Mining of Mineral Deposits
ISSN 2415-3443 (Online) | ISSN 2415-3435 (Print)
Journal homepage http://mining.in.ua
Volume 12 (2018), Issue 1, pp. 95-102

UDC 622.03: 622.23.02:622.273 https://doi.org/10.15407/mining12.01.095

IMPROVING THE EFFICIENCY OF BLASTING OPERATIONS IN MINES WITH THE HELP OF EMULSION EXPLOSIVES

V. Lyashenko[1*], A. Vorob'ev[2,3], V. Nebohin[4], K. Vorob'ev[5]

[1]*Ukrainian Research and Design Institute for Industrial Technology, Zhovti Vody, Ukraine*
[2]*Atyrau University of Oil and Gas, Atyrau, Kazakhstan*
[3]*Non-Commercial Partnership "Innovations in Subsoil Management", Moscow, Russian Federation*
[4]*LLC "NTO Tekhnotron", Zhovti Vody, Ukraine*
[5]*Engineering Academy of the Peoples' Friendship University of Russia, Moscow, Russian Federation*
**Corresponding author: e-mail vilyashenko2017@gmail.com, tel. +380565229064*

ABSTRACT

Purpose. To improve the efficiency of blasting operations in mines taking into consideration the upgrading of equipment used to charge blastholes as well as application of high-productive mining equipment of new generation.

Methods. The activities used mine experimental pressure-charged blasts to break oversize material as well as mine experimental analysis of blasthole charging to estimate the improvement of efficiency of the emulsion explosives (EEs).

Findings. It has cbeen determined that both sticked and bulk emulsion explosives of Ukrainit-PP-2 type as well as new options of charging facilities have following technological characteristics: availability of unique space-saving designs of two-component piston dosing pumps of double-action EE components; sufficiently high efficiency of blasthole charging being up to 60 kg of EE/min; ease of service and maintenance; rather long overhaul period of EE components as for the dosing pump as well as cheapness of attachable equipment; availability of both electronic and visual means to control EE preparation and charging.

Originality. It has been proved that the improvement of blasting operations in mines results from the intensified technological processes of blasthole charging characterized by the use of such high-productive self-propelled and space-saving facilities of new generation as machines of ZEVS-1 model and portable charges of ZEP-15 type as well as the use of such environmentally friendly bulk trinitrotoluene-free emulsion explosives as Ukrainit-PP-2.

Practical implications. Use of EEs in the process of mine blasting operations provides safety, high-quality rock breakage and fragmentation in the context of minimum toxicity of rock, breakage of rocks having any hardness and water content. Moreover, their use is economically efficient.

Keywords: *blasting operations, emulsion explosives, equipment, portable charger, charging machines, safety*

1. INTRODUCTION

Currently, underground mining is characterized by drastic worsening of mining and geological conditions, strict requirements as to labour protection, environment and the entrails of the earth, and vital activity security within a zone of mining objects influence (Trushko, Protosenya, Ochkurov, 2016; Busylo, Podkopaiev, Iordanov, & Chepiha, 2017; Dychkovskyi et al., 2018). Methods to prepare producing blocks by means of access ramps make it possible to improve mechanization level of mining operations, blasting operations and non-productive operations; delivery of rock mass, materials and equipment; safe and comfortable way for workforce to leave faces; and to improve the control over ventilation and other technological processes (Kozan & Liu, 2016; Khademian & Bagherpour, 2017; Wojtecki, Mendecki, & Zuberek, 2017). That is why the improvement of blasting operations in mines while using emulsion explosives and taking into consideration upgrading of extraction equipment, intensification of production processes with the use of self-propelled high-productive mining equipment of a new generation are the scientific and practical problems to be solved urgently (Navalkar, 2001; Jha, Jha, & Kumar, 2015).

The paper applies the integrated research technique involving the analysis of activities aimed at the improvement the efficiency of blasting operations in mines with the help of emulsion explosives. The technique takes into consideration the improvement of equipment to charge blastholes as well as the use of highly productive mining equipment of a new generation, underground investigations and experimental investigations according to both standard and innovative procedures.

