Mining Science, vol. 21, 2014, 33−41

www.miningscience.pwr.edu.pl

Mining Science
(previously Prace Naukowe Instytutu Górnictwa Politechniki Wrocławskiej. Górnictwo i Geologia)

ISSN 2300-9586
previously 0370-0798

Received: April 16, 2014, accepted: July 22, 2014

OPTIMIZATION OF THE ROCK BLASTINGS IN OPENCAST MINES USING HYDROMITE EMULSION EXPLOSIVES

Andrzej MARANDA[1], Barbara GOŁĄBEK[2*], Bernard KORYTKOWSKI[2], Jacek SUSZKA[2], Patrycja RINK[2]

[1] Military University of Technology, ul. Kaliskiego 2, 00-908 Warszawa, amaranda@wat.edu.pl
[2] Austin Powder Polska Sp. z o.o., 59-516 Zagrodno, Łukaszów 37

Abstract: In the current paper, measurement results of the detonation parameters for model emulsion explosives are presented, one of the matrices constituting a base for Hydromite – 100 and 70; the work additionally details the results of the rock blastings, carried out by means of the above mentioned materials. The blastings were executed in the following opencast mines: Kamienna Góra, Kopalnia Granodiorytu Łazany II, Łagów V and Warta Cement Plant. The goal of the proceedings was to optimize the blast grid for specific plants.

Keywords: emulsion explosives, detonation parameters, blast grid

1. INTRODUCTION

Modernization of the rock blastings in the mining industry depends on the development of the mining explosives. In recent years, emulsion explosives (EE) have become a dominant blasting material for the opencast mining. Polish Military University of Technology, together with mining explosive manufacturers, have for many years researched the modern explosive materials. Tests of the broadest scope were executed during market operations of the Blastexpol Sp. z o.o. company (see e.g. Maranda et al., 2001, Maranda et al., 2008a, Maranda et al., 2008b). The tests were aimed at determination of properties of the matrices, specifically their transport capabilities in relevant class, as well as EE detonation parameters, depending on their composition

[*] Corresponding author: Barbara Gołąbek, golabek.b@gmail.com

doi: 10.5277/ms142103

and density. Since Austin Powder Polska made its entry onto the Polish market, research was directed to modify EE composition in order to obtain optimum detonation parameters, combined with transport safety. Test results were presented in the papers by Maranda et al., 2012 and Maranda et al., 2013, dedicated to a new group of explosive materials – Hydromite. The current work covers mostly results of blastings executed in 2013 and beginning of 2014.

2. EE DETONATION PARAMETERS

There are two basic matrices used for manufacturing of emulsion explosive materials in Austin Powder Polska. The matrices have identical compositions (ammonium nitrate(V) – 64,4 %, sodium nitrate(V) – 14,6 %, organic phase – 6,0 %, water – 15 %), they, however, differ in viscosity. The matrix designated as Hydrox U exhibits viscosity of 120000 cPa, whereas the Hydrox S matrix – 55800 cPa.

During detonation parameters' tests, *detonation velocity* and *detonability* were evaluated for emulsion explosives containing Hydrox S and Hydrox U matrices. Detonation velocity constitutes one of the fundamental parameters, characterizing the explosive materials, which proves crucial for the scope of their application. Critical diameter measurements were also carried out. The sensor circuit method was adopted in the current work for measuring the detonation velocity of the explosive materials under consideration. The matrices were sensitized by the addition of 0,6 % of Expancel 461DET40 microspheres, in order to obtain the density of the EE used in mining plants. Samples of the explosive materials were prepared in laboratory conditions by precise mixing the matrices manufactured in Austin Powder Polska with the sensitizer. The detonation velocity tests were carried out in 46/50 mm PVC pipes. The test results are presented in the following Table 1.

Tab. 1. Detonation parameters of emulsion explosives sensitized by microspheres (Maranda et al. 2013)

Explosive composition, %			Density, g/cm^3	Detonation velocity, m/s	Critical diameter, mm
Hydrox S Matrix	Hydrox U Matrix	Micro-spheres			
99.4	–	0.6	1.03	5170 5140 5110	<25
–	99.4	0.6	1.04	5120 5100 5160	<25

For the onsite test in mines, two sorts of Hydromite 70 and 100 class explosives were selected, containing Hydrox U matrices. They were mechanically planted into the blast holes. Physicochemical, detonation and thermodynamic parameters of the Hydromite 70 and 100 materials are detailed in the Table 2.

