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CURRENT STATE AND MAIN TRENDS OF DEVELOPMENT OF EXPLOSIVE ORE PREPARATION PROCESSES IN OPEN-PITS

(Presented by Ph.D, professor Fedorenko P.Y.)

The analysis of development and current state of rock blasting works in iron ore open-pits was made. Comparative assessment of the impact of natural and technological factors on the quality of explosive preparation of explosive ores and their further processing was given. Main technological solutions, management of options which can lead to the impact on the quality of ore explosive preparation were compared and analyzed. The advantages of delayed blasting were analyzed. Assessment of various blasthole charges commutation schemes was given. Effective interaction of tension waves can be provided by operating of the range intervals of slowdown. The coefficient of charges convergation and the line of the least resistance can be changed by using one or another scheme.

Great prospects of improving the rock blasting operations is related to the use of borehole internally deceleration and the method of blasting into a clamped environment. Reducing the width of working platforms and complications of hydrogeological regime on deeply horizons of open-pits causing the reducing of effectiveness of classical quality control methods of explosive preparation. The main directions of improvement of explosive ore preparation technology with consideration of the parameters of current open-pits and a significant change in the geological and hydrogeological conditions of development were identified.

***Keywords**: iron ore mine; explosive ore preparation.*

Problem statement. Geometric parameters of ledge, layer structure, strength and other properties of rocks determine the results of rock mass breakage. Density, porosity, margin of strength to compression, tension and shear, modulus of elasticity, Poisson's ratio and several acoustic parameters (speed of longitudinal and transverse waves, acoustic rigidity, the absorption coefficient of elastic oscillation) are the fundamental physical and mechanical parameters that influence the quality of array breaking during blasting. Moreover, types of explosives, means of explosives, charges designs, schemes and methods of explosives have greatest impact on the breakage quality of rocks. From above mentioned factors it is possible to affect on results of explosion through technological factors. Mining theory has not yet had unambiguous solution to determine the optimal parameters of explosive ore pretreatment.

Analysis of recent research and publications. A lot of works of domestic and foreign literature [1-18] are devoted to the search of energy charge necessary for receiving a given lumpiness rock mass during large rocks breakage. The ability to adjust the degree of rock crushing with the help of specific energy of explosive (E) of any diameter charge was practically proved.

Problem setting. The aim of the article is to analyze the current state and determine the main directions of development of ore pretreatment processes at the quarries.

Statement of the fundamental material and research results. Widespread adoption of granular and slurry explosives has facilitated the significant improving of the breakage quality. Their use has provided high performance, water resistance and the possibility of mechanical wells charging. These explosives, according their specifications, have found application in large diameter wells. Simultaneously with the development of trotyl contained granular explosives ammonium nitrate componds were being developed and implemented. ANFO, a mixture of granulated ammonium nitrate and diesel, was practiced widely in the USSR. Such explosives were used in foreign far abroad. Their disadvantage is the poor stability of the mixture. Therefore execution of the work was necessary to stabilize the mixture by introducing special additives [1-4].

With the increase in area irrigation on deep levels, the necessity of exploitation of waterproof explosives arose. The explosives are divided into suspension, emulsion and gel-like depending on the composition and method of preparation. Widely used GLT-20explosive has found its application that has led to the establishment of specific equipment for the preparation of GLT-20 complexes and mixing-charging machines - Akvatol. Such complexes with capacity of 30 thousand tons a year are successfully used in quarries mining plants. In the US pits water-containing explosive mixtures are produced at stationary points and during charging wells by charge mixing machines by mixing pre-prepared components. One of the drawbacks is the inability of explosives application in high fracturing watered rocks as they penetrate into the cracks and washed through flowing water, which increases their relative costs and blasting, with unpredictable source of nitrate and TNT. From this aspect, the benefits of suspension explosives plasticized with gel are obvious, but the lack of power and lack of special mixing-charging machines for pumping viscous formulations in the water column limited the area of their application. Modern water gel explosives are multicomponent mixtures of rather complex manufacturing technology. They consist of liquid and solid phases, which are concentrated solution and granulated ammonium, sodium or calcium nitrate. The structure also includes combustible components and sensitizers. The variety of percentage of various components allows to obtain mixtures with a wide range of properties. Sometimes specific gravity of explosion varies from 2900 to 6100 kJ / kg, and density from 0.8 to 1.6 g / cm3.