2. MAIN PART OF THE ARTICLE

Increase in volume of raw material and its grade is impossible without changes in approaches concerning extraction methods and technical upgrading of mining enterprises. Blasting operations, remaining the basic procedure in the process of extraction of ores and other inorganic materials, are the considerable cost component in the context of the production price (Kanchibotla, 2003). Thus, to reduce expenses, connected with the purchase of industrially manufactured explosives, to better working conditions of blasters, to improve the efficiency of their operations and labour safety in the process of borehole charging, and to reduce environmental load, such leading world companies as Orica, Dino Nobel, Dino Mainer, AEL, BME, Maxam, IFI, Maclean Mine-Mate, BCJ and others are engaged in activities aimed at the mechanization of blasting operations with the use of EEs while tunnel driving and mining (Kovalenko & Kuprin, 2010; Nikulova & Timonina, 2010) as well as those aimed at the improvement of blasting equipment for extraction of minerals designed by A and M SIC manufactured in cooperation with SE "SkhidHZK", LLC "NTO Tekhnotron", LLC "Ekkom", LLC "Ukrvzryvtekhnologiya" and others (Kutuzov & Belin, 2011; Sorokin, Bezrodnyy, Borovkova, & Korsunovskaya, 2011).

2.1. Use of emulsion explosives in mines

Group of Ukrvzryvtekhnologiya Companies is one of the largest Ukrainian Companies carrying out the production of EEs under its own trade mark Ukrainit. Specialists of enterprises, being a part of the companies, connected with the production of Ukrainit components, started pilot testing aimed at the development of unique compositions of the bulk EEs components for underground use and equipment systems for mechanized preparing and blasthole charging in the process of tunneling and ore mining. Such companies as CJSC "Zaporizkyi zalizorudnyi kombinat" and SE "SkhidHZK" were selected as the base consuming enterprises for pilot EEs Ukrainit-PP-2. LLC "Ekkom" (Dnipro, Ukraine) performed a selection of "cold" composition of EEs components for underground use; LLC "NTO Tekhnotron" (Zhovti Vody, Ukraine) developed and manufactured portable charging, delivering, and supporting equipment to prepare and charge mechanically boreholes (Sivenkov, Ilyakhin, & Maslov, 2013; Lyashenko & Kislyy, 2014).

2.2. Sticked Ukrainit-P EE

The emulsion explosive is meant for surface and underground blasting operations in dry and wet holes and boreholes with the exception of gas- and dust-hazardous mines and ore mines. It is applied in the production environment where there is no possibility to use self-propelled charging facilities and means of mechanized charging. Tests in such Ukrainian ore mines as CJSC "Zaporizkyi zalizorudnyi kombinat", PJSC "Kryvorizkyi zalizorudnyi kombinat", and PJSC "EVRAZ Sukha Balka" have demonstrated that the sticks may be used as intermediate charges; to charges holes and boreholes; and for secondary breaking of oversize materials. The sticked Ukrainit-P EE withstands short-term (during two hours) heating up to 70°C. Quality of rock mass fragmentation is equal to that by the sticked 6 ZhV ammonite (Table 1).

Table 1. Physicochemical and blasting characteristics of the sticked EEs of Ukrainit type

Parameter	Standard		
Controlled parameters			
Appearance at the 20 – 70°C temperatures	Plastic gray or yellow homogenous mass with the inclusions of microspheres		
	P – S	P – SA	P – P
Density at 30 ± 100°C, g/cm^3	1.00 – 1.30		
Detonation completeness of open charge of the sticked EE with 32 mm diameter of ED-8Zh and of 100 g 6 ZhV ammonite	Complete		
Uncontrolled parameters			
Oxygen balance, %	–0.3 to –0.5	–0.5 to –1.5	–0.3 to –1.5
Specific volume of gas explosion products, dm^3/kg	820 – 840	800 – 820	840 – 860
Critical diameter of the open charge, mm	20	20	30
Detonation velocity of the charge, m/c, no less than	4900	4800	4400
Sensitiveness to impact according to GOST 4545: lower boundary (instrument No.3), mm, more than	500		
Toxic explosion gases in terms of CO, l/kg	up to 15.0	25.0 to 20.0	

2.3. Use of sticked Ukrainit-P EEs

The industrial explosion is inverted emulsion of water solution of oxidizer in carbohydrate phase; it has been sensibilized by means of glass or polymeric hollow microspheres. Detonating sticks of P – S type are manufactured in accordance with specification requirements 20.5-36373037-002:2012; they are used for hole and borehole blasting with any watering degree in the context of their long-term (up to 10 days) waterlogging. The sticks with EE are packed in corrugated containers; nominal sole weight within the container should not be more than 25 kg. Shelf life is 3 months from the EE production date. ED-8Zh or EDKZ-PM electric detonators without intermediate detonator are used to detonate hole and borehole charges with EEs of P – S type if diameter is 32 to 60 mm; P – S types use intermediate detonators. Use of non-electric initiating systems approved for permanent application according to established procedure is allowed (Golik, Ismailov, Stradanchenko, & Luk'yanov, 2016; Komashchenko, 2016).