Tab. 2. Physicochemical, thermodynamic and detonation parameters of Hydromites 70 and 100

Parameter	Hydromite	
	70	100
Density, g/cm^3	1,05–1,30	0,8–1,25
Minimum hole diameter [mm]	75	35
Detonation velocity in 35 mm steel pipes, m/s	> 4000 m/s	> 4000 m/s
Explosion temperature, K	2315	2141
Specific volume of the detonation products, dm^3/kg	925	914
Heat of detonation, kJ/kg	3016	2779
Blast ideal energy, kJ/kg	2510	2314
Specific energy, kJ/kg	794	726

3. RESULTS OF ONSITE TEST IN MINES

The mining industry, in virtually all of the opencast mining plants (not only those considered herein) are focused on extracting the final product of specific parameters, while minimizing investment and production costs. Having analysed the production costs, it occurs that the first stage of mining, namely detachment of the ore from an undisturbed soil by means of an explosive material, has crucial influence on the final product and its cost. The mining process must therefore become optimized in such a way as to provide minimal costs of obtaining the yield, maximum performance as well as highest possible quality. In order to reach this goal, specific process parameters must be fine-tuned, namely – drilling and blasting works need to be optimized. The above mentioned optimization refers to both technical parameters of the blast grids, as well as to selection of the explosive material properties, depending on geological and mining conditions of specific deposit (type of rock, its properties, mining susceptibility, proximity of buildings), capabilities to control the initiation of explosives. The following examples of blastings in different mines provide a review and comparison of changing technical parameters.

3.1. KAMIENNA GÓRA GRANITE QUARRY

Austin Powder Polska company started comprehensive blastings in the Kamienna Góra Granite Quarry beginning of 2013. The blasting works were carried out using

Hydromite 100 bulk emulsion explosive. The technical parameters of the blast grids previously used are presented in the Figure 1 and Table 3 (blasting No. 1).

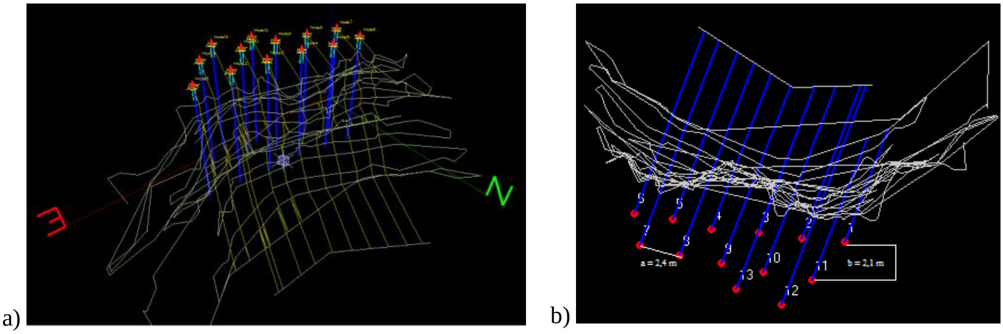

Fig. 1. View 3D (a) and technical parameters (b) of blasting no 1 in Kamienna Góra Granite Mine

The distances between holes and rows were not large, due to previously used explosives and block character of the granite deposit. Having analysed the results of the subsequent blastings, one could observe that the mined material is too fine. In spite of the charges separation in the blast hole and limitations implied by designated blasting areas (related to charge size), the fraction of the ore extracted at the first stage of mining would have to be increased.

Tab. 3. Technical parameters of blasting in Kamienna Góra Granite Mine

Technical parameter	Blasting No.				
	1	2	3	4	5
Number of long holes	13	12	18	27	20
Hole diameter, mm	89	89	89	89	89
Directional drilling, m	0.5	0.5	0.6	0.6	0.7
Wadding, m	2.0	2.0	2.0	2.0	2.0
Mean face height, m	11.0	10.0	11.0	11.0	11.0
Distance between holes, m	2.4	2.6	3	3.2	3.4
Distance between rows, m	2.1	2.3	2.5	2.8	2.8
Reach, m	3.5	3.3	3.5	3.5	3.5
Density, g/cm^3	2.65	2.65	2.65	2.65	2.65

Therefore, a decision was taken to systematically increase the distances of the blasting hole grids, in order to reach the distance between holes of 3.4 m and the distance between rows of 2.8 m in last November (Fig. 2, Table 3, Test 5).

The rock mass extracted by means of the explosive material proved to be of a proper granularity.

