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CHANGES IN THE BLASTING TECHNIQUES DURING RECENT YEARS IN POLAND

Польша – страна с богатыми минеральными ресурсами. Большая их часть добывается с использованием взрывных работ, как при подземной, так и при открытой разработке месторождений полезных ископаемых. Описаны изменения и тенденции в развитии взрывных технологий, произошедших в Польше в течение последних лет. Особое внимание уделяется освещению новых компаний, появляющихся на рынке и специализирующихся на оказании услуг по проведению взрывных работ на рудниках, и автоматизации взрывных работ и появлению новых технологий в этой области. Рассмотрена практика ведения работ на открытых горных выработках с точки зрения предотвращения негативного воздействия взрывного метода очистки забоя на окружающую среду. Освещаются различные методики буровзрывных работ и применение компьютерных технологий в данной сфере.

Poland is a country rich in the mineral resources. Many of them are extracted by using blasting techniques both underground and open mining. The paper presents changes and trends in development of blasting techniques in the recent years in Poland. Special attention is paid to business entities appearing on the market, which specialize in blasting services in mines, as well as to mechanization of blasting works progress and evolving of modern explosives production technologies. In addition, the paper underlines open-pit mines practices in respect of prevention from harmful influence of explosives hewing method on the environment. Furthermore, various blasting works development methods and the use of computer software on these matters are introduced.

Introduction

During the last few years in Poland important changes as well as the significant progress in blasting techniques can be observed. These developments result from the new legal regulations, the privatisation of open pit mines, coming into existence of the service companies and also the new methods of manufacturing blasting materials. This has caused the noticeable changes in the structure of blasting material use. The tendencies of growth in a number of researches and preventive activities, aiming at the reduction of negative effects of the blasting works, are also observed.

It is worth underlining that the blasting technique, due to the mechanical properties of a mineable centre, is still one of the basic methods of the mineral resources exploitation in the extractive industry.

Main directions of changes

One of the main directions of changes is appearing the business entities on the market, which obtain a concession on manufacturing and rotating of blasting materials for the civil purposes [2]. They can supply mines with explosives and/or provide services in the field of blasting works. This comes from a need for adapting blasting works in the extractive industry to the technical and economical conditions existing in a company. The new legal regulations in the explosives application foster changes to a large extent [10, 11].

The activity of the business entities, carried on under contract of the mining companies in the field of explosives supply and blasting works performance, varies significantly and can be divided into 5 groups [1]:

1. explosives delivery through an entity possessing the concession for their manufacturing and/or rotating from a producer to the explosives storehouse at a mine site or directly on site of blasting works;

2. explosives delivery through an entity *not* possessing the concession for their manufacturing and/or rotating from a producer to the

explosives storehouse at a mine site or directly on site of blasting works;

3. blasting works performance with using explosives made-manufactured, delivered through another entity to the explosives storehouse or on site of blasting works;

4. blasting works performance with using the self-propelled blending devices or the appliances producing explosives on site of the blasting works,

5. co-operation of an entity at the explosive producing and its loading to the blast-holes, while the appliances producing and loading explosives are the property of a mining operator.

Growth on the market of services for the mining companies gives a possibility of ordering the majority of activities and works connected with the blasting works preparing and conducting from external companies. It allows to abandon the traditional model of a mining company. As far as the delivery of explosives goes, their storage in the explosives storehouses, drilling of the blast-holes, blasting charges installing and their initiation were performed by the mining company employees by means of the devices and equipment belonging to this mine [1].

The two basic systems of the blasting works proceeding, which are also presented at the figure 1, can be distinguished [5]:

I. internal (own) – an operator performs the drilling and blasting works by means of own staff and resources belonging to this company,

II. external (ordered) – a part or the whole drilling and blasting works are ordered by an operator from a specialized company. This system calls for adapting services to the needs of principal and forces service companies to possessing a flexible and qualified drilling and blasting team as well as the modern devices and equipment.