2.4. Manufacturing of primers

Following conditions are adhered in the process of their manufacturing with the use of electric detonators (EDs) or a plain detonator of non-electric initiating system (PD NEIS): ED or PD NEIS is placed and fixed safely in such a way to avoid the possibility of its pulling out of the stick or pulling out of terminal leads from the primer in the charging process. ED or PD NEIS should be placed carefully into 6 – 7 cm hollow formed with the help of wooden stick (Lyashenko, Nebogin, & Shkarin, 2016; Komashchenko, Vorob'yev, & Belin, 2017).

2.5 Manufacturing of a primer within the stick end

A live-primer is run through within a central part of the stick end by means of a plain detonator; after that, the latter is put in the end part of the live-primer (Fig. 1).

A loop is thrown to keep vertically for electrical system. In the context of non-electric system, the stick is rounded with the help of a cord or adhesive tape. If boreholes are loaded with the use charging devices, to prevent a contact between explosives and the well rocks ("into-sleeve" charging), a primer with Ukrainit-P EE is placed "out of sleeve". It is not recommended to use a primer with Ukrainit-P EE without a sleeve while charging dry boreholes with explosives, which temperature is higher than 45°C.

(a) (b) (c)

Figure 1. Manufacturing of primers on the basis of Ukrainit-P EE of P – S type: (a), (b) and (c) are process of a primer manufacturing: a live-primer is run through the central part of a primer by means of a plain detonator; then, it is put in the end part of the live-primer; the stick is rounded with the help of a cord or adhesive tape respectively (general view)

Test underground explosions of a pressure charge to break oversize material using Ukrainit-P EE of P – S type demonstrated positive results (Fig. 2).

(a)

(b)

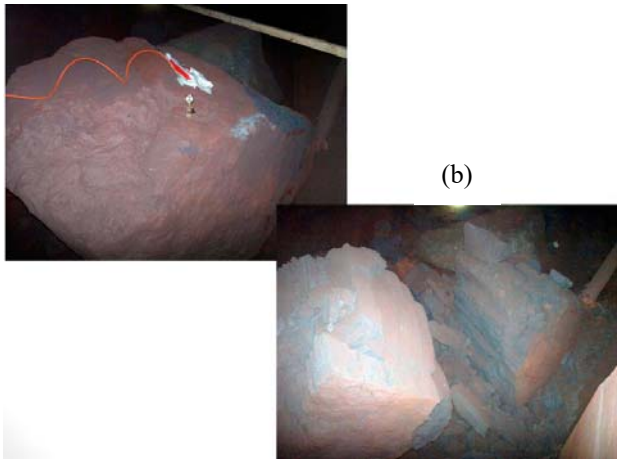

Figure 2. Explosion results with the use of a pressure charge of Ukrainit-P EE of P – S type while breaking oversize material: a is a pressure charge on oversize material ((a) watch is used for scale); (b) is the explosion result (general view)

2.6. Bulk Ukrainit-PP-2 EE

The emulsion explosive is meant for surface and underground blasting operations in the context of mines being gas- and dust-nonhazardous within rocks of any strength and watering with the use of self-propelled charging equipment and means of mechanized charging (if there is the access of self-propelled to face) (Table 2).

The explosive is a mixture of emulsion composition (EC) and gas-generative additive GGD-U required to sensibilize the emulsion by means of oxygen bubbles. It belongs to class 2 according to application conditions.