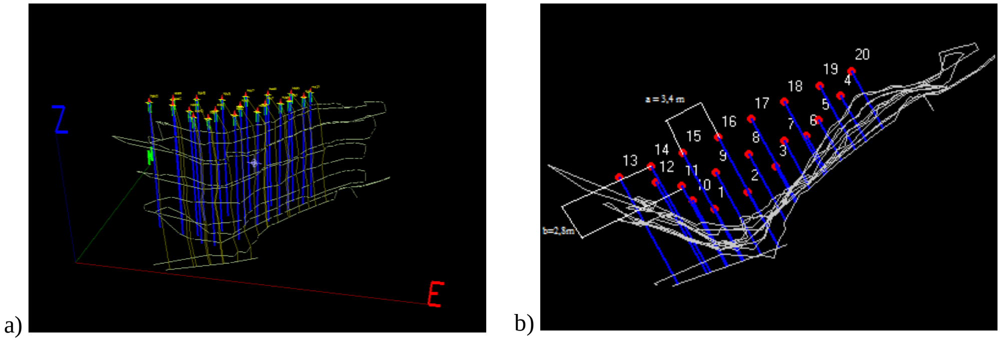

Fig. 2. View 3D (a) and technical parameters (b) of blasting no 5 in Kamienna Góra Granite Mine

3.2. ŁAŻANY II GRANODIORITE MINE

Łażany II Granodiorite Mine is located nearby Strzegom; it yields ca. 600 thousand tons of the ore annually. Granodiorite of the Łażany II deposit, created through magmatic intrusion, comes in several lithologic types. In 70 %, it is light-gray granodiorite of medium granularity, the remaining 30% is tonalite – dark gray, fine grain rock. The deposit exhibits numerous fault areas with cracks in the ceiling area. However, the deeper into the deposit, the more its structure can be regarded as block. The Łażany II Granodiorite Mine is located close to the two gas pipelines in operation: one situated approximately 170 m and another, approximately 250 m from the mine.

The tests were carried out using Hydromite 100 explosive. Thanks to the proper selection of delays, precision of the bores and measurements (both at check-up as well as those taken at the design phase) it become possible in July 2013 to adjust the charges: the total – from 2500 kg to 4000 kg; and the delay from 60 kg to 75 kg. The tests and measurements were carried out by POLTEGOR INSTYTUT. In the Figure 3, a 3D view is presented (a) as well as the technical parameters of the hole grid for one of the first blastings. Subsequently in Figure 4, the optimized blast grid is depicted, while Table 4 enables comparison of the parameters of the similar blastings.

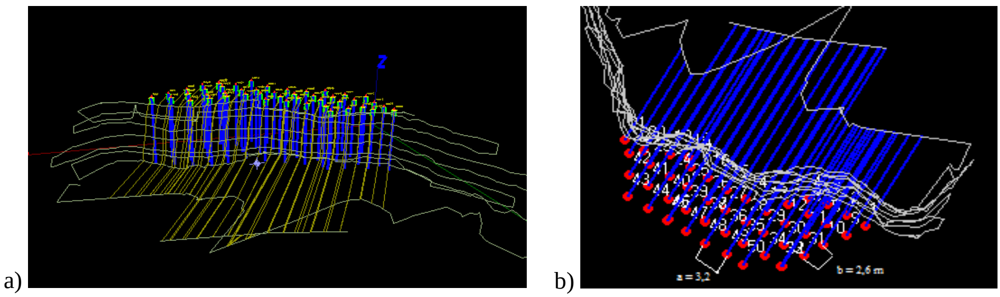

Fig. 3. View 3D (a) and technical parameters (b) of blasting no 1 in Łażany II Mine

Tab. 4. Technical parameters of blasting in Mine Łażany II

Technical parameter	Blasting No.	
	1	2
Number of long holes	50	57
Hole diameter, mm	89	89
Directional drilling, m	1.0	1.0
Wadding, m	2.5	2.5
Mean face height, m	10.7	9.1
Distance between holes, m	3.2	3.7
Distance between rows, m	2.6	3
Reach, m	3.5	3.2
Density, g/cm^3	2.65	2.65

