2Б і розробити методику з їх визначення для ефективної розробки родовищ корисних копалин підземним способом.

Методика. Для досягнення поставленої мети використано комплекс сучасних методів досліджень, що включає аналіз літературних джерел, проєктно-конструкторської документації та практики відпрацювання залізорудних родовищ на значних глибинах, теоретичні узагальнення лабораторних й промислових експериментів, методи й прийоми техніко-економічного, графоаналітичного і кореляційного аналізу.

Результати. Встановлені закономірності зміни величини лінії найменшого опору від межі міцності руди на одновісне стискання та діаметру вибухових свердловин. Отримані закономірності дали змогу розробити методику розрахунку раціональних параметрів буропідривних робіт при використанні емульсійної вибухової речовини типу Україніт ПП–2Б в умовах глибоких горизонтів шахт Кривбасу. Встановлені залежності техніко-економічних показників застосування емульсійної ВР типу Україніт ПП–2Б при відбиванні руди від гірничо-геологічних та гірничотехнічних чинників. На основі встановлених раціональних параметрів буропідривних робіт запропоновано та економічно обґрунтовано варіант технологічної схеми відбивання залізних руд за допомогою емульсійної вибухової речовини типу Україніт ПП–2Б із заряджанням висхідних віял глибоких свердловин за допомогою самохідного зарядного модулю RTCh–23.

Наукова новизна. Встановлені степеневі залежності лінії найменшого опору від межі міцності руди на одновісне стискання та діаметру вибухових свердловин при застосуванні емульсійної вибухової речовини типу Україніт ПП–2Б.

Практична значимість. Розроблено методику розрахунку параметрів буропідривних робіт при використанні емульсійної ВР типу Україніт ПП–2Б в умовах глибоких горизонтів шахт Кривбасу. Економічно обґрунтовано варіант технологічної схеми відбивання залізних руд за допомогою емульсійної вибухової речовини типу Україніт ПП–2Б, що дасть змогу досягти річного економічного ефекту у розмірі 11,9 млн грн.

Висновки. Встановлено, що застосування емульсійної вибухової речовини типу Україніт ПП–2Б є безальтернативним напрямом при подальшій розробці корисних копалин на значних глибинах, який дозволить на 21% здешевити проведення технологічного процесу відбивання і знизити у 2,6–3,9 рази шкідливий екологічний вплив на навколишнє середовище.

Ключові слова: буропідривні роботи, тротилвмісна вибухова речовина, емульсійна вибухова речовина, лінія найменшого опору, діаметр свердловини.

Аннотация. Цель. Определить и обосновать рациональные параметры буровзрывных работ при применении эмульсионного взрывчатого вещества типа Украинит ПП–2Б и разработать методику по их определению для эффективной разработки месторождений полезных ископаемых подземным способом.

Методика. Для достижения поставленной цели использован комплекс современных методов исследований, включая анализ литературных источников, проектно-конструкторской документации и практики отработки железорудных месторождений на больших глубинах, теоретические обобщения лабораторных и промышленных экспериментов, методы и приемы технико-экономического, графоаналитического и корреляционного анализа.

Результаты. Установлены закономерности изменения величины линии наименьшего сопротивления от предела прочности руды на одноосное сжатие и диаметра взрывных скважин. Полученные закономерности позволили разработать методику расчета рациональных параметров буровзрывных работ при использовании эмульсионного взрывчатого вещества типа Украинит ПП–2Б в условиях глубоких горизонтов шахт Кривбасса. Установлены зависимости технико-экономических показателей применения эмульсионного взрывчатого вещества типа Украинит ПП–2Б при отбойке руды от горно-геологических и горнотехнических факторов. На основании установленных рациональных параметров буровзрывных работ предложен и экономически обоснован вариант технологической схемы отбойки железных руд с помощью эмульсионного взрывчатого вещества типа Украинит ПП–2Б с заряжанием восходящих вееров глубоких скважин при помощи самоходного зарядного модуля RTCh–23.

Научная новизна. Установлены степенные зависимости линии наименьшего сопротивления от предела прочности руды на одноосное сжатие и диаметра взрывных скважин при применении эмульсионного взрывчатого вещества типа Украинит ПП–2Б.

Практическая значимость. Разработана методика расчета параметров буровзрывных работ при использовании эмульсионного взрывчатого вещества типа Украинит ПП–2Б в условиях глубоких горизонтов шахт Кривбасса. Экономически обоснованно вариант технологической схемы отбойки железных руд при помощи эмульсионного взрывчатого вещества типа Украинит ПП–2Б, что позволит достичь годового экономического эффекта в размере 11,9 млн грн.

Выводы. Установлено, что применение эмульсионного взрывчатого вещества типа Украинит ПП–2Б является безальтернативным направлением при дальнейшей разработке полезных ископаемых на больших глубинах, который позволит на 21% удешевить проведение технологического процесса отбойки и снизить в 2,6–3,9 раза вредное экологическое воздействие на окружающую среду.

Ключевые слова: буровзрывные работы, тротил содержащее взрывчатое вещество, эмульсионное взрывчатое вещество, линия наименьшего сопротивления, диаметр скважины.

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