Table 2. Physicochemical and blasting characteristics of the bulk Ukrainit-PP-2 EE

Parameter	Standard
Controlled parameters	
Appearance at the 20 – 70°C temperatures	Plastic gray or yellow homogenous mass with the inclusions of microspheres
Gas-generation degree at 30 ± 10°C temperatures during 30 minutes, %, no less than	6
Density at 30 ± 10° temperatures an hour after sampling, kg/m^3	1100 – 1410
Completeness of bagged charge which diameter is 50 mm of 6 ZhV ammonite which mass is 50 g	Complete
Uncontrolled parameters	
Oxygen balance, %	–0.18 to –2.15
Nominal explosion heat, kJ/kg	2900 – 3100
Nominal explosion gas volume	762 – 892
Critical diameter of open charge, mm	35 – 40
Sensitiveness to impact after gas generation according to GOST 4545: lower boundary (instrument No.3), mm, more than	500
Sensitiveness to friction after gas generation (instrument K-44-3): lower boundary, MPa (kgf/cm^2)	668 (6810)
Comparative performance relative to 6 ZhV ammonite	1.05
Toxic gases in the context of 250 g of Ukrainit-PP-2 EE in carton wrapper with 40 mm diameter in terms of CO, l/kg, no more	up to 33

The explosive is manufactured within places of its use with the help of mixing-charging bulk trucks (MCBTs) or charges while proportional mixing of the components while charging holes and boreholes.

To compare with the current industrial trotyl-containing EEs, the proposed techniques to prepare and use the sticked Ukrainit-P EEs and the bulk Ukrainit-PP-2 EEs help improve safety level of blasting and its economic efficiency. Innovative engineering solutions and modern equipment are involved to manufacture Ukrainit EEs. At the moment, the State service of mining supervision and industrial safety of Ukraine has brought Ukrainit-PP-2 EEs into operation; Ukrainit-P EE is at the final stage of approval tests (Jonson, 2012; Lyashenko & Golik, 2017).

2.7. Charger of ZEP-10 type

According to specification requirements 29.5-23647075-018, the device is meant for preparing and mechanized charging by means of bulk emulsion explosive Ukrainit-PP-2 to be used in dry and wet blastholes which diameter is not less than 36 mm for rocks of any strength while tunneling in mines being gas- and dust nonhazardous or for open-pit mining operations (Table 3). Automated slide-type valve controls dosing pump of the EE components.

Table 3. Specifications of ZEP-10 charger

Parameter	Value
Capacity in terms of EE, kg/min, within	10.0 – 15.0
GGA-EC ratio, %, in terms of mass	1.0 ± 0.1:99
Output EE pressure and dosing pump pressure, MPa, no more than	0.8
Pressure of energy source (pressurized air), MPa, within	0.45 – 0.60
Pressure of the pressurized air, MPa (kg/cm^2), no less than	0.45 (4.50)
Consumption of the pressurized air, m^3/min, within	0.25 – 0.35
Transportation distance of the EE, m, no more than	9.0
Container volume of the GGA, *l*, no less than	2.0
Container volume of the EC, *l*, no less than	25.0
Overall dimensions during transportation, mm, no more than	600×600×400
Weight of the charger (without components)	30.0

2.8. Portable ZEP-15 charger

Efficiency of a hole charging is up to 15 kg/min with pneumatic or water drive (Fig. 3). The results obtained in the process of ZEP-15 charger and Ukrainit-PP-2 EE tests have shown that the technology helps develop productively and safely as well as charge mechanically blastholes with powerful and environmentally friendly EE while obtaining gas content of a mine working after blasting.

2.9. Self-propelled (blasthole) charger for EEs of ZEVS-1 type

High technical productivity and possibility to charge 2 to 3 stopes during a shift is the basic criterion for the expediency to use high-cost self-propelled facilities. That will reduce payback periods while improving economic efficiency of the equipment being used (Table 4 and Fig. 4).

In the context of the available methods when stopes are charged and blasted at the end of a shift, average charging takes 40 to 50 minutes; that is ones stope should be charged up during 15 – 20 minutes.