The subsequent changes, which have undergone changes during the last few years, refer to the methods of blasting materials manufacturing and also a structure and assortment of explosives consumption. The table 1 presents the proportional share of basic explosives consumption in underground and open pit mining with respect to the total consumption in mining in 2003. This differences are connected to applying various methods of blasting techniques in both underground and open pit mining.

Table 1. **A share of underground and open pit mining in total explosives consumption in mining in 2003 (source [7])**

Assortment	A share of underground mining in total consumption, %	A share of open pit mining in total consumption, %
Explosives	58,8	41,1
Detonators – in total	94,5	5,1
Electric detonators	95,6	3,9
Non-electric detonators	85,6	14,4
Detonating fuse	71,8	28,2

In Polish mining industry more and more often explosives are manufactured on site of blasting works, most of all in open pit mining companies [2]. These materials are very modern and safe in use, produced out of non-explosive and little toxic constituents. Particular constituents are transported in special containers of the bulk emulsion/ANFO trucks and they are precisely blended in proper proportion. The non-explosive emulsion undergoes sensitisation as it is pumped into blast-holes. During the blasting materials pumping process it is possible to adjust constituents proportion and the loading density in order to obtain properties suitable to the mineable centre. This regards emulsions HaevyANFO and ANFO. Thanks to modernisation of a fleet of machines and a need of being up to the clients' requirements the stationary plants have also brought into the market a new generation of explosives.

One can also observe a growth of use of non-electric initiation system, which has a lot of advantages, a/o:

– high safety of blasting works performance – insensitivity on influence of currents and electrical devices as well as lack of electric elements in detonators,

– simplicity in connecting of non-electric detonators cord and the blasting net by means of surface connectors,

– possibility of increasing a range of blasting works performance thanks to unlimited number of connectors delay degree.