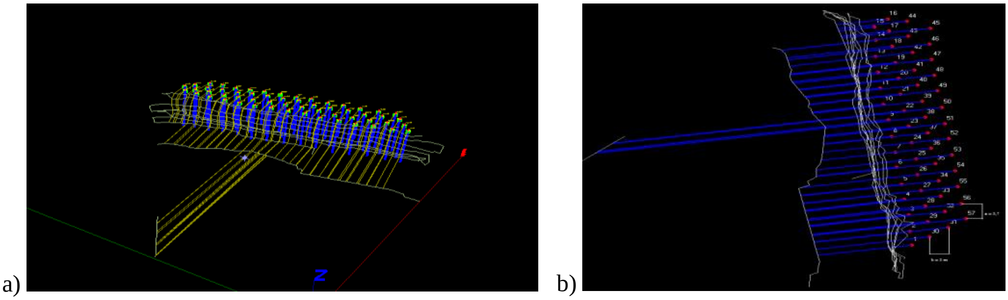

Fig. 4. View 3D (a) and technical parameters (b) of blasting no 2 in Łażany II Mine

3.3. ŁAGÓW V MINE

Łagów V Mine is situated nearby Kielce, it yields approximately 1.5 million tons of the ore annually. It contains the limestone deposit of gray colour, criss-crossed with quarternary formations – sand and clay. There are also numerous occurrences of litho-facial aberrations present; the nearest buildings are located approximately 200 m from the mine (excavation in the buildings' vicinity is discontinued). In the following diagrams, the blast grid for one of the initial blastings is presented (as of 11/11/2013, Fig. 5) as well as the optimized grid (as of 03/11/2014, Fig. 6). The Table 5 presents the comparison of the technical parameters of initial blastings and the optimized ones.

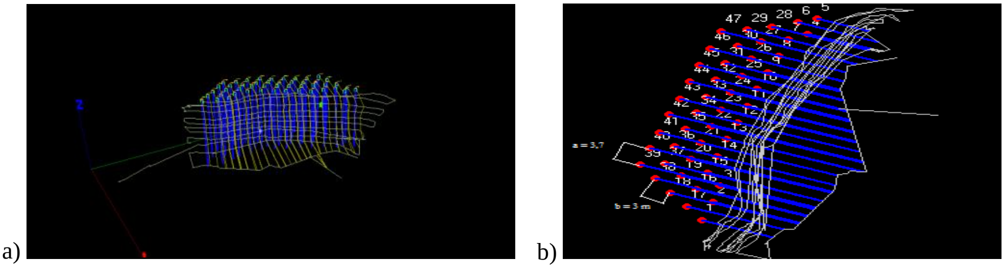

Fig. 5. View 3D (a) and technical parameters (b) of blasting no 1 in Łagów V Mine

a) b)

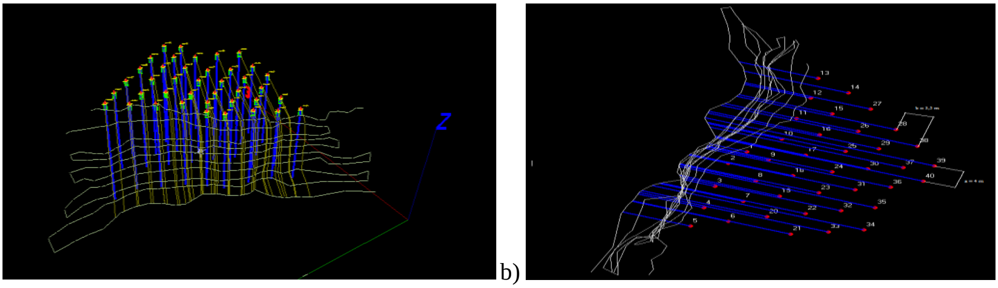

Fig. 6. View 3D (a) and technical parameters (b) of blasting no 2 in Łagów V Mine

Tab. 5. Technical parameters of blasting in Łagów V Mine

Technical parameter	Blasting No	
	1	2
Number of long holes	47	40
Hole diameter, mm	95	95
Directional drilling, m	1.0	1.0
Wadding, m	3.0	3.0
Mean face height, m	18.0	14.0
Distance between holes, m	3.7	4.0
Distance between rows, m	3.0	3.5
Reach, m	3.8	3.8
Density, g/cm^3	2.67	2.67

3.4. WARTA CEMENT PLANT QUARRIES

The limestone is extracted from the following deposits: Działoszyn, Niwiska and Trębaczew, to be augmented in future by a new deposit – Pajęczno-Makowiska I. Until commencement of the Austin Powder company operations, saletrol-type explosives were used in the Warta Cement Plant quarry deposits, loaded into the blast holes by loader systems or from bags, as well as the heavy-ANFO type explosives, whose detonation parameters seemed optimal for extraction of these ores. For the described

a) b)

