GOSPODARKA SUROWCAMI MINERALNYMI

Tom 24 2008 Zeszyt 4/2

KAZEM ORAEE*, A.H. BANGIAN**, A. PARHIZKAR***

Economical modeling for identification of best drilling choice in sublevel stoping

Introduction

Basically in mining, extraction by the lowest possible cost and the highest production rate are the most important items for decision making of production planning. Also in sublevel stoping method, which is one of the most useful hard-rock underground mining methods, it is possible to execute several productions drilling systems depend on geometry of ore body. Therefore in order to apply sublevel stoping, economical consideration to compare viable production drilling is essential to identify the best choice. In this paper with respect to the mentioned idea, first sublevel stoping method is described in brief and after that economic comparison of different drilling systems. In the next stage the criteria of drilling systems of economic comparison is discussed. Consequently economic comparison of drilling system of sublevel stoping is analyzed on account of a wide range hypothesize production block designations, in different thicknesses of ore body and heights of production block. As a result, amount of dissimilar production costs identify the best drilling choice. Consequently mathematical model is developed based on the out puts from designations. The variables are thickness of ore body and height of production block. The output is dissimilar production cost of each drilling choice. Therefore for identification of best drilling choice in feasibility study the model is fruitful for primary estimations.

* Stirling University, Sterling, UK.
** Islamic Azad University - Tehran South Branch, Mining Engineering dpt., Tehran, Iran.
*** Islamic Azad University - Science & Research branch, Tehran, Iran.

1. Sublevel stoping method in brief

Sublevel stoping is one of the most appropriate underground mining methods of steeply dipping hard-rock ore bodies. Herein mining method existence of a high plunge length in the ore body is essential. It provides required geometrical form to create gravitational ore flow from end point of production sublevel drifts to draw points in open stopes. Also this condition there is chance of loading up to 80% of the broken ore without remote controls (Jimeno, 1995). As a result; following development of production sublevel drifts, production drilling, charging and blasting, the blasted ore is prepared to load in draw points in the bottom of an open stope. So, the operation will have higher performance to existence of the over 70 degrees dip rate of the major dimension of the ore body. Sublevel stoping is practical to apply in ore bodies which have competent hanging and foot wall rock. Furthermore the ore has to be in a stable situation. Lowest rate of essential compressive strength of the rock walls to apply sublevel stoping is 55 MPa normally. Also sublevel stoping doesn't have a limitation in deep rate. Up to now sublevel stopping method has been applied in depth about 900 m under the surface. In ore bodies which have over 6 m width range, appropriate geometrical form is create to utilize drilling and blasting pattern with high production rate.

Uniformity and regularity in boundaries, dip tendency, shape, width and grade distribution is an essential supposition to choose sublevel stoping method for an ore body. Therefore the implementation selective mining in this method is impossible. Also ideal planning is necessary to smooth production rates. Initial recovery of ore in a stope or pillar block is from 35% to 50% in this method in general (Mann 1998). As above mentioned, production activities of sublevel stoping method is summarized to achieve production drilling, charging and blasting and then just loading of blasted ore in draw points. Therefore the most effective stage on production rate in sublevel stoping sequences would be type of drilling system. In other word the main influential operation stage to define production rate and economical result in a period of time could be associated to select type of drilling system.

Ring drilling and parallel drilling are two main drilling systems in sublevel stoping which have high level productivity. In Figure 1 a schematic illustration of ring drilling pattern has been demonstrated in an open stope (Fig. 1A). In this style of production drilling, blast holes are drilled on a ring pattern in ore body from the endpoint of each production sublevel drift to around the drift in a radial form. Mechanized hydraulic Ring drill rig is the most fitting drilling equipment in this regard. Common diameter of blast holes in ring drilling system are between 48–64 mm with lengths up to 25 m. Longholes don't generally exceed 25 m because hole deviation and manage turn into big problems (Mann 1998). The performance of the drilling system in this respect is between 120–180 m in a shift. Also the production range of drilling and blasting in this case would be between 1.5–2.5 cubic meters ore per drilled meter (Gertsch, Bullock 1998). In each blasting 3 or 4 rows are blasted generally. Blast hole spacing is unlike in collars and ends but burden is regular.