Figure 3. Portable ЗЭП-15 charger

Table 4. Specifications of ZEVS-1 charger

Parameter	Value
Chassis type	Self-propelled chassis SSh-2540 (improved and reinforced or equivalent)
Capacity of a diesel of self-propelled chassis, kW (h. p.)	18.4 (25.0)
Capacity of a diesel of oil-pumping station (to charge blastholes), kW (h. p.)	4.4 (6.0)
Maximum capacity of the charger in terms of EE if viscosity of emulsion composition is up to 25000 CP, kg/min, up to	60.0
The number of pump units to charge EEs, pieces	2
Length of EE transportation, m, no more than	12.0
Weight of EC being transported if charge is 90% of CP, kg, no more than	400.0
Weight of GGA being transported if charge is 90%, kg, no more than	10.0
Weight of technical water being transported, kg, no more than	40.0
Overall dimensions of the charger (for transport), mm, no more than	4500×1900×2300
Kerb total weight of the charger, kg, no more than	3400.0

Figure 4. Self-propelled (blasthole) charger for EEs of ZEVS-type (general view)

Such efficiency is possible if only a stope is being charged by means of two machines or by means of one machine equipped with two dosing pumps. In the context

of minor appreciation and keeping of small sizes, the self-propelled blasthole EE charger of ZEVS-1 type has been equipped with two plunger dosing pumps of original design being of small sizes and weight (up to 25 kg/unit); that has made it possible to develop altogether packaged self-propelled charger which overall capacity is up to 60 kg/min. Figure 5 demonstrates hole charging by means of Ukrainit-PP-2 EE in the context of CJSC "Zaporizkyi zalizorudnyi kombinat".

(a)

(b)

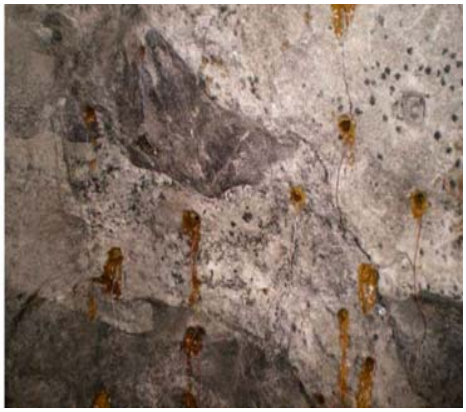

Figure 5. Charging of bulk Ukrainit-PP-2 EE with the help of ZEP-10 charger: (a) and (b) are charging process and the process termination respectively (general view)

A process of crude ore mining is provided by scientific support and own production facilities to manufacture extraction and preparation equipment. A and M SIC has research and production facilities with closed machine-building and instrument-making cycle to manufacture pilot samples of the advanced designs. SE "SkhidHZK", LLC "NTO Tekhnotron" have complete technological cycle of machine-building activities. Their cooperation makes it possible to organize mass production of mining equipment within the short periods of time. In the context of the mining equipment production, the branch specialists have developed mechanisms and means of control which can be used successfully by enterprises of non-ferrous and mining and metallurgical industries excluding the import of the equipment. Value of the cooperation is in the fact that the enterprises can work in a closed cycle: development of new products, production of pilot samples, testing and inspecting by an acceptance committee, performance of operations on clients' requests.

Hence, resulting from the complex of scientific and research, design and experimental, and production activities, the authors have determined modern technical level of charging, auxiliary, and blasting equipment developed by A and M SIC and produced in cooperation with SE "SkhidHZK" and LLC "NTO Tekhnotron". Increase in the efficiency of mining operations in Ukrainian mines based upon the introduction of highly productive extraction equipment of a new generation makes it possible to intensify technological processes, EE charging and blasting mechanization etc.

Figure 6 demonstrates technological scheme of Ukrainit-PP-2 EE components delivery in the context of PJSC "Kryvbaszalizrudkom".

2.10. The introduction results

Currently, both volumes of scopes of the environmentally friendly Ukrainit-PP-2 EE introduction have increased greatly since both geography and sphere of its application in Ukrainian mines extended (CJSC "Zaporizkyi zalizorudnyi kombinat", PJSC "EVRAZ Sukha Balka" in Kryvy Rih, LLC "Vostok-Ruda" in Zhovti Vody). Moreover, CJSC "Zaporizkyi zalizorudnyi kombinat" has also piloted experimental charges of circular line of wells which diameters are 89 to 105 mm, and length is up to 30 m. Besides, efforts to improve the technology for EE components preparation are underway. With the support of the State Service of Mines Inspectorate and Industrial Safety of Ukraine and Kryvyi Rih Mining Inspection, Ukrainit-PP-2 EE will continue to be tested industrially in mines of CJSC "Zaporizkyi zalizorudnyi kombinat" and SE "SkhidHZK". Other enterprises of the leading mining countries are also interested in piloting of the emulsion explosives (Manolas & Arusu, 2012; Gupta & Trapathy, 2013).