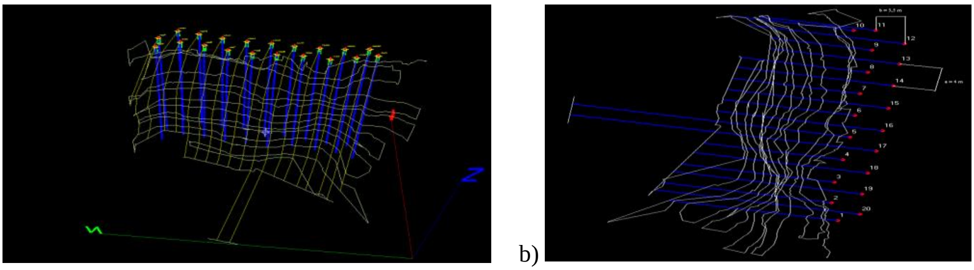

Fig. 7. View 3D (a) and technical parameters (b) of blasting no 1 in Cement Plant Warta excavation

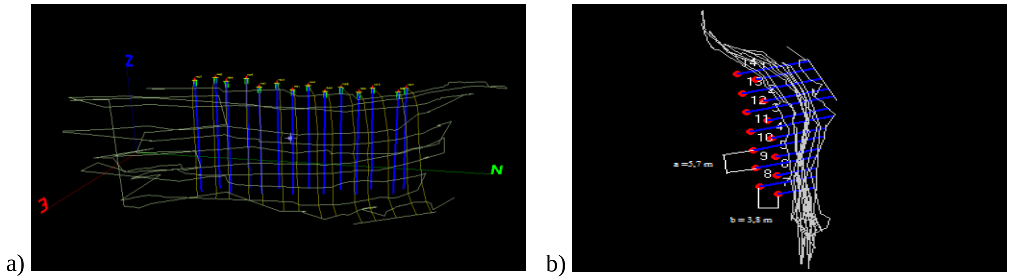

Fig. 8. View 3D (a) and technical parameters (b) of blasting no 2 in Cement Plant Warta excavation

extraction tests, Hydromite 70 explosives were used. In the Figure 7 3D view (a)nd technical parameters of the blast grid are presented for one of the initial blastings. In the Figure 8 optimized grid blasting is shown, whereas the Table 6 presents comparison of the blasting parameters.

Tab. 6. Technical parameters of blasting in Cement Plant Warta excavation

Technical parameter	Blasting No	
	1	2
Number of long holes	20	14
Hole diameter, mm	95	95
Directional drilling, m	1.0	1.0
Wadding, m	4.0	4.0
Mean face height, m	18.0	18.0
Distance between holes, m	4.0	5.7
Distance between rows, m	3.5	3.8
Reach, m	4.3	4.0
Density, g/cm^3	2.0	2.0

4. SUMMARY

Blastings using Hydromite 70 and 100 explosives demonstrated possible optimization of the blast grid enabling highly increased yield of the ore per meter of the blast hole (Fig. 9). Hence, significant savings can be obtained in drilling works as well as in blasting resources to be used.

The results of the operational blastings as well as measurements of the paraseismic waves characteristics (conducted but not presented in the current paper) indicate that:

1. Bulk Hydromite explosives can replace saletrol type explosive materials as well as shelled explosives.
2. Increasing blast grid parameters did not affect intensity of the paraseismic wave propagation. Such effect can be achieved by using explosives of mixed densities.

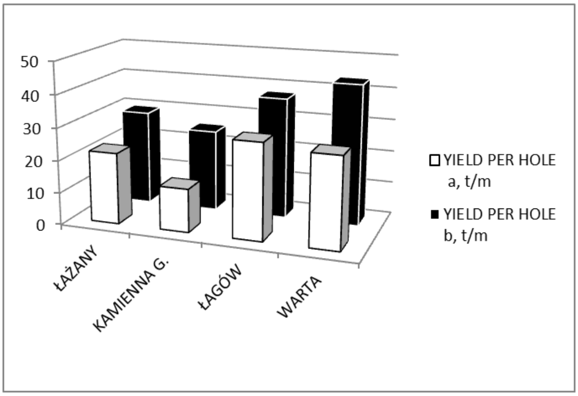

Fig. 9. The yield of mined rock, grid blasting: a – output, b – optimized

3. Large blastings are not dangerous; increasing the total charge while retaining the delayed charge, proper time intervals as well as the blast grid parameters plus drilling precision do not affect the safety of the blastings.

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