Parallel drilling system is the recent production drilling pattern of sublevel stoping which is performed by high pressure DTH jumbos. Extending of the endpoint of a production drift is

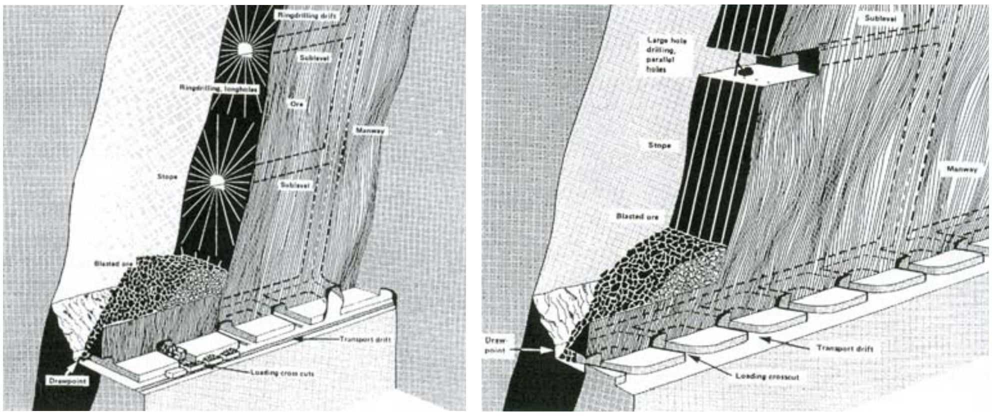

Fig. 1. Schematic illustration of A (left): ring drilling, B (right): parallel drilling

Rys. 1. Ilustracja schematyczna A (z lewej): wiercenie pierścieniowe, B (z prawej): wiercenie równoległe

the first stage to implement Parallel drilling system. If so production drift's sides are excavated in width up to thickness of the ore body. Blast holes diameter in parallel drilling is between 105–165 mm with lengths up to 90 m. The performance of the drilling system in this respect is about 50 m in a shift. Also ore production range of drilling and blasting related hole lengths is between 8–18 m^3/m (Fig. 1B).

In this case blast holes are drilled in bottom of the production drifts downward to draw points. In general the inclination of blast holes equals the maximum dip of the ore body. Large diameter Longholes with large scale blasting have been specified in this drilling pattern. This specification is the main cause to appear mass production in sublevel stoping method. Production drifts distance in a vertical alignment in order to implement this system is over 50 meters commonly. Although excavation of one production drift at the top of the open stope is a typical designation. In this case length of the blast holes is defined as the distance of bottom of a production drift to undercutting space. Therefore by execution parallel drilling system, development of production drifts gets the lowest doable cost rate. Also spacing and burden of blast holes regarding large diameter in parallel pattern get to the largest possible range in underground production drilling. Therefore total length of the holes in an open stope reaches to least amount achievable rate. In order to application of high pressure DTH jumbos, economical condition of sublevel stoping has been changed in the recent decades. Regarding appearance this convenience sublevel stoping has been found more attractive application.

Furthermore there are some other type of long hole drilling pattern which have created of combined parallel and ring drilling properties as underhand fan drilling by DTH jumbos. As a case in El Soldado mine underhand fan pattern has been implemented with blast holes' diameter 165 mm and length 80 m by DTH system (Contador, Glavic 2001). High pressure DTH hammers in parallel drilling system have the highest rate of drilling's accuracy. Inaccuracy of this equipment is less than 2% up to 120 m hole length of the blast hole in general (Haycocks, Aelick 1992).

2. Economic Comparison of drilling systems

One of the most important stages in sublevel stoping decision making processes is selection of the best alternative of drilling system. Whereas ring and parallel drilling systems are the most effective drilling methods in sublevel stoping in productivity and mechanize ability views, in this paper economic consideration has been performed on just two systems. The economic consideration has been executed basis of a typical range of assumed ore body different thicknesses and hypothesized different possible heights of a production block.

2.1. The criteria of economic comparing of drilling systems

Whereas most costs of the execution of sublevel stoping designations are similar, such as; opening of mine, development of accesses and main haulage levels, development of stopes, loading in draw points and hauling in transportation levels, these costs are not effective on economic differences between different designations. Hence just dissimilar costs such as; production sublevel drifts' development, production drilling and amount of explosives, have been considered regarding economic comparison consideration in this paper.

2.2. Procedure of Economic comparison

Regarding economic comparison on the basis of the dissimilar costs of implementation of sublevel stoping designations, three category of cost would be considered as bellow:

— production sublevel drifts development cost,
— production drilling cost,
— consumable explosives cost.