Considerable interest is a new kind of water-containig mixtures - emulsion explosives that developed and were introduced in the late 60s in the US and dominate in present in conditions of watered rocks. A distinctive feature of these explosives is a large surface contact between the fuel and oxidizer through fine dispersion. They are characterized by high efficiency, safety and environmental friendliness, the ability to regulate their detonation characteristics, structure stability and water resistance. Ukrainian variant of emulsion explosive named Ukrayinit-D was developed under R.S. Krysin leadership [5-7]. It consists of high-concentrated binary oxidizer solution, complex emulsifier, expanded perlite. According to its ability sensitizing perlite is equivalent to most microspheres, but the speed of emulsion explosives detonation is lower. Emulsion explosives Emulhim CMM has a density of 1,15-1,35 g / cm3 and heat blast 2,633 kJ / kg, which is 0.62 TNT. It is not enough for crushing of hard and very hard rocks.

The foregoing leads to the conclusion that development at different times in different countries of industrial explosives for conducting mining operation followed by increasing the proportion of explosives preparation with local non-explosive components. It sought to improve their environmental performance, including the removing of obsolete trotyl-contained explosives. Emulsion explosives are the most suitable for deep-ore pits that work off water fields.

While open pit mining two types of initiation are used: linear and point (multipoint) that can be realized through various explosives [8-10].

Practice has shown that the most effective way to initiate hole charges in quarries is initiating point using powerful fighters [11-12].

A great variety of explosives and mining conditions of exploitation of deposits contributed to development of new reliable and safe means and methods of initiation. One of these achievements in blasting technology is the creation, development and widespread adoption of reliable systems of non-electric initiation with the slowdown in the well. These systems are Nonel, Detalayn, Primadet, Herkudet etc., guaranteeing safety, are not affected by external electricity and lightning. For a long time, detonation relay of SDBDC or RP type were widely used enabled to ensure the specified sequence explosion, but could not provide inner drill slowdown.

The design of drill charge affects significantly the performance of drilling and blasting during open-cut mining. According the performance all the existing structures are divided into several groups.

In drill charges with a solid column of explosive initiation point for the detonation wave front with the axis of the charge is a first approximation angle of 90 °. In this case, the stress waves in the environment form a cylindrical charge area where an active process of detonation takes place, conical or spherical front, depending on the ratio of velocities of detonation explosives and sound waves in the environment.

The location of the point of initiation charge is very important. The research has established that at the point of connection scarp slope of the voltage sole, causing shear deformation on the plane soles, twice when initiating bottom than at the top initiation. The questions of tangential stresses along the line of the slope at this point are the opposite in direction. As [13] showed initiating changes at the lower angle between the front wave voltages and scarp slope leads to increased intensity of fragmentation and improves the quality of working sole ledge. Thus an important conclusion is that the direction of a detonation charge is crucial in the distribution of pulses explosion in the environment. This is confirmed in [9], which states that when initiating hole charges from bellow cause the output reduction of the oversize in 6-10% and 10-12% of total costs of drilling operations. As for multipoint initiation, its effectiveness is evaluated differently. The possibility of meeting detonation waves in previously surveyed place of hole or blasthole is noted. Intense fragmentation of the rock mass takes place through repeated pressure increase during the interaction of two detonation wave. The greatest effect is observed during the waves meeting at the foot ledge. The interaction of stress fields in the environment in case of the spread of detonation processes towards each other is also indicated. Some researchers believe that the linear initiating explosive charge by detonating cord parallel to the axis of the charge increases explosive crater, the degree of crushing environment. These phenomena are associated with a time decrease of explosive transformation in charge. The linear charge initiating varies not only in speed but also in the direction of propagation of the detonation wave [14, 15].