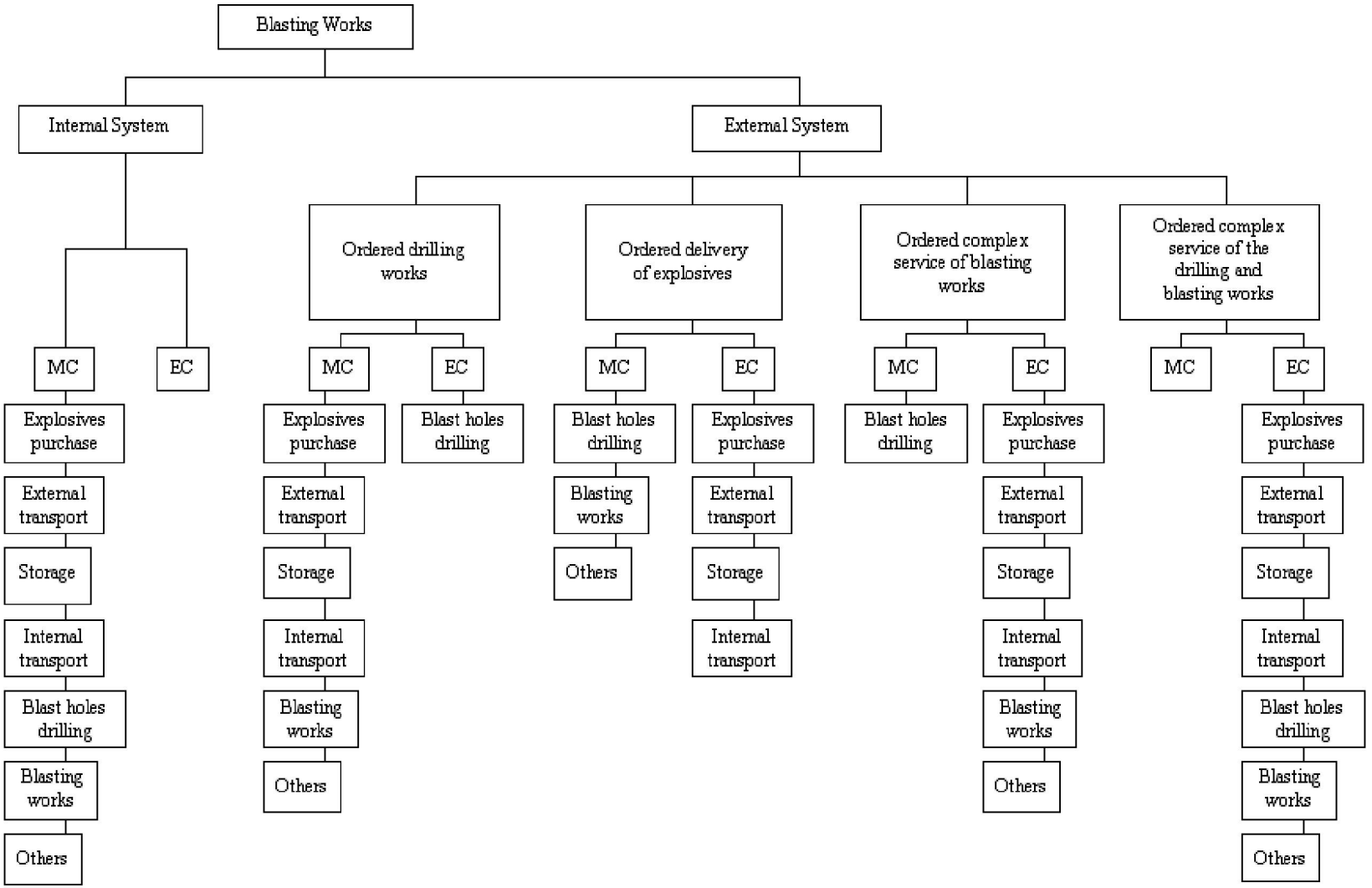


Figure 1. Variants of the drilling and blasting works conducting [6]: MC – mining company, EC – external company

While designing blasting by means of the non-electric system one can initiate blast-holes situated in one- or multi-series as well as conduct simulative calculations in order to avoid threats of particular charges initiation times superimposing.

Thanks to modern blasting materials and the non-electric system application the convenience and safety of blasting works have improved. If the blasting works are designed correctly the excavated material granulation, side walls smooth and decrease of fracturing beyond the charges initiation line can be achieved.

Important place in blasting techniques takes prevention of the blasting works harmful impact on the environment, which are caused by open pit mining activities. Among the negative effects first off all one should mention hazards caused by a shock wave activity, chip stones dispersion and rock mass seismic vibrations, which occur around the place of blasting. Methods of these danger areas determination have been contained in a legal order [10].

The preventive activities in a field of blasting works impacts in mines should include:

– determination of optimal blasting parameters,

– proper assign of the exploitation face considering the location of buildings in a vicinity,

– making inventory of the objects technical state,

– recognition of vibrations propagation directions and the degree of their intensity in a vicinity of excavation workings,

– cyclic measurements of vibrations intensity,

– in special cases – monitoring of an object put at risk,

– use of better explosives i.e. emulsions HaevyANFO and ANFO for the sake of effective mining,

– introduction of non-electric initiation in order to improve the blasting works safety and make better use of millisecond initiation possibilities.

Negative impacts of vibrations, being activated through mining operations by means of explosives, on buildings (historic, industrial, residential or economic) in a vicinity of excavation workings, call for s special concern. For the correct assessment of the paraseismic vibrations hazard the analysis of vibrations frequency is applied [8]. Modelling of vibrations intensity and determination of allowable blasting charges (safe for buildings) is performed by experimental determination of unknown parameters of the basic equation of vibrations propagation, which is presented below [9]:

$$u = KQ^{\alpha} r^{-\beta}, \qquad (1)$$

where u –vibrations intensity; Q –explosives charge; r – a measurement distance from the place of blasting; K, α, β – parameters determined experimentally in given geological and mining conditions.