3. DISCUSSION

Currently domestic equipment to prepare and charge by means of emulsion explosives is being designed. Moreover, efforts to introduce the innovative technologies of mineral mining are underway. Application of the EEs while underground ore mining as well as wide-range implementation of the modern blasting technologies in mines is complicated by out-of-date mining methods, features of iron-ore and uranium deposit development, traditions and staff available in the mining regions as well as the lack of normative documents and the State Program aimed at the transition to trinitrotoluene-free blasting technologies.

Nevertheless, the enterprises being a part of companies engaged in Ukrainit EE started experimental and design activities for the development of the unique compositions of the EE for underground use as well as equipment systems for mechanized preparation and charge of holes and boreholes while tunneling, ore mining, and mine logistics.

Such leaders of ore-mining industry (having up-to-date facilities and mining technology) as CJSC "Zaporizkyi zalizorudnyi kombinat" and SE "SkhidHZK" have been selected as the basic consuming enterprises of the experimental Ukrainit EE.

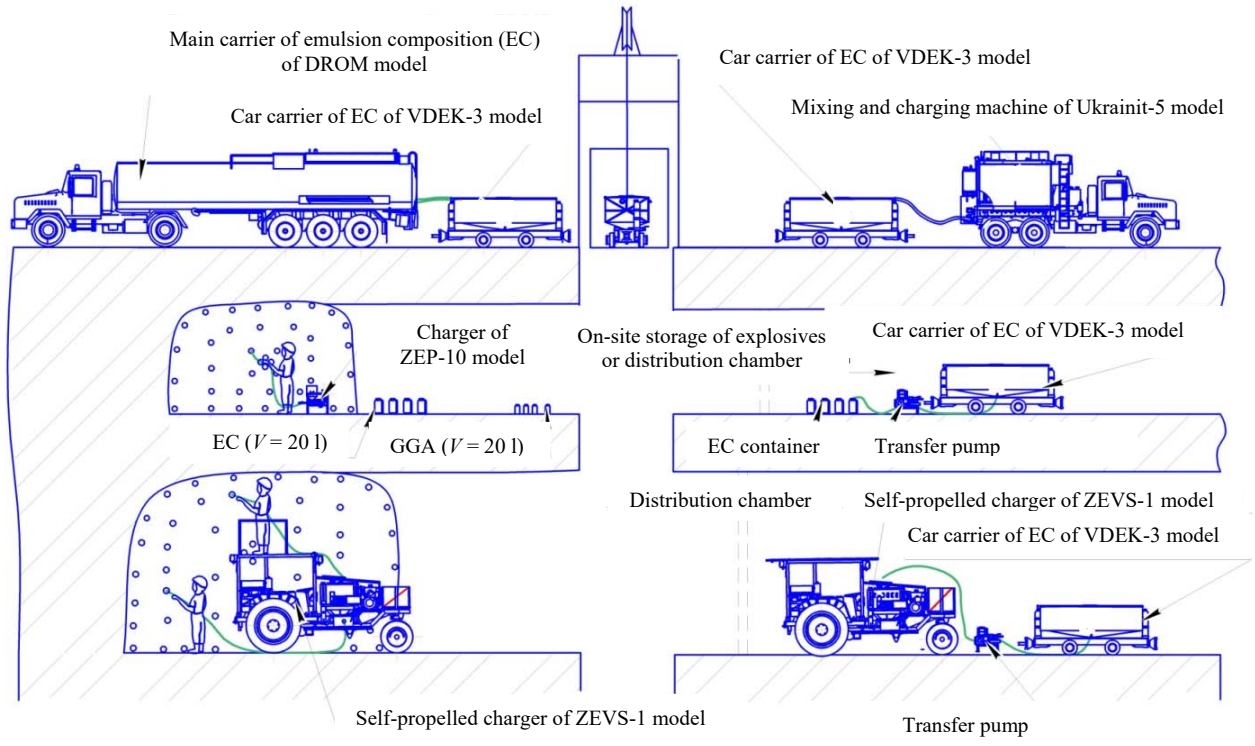

Figure 6. Technological scheme of Ukrainit-PP-2 EE components delivery in the context of PJSC "Kryvbaszalizrudkom"

LLC "Ekkom" has proportioned "cold" mixture of Ukrainit EE for underground use and LLC "NTO Tekhnotron" has developed and produced mixing and charging stand to prepare and charge mechanically holes and boreholes.