A significant amount of research of the possibilities of the line initiating in terms of Kryvbas quarries exploration is made by specialists of the enterprise "Kryvbasvybuhprom". Various designs of hole charges using linear initiators, combinations of low-power and high-power cords and cooperation schemes of charges of different designs are developed.

Combined charges, made up of different types of explosives allowing to change the design of energy explosives of ledge height, which destroyed depending on the properties of rocks that make up the array, provoke some interest. Decked charges consisted of two or more parts separated by air spaces have also been used in practice. This design is effective in the case of consecutive initiation of the lower and upper parts of the charge, thus increasing the time and the degree of influence of the explosion to the array and use of different types of explosives.

У цьому випадку застосовують також звичайне контурне підривання з попереднім щілиноутворенням. У додатково пробурених зближених свердловинах формують заряди зі зменшеною лінійною масою, з радіальними повітряними проміжками.

The charge designs of air spaces above the charge and locking devices and blasting of parts of charge with inner hole slowdown have occurred. Hole charge construction with boiler extensions, axial cavity, and stepped charges have also been applied. The application in the charge constructions the so-called special universal channel militants that successfully tested in combination with the new explosive Ukrayinit-M is noteworthy. There are cases of use of combined charges from waterproof and hydrolabile explosives in irrigated wells with stagnant water. Positive results occurred when using special designs of charges of air and inert intervals at breaking rocks in the vicinity of the protected objects, to reduce the destruction of the array. In this case simple contour blasting with the previous slot-formation is used. Charges with reduced linear weight with radial air gap are formed additionally in addition drilled adjacent wells.

One of the most important advances in blasting is the use of multi-delayed explosives, providing high-quality crushing rock mass and reducing the seismic effect. One of the main factors determining the efficiency of slow explosion is the time interval between explosions slowdown charge or series of charges. With the delayed explosion imposition of the processes takes place that occur in the rock at the moment of the explosion, and their interaction in various stages of development. Depending on the value of delay, character interaction charges also changes. There are several hypotheses according to the conditions of charge interaction showing that crushing rocks with this method of blasting improves the interaction of waves of stress and the use of stress state array caused by previous explosion related charges, the formation of additional free surface or the interface between the parts of the array, destroyed and being destroyed, which allows it to deform during the subsequent explosion and move in the direction of the newly created surface; collision of rock masses moved by explosion. The mechanism of explosive destruction of rocks with different properties affects significantly the process of rock destruction while delayed explosion.

Range of deceleration interval change, providing interaction of stress wave and use rock stress state depends on the parameters of the stress wave and velocity of elastic waves. There are several ways to determine the deceleration interval. Each of the ways is based on the author's views on the mechanism of explosive destruction. The best known methods for determining the deceleration interval are made by G.I. Pokrovsky, A.N. Hanukayevym, V.N. Mosintsem. All the proposed methods can only tentatively establish rational deceleration intervals for specific conditions. In the course of explosion research it is clarified to bring explosion slow mode to the optimum to obtain the best results fragmentation and collapse of the blasted rock mass [16].

Many different schemes of explosion are used in terms of opencast. The convergence rate of charge and the line of least resistance can be changed applying a particular scheme. According to the number of explosive loads influenced on the prism of rock bounded by the nearest charges, schemes can be divided into groups, each of which provides a specific regime of explosive loads: one-, two-, three- or fourfold load.