After transformation of the dependency (1), where $\rho = \frac{Q^n}{r}$, the equation takes the form with two unknowns:

$$u = K\left(\frac{Q^n}{r}\right)^{\beta} = K\rho^{\beta}. \qquad (2)$$

In such a case the charge can be calculated from the following formula:

$$Q = \left(\frac{u}{K}\right)^{\frac{1}{\beta \cdot n}} r^{\frac{1}{n}}. \qquad (3)$$

Benefiting from many years of analysing the seismic blasting effect a methodology of determination the suitable proportion of powered exponent $n = \alpha/\beta = 1/3$, $1/2$ or $2/3$ has been developed. This in turn allows to take advantage of the equation (2). Long-lasting research have shown that the exponents equals to $n = 1/2$ or sometimes exceeds even $n = 2/3$, which substantially changes dependency of the velocity u from Q and r. At $n = 1/3$ one obtains high quantities of the allowable charge. Simultaneously, an increase of quantity n is accompanied with a decrease of safety degree. This method is suitable only when the conditions of blasting works, waves propagation, vibrations receiving, applied measuring apparatus and measurement accuracy are recognised in details. An influence of the total charge Q_c and the millisecond delay charge Q_z on vibrations

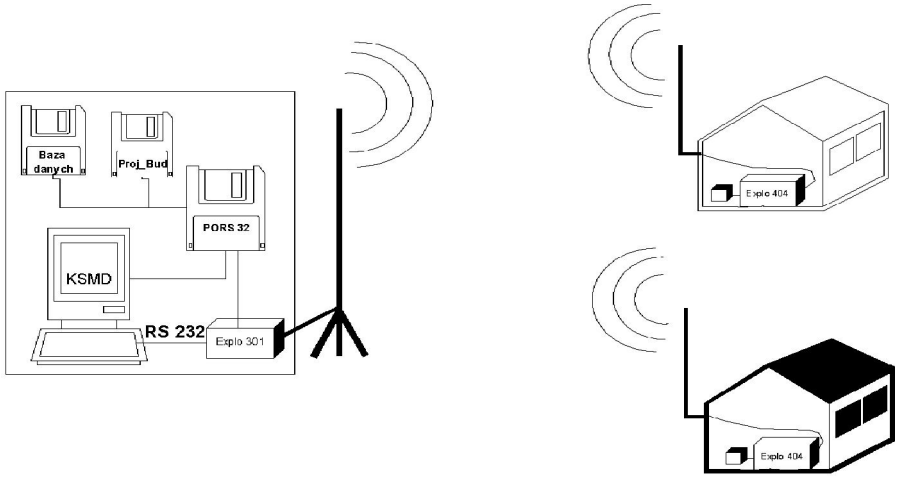


Figure 2. Arrangement of the KSMD [4]

intensity are not yet fully investigated. Therefore the principle expressed with the formula (2) is too general and calls for further research. Determination of the blasting allowable charges is to assure safety of the objects, facilities and people. For the assessment of the vibrations impact on buildings and on human beings in buildings the following Polish standards PN-85/B-02170 PN-88/B-02171 [12] are broadly applied. First of the mentioned standards contains the dynamic impacts scales SWD I and SWD II.

At present the most effective research method is continuous vibrations registration through a long period of time i.e. monitoring. It allows to register vibrations caused through everyday mine activities. It considers all the geometrical changes, quantities of charges, kinds of explosives, millisecond delays and initiation schemes. These differences cannot be captured by means of control measurements. In Poland, thanks to researches in a field of negative effects of blasting works on the environment elimination, conducted in the Department of Surface Mining (AGH University of Science and Technology) through the Laboratory Team of Blasting Works and Environmental Protection, the On-site Mine Vibration Monitoring Facility (*abbr. in Polish* KSMD) has been constructed [5]. The computerised system KSMD includes: a blasting works design, registration of vibrations, radio or telephonic communication of the data transmission into a computer, documentation of causes and results of works effect on the environment. The arrangement of the KSMD is outlined at the figure 2.