In particular, it has been identified that sticked and bulk Ukrainit-PP-2 EEs as well as charging machines differ from their world analogues in following specifications:

– availability of original small-size designs of two-component plunger dosing pumps for EE components of double action having mixing unit to obtain the explosive right at the outlet of the pump (within the charging hose) while foreign analogous machines have up to three units of expensive auger pumps and complicated system of proportional electric hydraulics controlled by a high-cost programmable component;

– sufficiently high efficiency of borehole charging – up to 60 kg of EE/min. Monthly volumes of the EE output are up to100 t;

– simple service and maintenance, rather high output after capital repair in terms of dosing pump of EE components as well as significantly lower cost of the attachable equipment;

– availability of both electronic and visual control means over the process of EE preparation and charge (float level indicator of EC and GGA liquid indicator), possibility of manual changes in dosing and output of dosing pump as for EE components by a chargeman.

4. CONCLUSIONS

Resulting from the complex of scientific and research, experimental and design as well as production activities, the autos have determined modern technical level of charging, auxiliary, and blasting equipment developed by A and M SIC and manufactured in cooperation with SE "SkhidHZK" and LLC "NTO Tekhnotron".

Use of such high-productive self-propelled and small-size charging facilities of a new generation as ZEVS-1 and portable charges ZEP-15 to mechanize blasting operations by means of bulk environmentally-friendly and trinitrotoluol-free emulsion explosives Ukrainit-PP-2 while tunneling and mineral extracting in mines will help improve the efficiency of blasting, mechanize and intensify technological processes in mines of PJSC "Kryvorizkyi zalizorudnyi kombinat", PJSC "EVRAZ Sukha Balka", LLC "Vostok-Ruda", CJSC "Zaporizkyi zalizorudnyi kombinat" etc. Technological scheme to deliver components of Ukrainit-PP-2 EEs has been successfully tested in mines PJSC "Kryvbaszalizrudkom".

ACKNOWLEDGEMENTS

The studies have been carried out according to the materials of the report with the participation of the authors in 15th International Conference Resource-generative, low-waste, and nature-protective technologies of mineral development (Vorob'yev, Lyashenko, & Nebogin, 2015) in association with such experts as P.A. Kysly, N.N. Shvets, V.S. Cherevyk, A.I. Lytvyn (A and M SIC), V.I. Boiko, A.S. Karaban, M.B. Kolesaiev, V.V. Shkaryn (LLC "NTO Tekhnotron") and others.

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ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ ВЕДЕННЯ ВИБУХОВИХ РОБІТ ЗА ДОПОМОГОЮ ЕМУЛЬСІЙНИХ ВИБУХОВИХ РЕЧОВИН НА ШАХТАХ

В. Ляшенко, А. Воробйов, В. Небогін, К. Воробйов

Мета. Підвищення ефективності виконання вибухових робіт за допомогою емульсійних вибухових речовин на шахтах з урахуванням вдосконалення обладнання для заряджання вибухових свердловин, а також застосування високопродуктивної гірничої техніки нового покоління.

Методика. В роботі для оцінки підвищення ефективності виробництва вибухових робіт за допомогою емульсійних вибухових речовин на шахтах використані шахтні експериментальні вибухи накладного заряду при руйнуванні негабариту й шахтні експериментальні дослідження процесу заряджання шпурів.

Результати. Встановлено, що патроновані та наливні емульсійні вибухові речовини (ЕВР) типу Україніт-ПП-2 і нові варіанти зарядних машин мають наступні технологічні особливості: наявність у своєму складі оригінальних малогабаритних конструкцій двокомпонентних поршневих насосів-дозаторів компонентів ЕВР подвійної дії; досить високу продуктивність заряджання свердловин – до 60 кг ЕВР/хв; простоту в обслуговуванні та ремонтах; досить високе напрацювання до капремонту насосу-дозатора компонентів ЕВР, а також значно

меншу вартість навісного обладнання; наявність як електронних, так і візуальних засобів контролю за приготуванням і заряджанням ЕВР.