Toward the front of the breaking, on the edge of the ledge, the schemes of slow mode explosion are divided into longitudinal, lateral, diagonal, and with a curve and an arch-like placement concerning the charge groups that are undermined. The majority of schemes have a straight configuration of breaking front, formed by simultaneously initiating charges arranged in a straight line; the distance between them does not exceed double the radius of destruction. The angular configuration of the breaking front is obtained as a result of slow mode sequential explosive charges arranged in one row. In addition, there is also the so-called tooth breaking line that is formed by simultaneous explosive charges arranged at a distance greater than double the radius of destruction and curve line of driving off that overruns wedge and trapezoid explosion schemes. Curved breaking line that is characteristic of the radial explosion schemes is limited in its use [17].

With the help of explosion schemes it is possible to control blasting parameters and the rate of loosening of the rock mass. Improving the quality of crushing of rocks depends on the breaking conditions. In recent years, the rock breaking of the so-called clamped environment is successfully applied. This method of blasting is performed in several versions that differ in the number and location of surface exposure, the nature of a retaining wall and firing sequence of individual charges, which determine the explosion scheme. The first option embraces explosives in a completely clamped environment where there is only one free space (holding split trench, sump and other special workings). The second option deals with undermining the system of charges in block retaining wall on the ledge, the value of which either eliminates visible horizontal displacement of blasted rock mass, or contributes to a significant reduction of the width of the collapse. The third option refers to the explosion of significant amount of longitudinal rows of hole charges (5-6) in the case of diagonal or cross explosion schemes. In this case, the retaining wall of a messy rock mass is optional. Method of blasting in clamped medium is very effective because it allows to control the explosion energy of the rock mass quality preparation.

Taking into consideration the growing volume of blasting and the blocks location undermined at considerable distances from each other, a need to develop management systems explosion in the distance has arisen. Such systems were developed at the Leningrad Mining Institute, Kyiv Institute of Automation and "Kryvbasvybuhprom" enterprise together with NDIChermet. However, only the radioblasting system "Grim" has found its application. This device consists of a command and executive units. Command unit together with the radio transceiver is installed outside the

danger zone on the edge of open pit and transmits coded commands to test the radio channel and blasting. The unit can be installed in a specially equipped vehicle. The number of operational units that work with one command unit is not limited. Application of radioblasting on the opencast pits helps to reduce the consumption of detonating cord, reduce labor costs for installation of explosive network and increase seismic safety work.

Taking into account the increase in irrigated area of the rock with depth development, methods of blasting in such conditions are particularly important. Modern water-resistant explosives are above mentioned. However, their use is conditioned by clear information on the irrigated areas of deposits. The state of water in the well is of particular importance. The practice shows that in some wells the speed of water filtration reaches 10 m / day. To determine the irrigated areas the special hydromaps has been developed. Under the conditions of Kryvbas irrigated area of opencast pit field is conventionally divided into four zones with stagnant, poorly running, running and heavy running water of the numerical values of speed of water filtration, using the developed by V.N. Udalov blasting classification for hydrodynamic regime. To save the charge in conditions of a high speed of water filtration, well sides or explosive charges should be dampproofed. The attempts to use for this aim plastic film (sleeve) during charging do not give the desired results due to lower performance of charge vehicles and low reliability of waterproofing. That is why only waterproof TNT explosives can serve as the basic methods of blasting in irrigated conditions [18].

Conclusions and directions for future research. Analyzing the current state of blasting in opencast pits, the following conclusions can be made.

In the reached depths of opencast pits modern geological and mining-technical conditions of mining have changed. Specific gravity of hard, fractured, irrigated, rocks has significantly been increased. The width of working areas has been decreased, that does not allow to use the multi-delayed blasting for quality crushing, forming a compact collapse of the blasted rock mass and a high degree of processing soles in full.

The problem of management of explosion preparation of rock mass with previous explosive weakening of pieces remains unsolved.

The necessity arose to solve two major problems for the mining and processing redistribution: obtaining quality output for crushing and weakening for grinding layer and receiving a given ratio between factions of different sizes for self-grinding mills.

In connection with the above presented research, the development of effective methods of blasting of iron quartzite, providing efficient mining and processing redistribution on the basis of altered conditions of modern mining and enrichment plants is urgent.

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