The KSM consists of a basic station EXPLO 301, which co-operates with a computer, and a number of measuring stations EXPLO 404 placed in protected objects [4]. The system as a whole is controlled through the Blasting Works Management Program (*abbr. in Polish* PORS32). The monitoring facilitates a level of induced vibrations control as well as a prompt reaction on the occurring exceed of standards. Using the monitoring station and collecting the full data measured in a number of mines may be of a great value for further developments of methods applied in blasting techniques.

Conclusions

Currently we witness the dynamic changes undergoing in the civil application of blasting techniques. Undoubtedly it is difficult to predict future activities and tendencies in this field. However one may be able to observe an intensification of competition on the market and a broadened range of services offered by the companies manufacturing blasting materials. Very likely the present differences in a level of the accessible products and services quality and their prices will become nearly equal. Certainly completely new blasting materials with higher degree of safety with respect to natural hazards existing in mines will be elaborated and introduced to the market. The methods of determi-

nation of safe limits of charges series quantities with non-electric detonators will be further investigated. In order to lessen the harmful effects of blasting works, the extensive use of the vibration monitoring facilities can be expected. Perhaps in the future the electronic initiation system will turn out to be a modern alternative for non-electric detonators.

LITERATURE

[1] *Batko P.*, *Morawa R.*: Business and Engaged in Running and Blasting Works in Pits. Kwartalnik Górnictwo i Geoinżynieria, z. 3/1.Wydawnictwa AGH, Kraków 2004.

[2] *Batko P.*: Selected Problems of Blasting Techniques in the Economy. Kwartalnik Górnictwo i Geoinżynieria, z. 3/1.Wydawnictwa AGH, Kraków 2004.

[3] *Biessikirski R.*, *Kamiński Z.*, *Winzer J.*: Preventive Measures Taken by Open Mines Towards Blasting Effecting the Environment. Conference: Blasting Techniques in Mining. ART-TEKST, Jaszowiec 2001.

[4] *Biessikirski R.*, *Sieradzki J.*, *Winzer J*,: The On – Site Mine Vibration Monitoring Facility. Conference: Blasting Techniques in Mining. ART-TEKST, Jaszowiec 2001.

[5] *Biessikirski R.*, *Winzer J.*: New Solutions in Organization of Blasting Works in Open Mining. Kwartalnik Górnictwo i Geoinżynieria, z. 3/1.Wydawnictwa AGH, Kraków 2004.

[6] *Hebda A.*, *Kawalec P.*, *Kozioł W.*, *Lewicki J.: Professional Risk in Open Pits Mines*. Biblioteka Szkoły Eksploatacji Podziemnej, Kraków 2004.

[7] *Krzelowski J.*, *Szulik A.*: On the Usage of Explosives in Mines. Kwartalnik Górnictwo i Geoinżynieria, z. 3/1.Wydawnictwa AGH, Kraków 2004.

[8] *Onderka Z.*, *Sieradzki J.*: Environmental Effect of Blasting in Open Mines – the Actual State of the Art and Recommendations for Future Investigations. Kwartalnik Górnictwo i Geoinżynieria, z. 3/1.Wydawnictwa AGH, Kraków 2004.

[9] *Onderka Z.: Seismic Effect of Blasting – Remarks and Recommendation*. Conference: Blasting Techniques in Mining. ART-TEKST, Jaszowiec 2001.

[10] Rozporządzenie Ministra Gospodarki, Pracy i Polityki Społecznej z dnia 1 kwietnia 2003 roku w sprawie przechowywania i używania środków strzałowych i sprzętu strzałowego w zakładach górniczych (Dz.U. Nr 72, poz 655).

[11] Ustawa z dnia 21 czerwca 2002 roku o materiałach wybuchowych przeznaczonych do użytku cywilnego (Dz.U. Nr 117, poz 1007).

[12] Norms: PN-85/B-02171 i PN-88/B-02170.