Наукова новизна. Доведено, що підвищення ефективності виробництва вибухових робіт на шахтах досягається інтенсифікацією технологічних процесів заряджання вибухових свердловин, що відрізняються застосуванням високопродуктивної самохідної та малогабаритної техніки нового покоління, таких як машини моделі ЗЕВС-1 і переносні зарядники моделі ЗЕП-15 та використанням наливних, екологічно чистих, безтротилових ЕВР Україніт-ПП-2.

Практична значимість. Застосування ЕВР на шахтах при веденні вибухових робіт забезпечує безнебезпечне ведення робіт, високу якість відбійки і дроблення гірських порід при мінімальній токсичності, руйнування гірської породи будь-якої міцності й обводненості та економічну ефективність.

Ключові слова: *вибухові роботи, емульсійні вибухові речовини, обладнання, переносний зарядник, машини зарядні, безпеку робіт*

ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ ВЕДЕНИЯ ВЗРЫВНЫХ РАБОТ С ПОМОЩЬЮ ЭМУЛЬСИОННЫХ ВЗРЫВЧАТЫХ ВЕЩЕСТВ НА ШАХТАХ

В. Ляшенко, А. Воробьев, В. Небогин, К. Воробьев

Цель. Повышение эффективности производства взрывных работ с помощью эмульсионных взрывчатых веществ на шахтах с учетом совершенствования оборудования для заряжания взрывных скважин, а также применения высокопроизводительной горной техники нового поколения.

Методика. В работе для оценки повышения эффективности производства взрывных работ с помощью эмульсионных взрывчатых веществ на шахтах использовались шахтные экспериментальные взрывы накладного заряда при разрушении негабарита и шахтные экспериментальные исследования процесса заряжания шпуров.

Результаты. Установлено, что патронированные и наливные эмульсионных взрывчатых веществ (ЭВВ) типа Украинит-ПП-2 и новые варианты зарядных машин имеют следующие технологические особенности: наличие в своем составе оригинальных малогабаритных конструкций двухкомпонентных поршневых насосов-дозаторов компонентов ЭВВ двойного действия; достаточно высокую производительность заряжания скважин – до 60 кг ЭВВ/мин; простоту в обслуживании и ремонтах, достаточно высокую наработку до капремонта по насосу-дозатору компонентов ЭВВ, а также значительно меньшую стоимость навесного оборудования; наличие как электронных, так и визуальных средств контроля за приготовлением и заряжанием ЭВВ.

Научная новизна. Доказано, что повышение эффективности производства взрывных работ на шахтах достигается интенсификацией технологических процессов заряжания взрывных скважин, отличающихся применением высокопроизводительной самоходной и малогабаритной техники нового поколения, таких как машины модели ЗЭВС-1 и переносные зарядчики модели ЗЭП-15 и использованием наливных, экологически чистых, бестротиловых ЭВВ Украинит-ПП-2.

Практическая значимость. Применение ЭВВ на шахтах при ведении взрывных работ обеспечивает безопасное ведение работ, высокое качество отбойки и дробления горных пород при минимальной токсичности, разрушение горной породы любой степени крепости и обводненности и экономическую эффективность.

Ключевые слова: *взрывные работы, эмульсионные взрывчатые вещества, оборудование, переносной зарядчик, машины зарядные, безопасность работ*

ARTICLE INFO

Received: 1 November 2017
Accepted: 14 February 2018
Available online: 26 February 2018

ABOUT AUTHORS

Vasyl Lyashenko, Candidate of Technical Sciences, Chief of the Research Department, Ukrainian Research and Design Institute for Industrial Technology, 37 Slavy Ave., 52204, Zhovti Vody, Ukraine. E-mail: vilyashenko2017@gmail.com

Aleksander Vorob'ev, Doctor of Technical Sciences, Vice Rector for Science and Innovations of the Atyrau University of Oil and Gas, 45a Baymuhanova St, 060027, Atyrau, Kazakhstan. E-mail: fogel_al@mail.ru

Valerii Nebohin, Director of the LLC "NTO Tekhnotron", 1 Savodska St, 52204, Zhovti Vody, Ukraine. E-mail: info@technotron.com.ua

Kirill Vorob'ev, PhD Student of the Mining, Oil and Gas Business Department, Engineering Academy of the Peoples' Friendship University of Russia, 6 Miklukho-Maklaya St, 117198, Moscow, Russian Federation. E-mail: k.vorobyev98@mail.ru