Therefore due to calculation of the total dissimilar cost of each drilling system, the total cost of each production block on the basis of both ring and parallel drilling would be calculate according to 'equation (1)':

$$P = C / V \tag{1}$$

In equation (1) where P is the total dissimilar production costs per in situ ore volume unit, C is the total dissimilar production costs of a production block and V is the total volume of in situ ore in a production block. Further to description of the above mentioned criteria, three indexes are described as economic comparison indexes between ring and parallel drilling systems in each production block as follow:

— production block dimensions,
— drilling and blasting pattern,
— total Dissimilar costs.

Respecting consideration of economic comparison basis of dissimilar, production block dimensions would be assumed as Table 1 explanation.

TABLE 1

Production block dimensions explanation

TABELA 1

Objaśnienie wymiarów bloku produkcyjnego

Block dimensions	Description	Typical range [m]
Length	Horizontal distance between slot raise and access raise align length of the stop	90
Width	Horizontal distance between boundaries of hanging wall and footwall	10–40
Height	Vertical distance between bottom of crown pillar and stop undercut	30–90

Drilling and blasting pattern would be designed on the basis of a typical pattern (Pugh, Rsmussen 1982). The explanation of the pattern is described in Table 2 and Table 3 regarding ring and parallel drilling systems. In all tables for preventing to cover big space by the name of drilling equipment, the abbreviation Ring drilling J. instead of Ring drilling jumbo and HP DTH J. instead of high pressure DTH Jumbo have been applied.

TABLE 2

Typical drilling/blasting pattern design for ring drilling

TABELA 2

Projekt typowego rozplanowania wierceń/robót strzelniczych dla wierceń pierścieniowych

Parameter	Description	Unit
Hole diameter	51	mm
Drilling rig type	Ring drilling J.	–
Production drift cross section	3×3	m
Vertical distance between sublevels	12	m
Horizontal distance between production drifts	Min 6	m
Hole length	Max 24	m
Spacing in front holes	Min:0.1, often:0.5	m
Spacing in end holes	Max 2.5	m
Burden	1.5	m
Hole dip	Max 10 along stope slot	degree
ANFO consumption	1.9	Kg/m of hole
Primer consumption	0.14	Cartridge/m of hole
Cordtex consumption	1.5	m/m of hole

TABLE 3

Typical drilling and blasting pattern design for parallel drilling

TABELA 3

Projekt typowego rozplanowania wierceń / robót strzelniczych dla wierceń równoległych

Parameter	Description	Unit
Hole diameter	152	mm
Drilling rig type	HP DTH J.	–
Number of production drifts per stope	1	–
Height of production drifts	4	m
Width of production drifts	Stope width	m
Hole length	Max 120	m
Spacing	4	m
Burden	3.7	m
Distance between last hole and hanging wall/footwall	1.4	m
Number of additional holes in slot	2	–
ANFO consumption	13.88	Kg/m of hole
Primer consumption	12	Cartridge/m of hole
Cordtex consumption	2.5	m/m of hole

The principle of cost calculation is assumed basis of a typical model (Pugh, Rsmussen 1982) according Table 4.

TABLE 4

Costs determination, based on SME values in $US

TABELA 4

Określenie kosztów na podstawie wartości SME w $US

Parameter	Description	Unit
Production drift development, 3×3 m	12.75	$\$/m^3$
Production drift development, 4 m height	12.3	$\$/m^3$
Drilling, 51 mm diameter, ring	2.95	$/m
Drilling, 152 mm diameter, parallel	8.2	$/m
ANFO	265	$/ton
Primer	1.25	$/cartridge
Cordtex	1.64	$/m

The ore body geometry parameters as regards consideration of economic comparison on the basis of the execution of high performance ring and drilling systems would be assumed as follow:

— thickness of ore body: 10 to 40 m,

— dip of ore body (dip of the biggest alignment of the ore body) : 90°.

Thickness and Dip of ore body is hypothesized basis of achievement high performance sublevel stoping production rate. Due to consideration of economic comparison in various geometrical conditions of ore body and stope designation, calculation of the costs has been carried out on the basis of the detail which is explained in Table 5. Height of the production block due to economic comparison consideration is assumed like vertical distance between crown pillar and sill pillar. Regarding to deduction of under cutting space elevation from the vertical distance between mentioned pillars, the fit range of elevation to get high performance production rate is supposed equal 35 to 90 m according to Table 5.

TABLE 5

Project of the economic comparison of ring and parallel drilling systems as compared with variation of thickness of ore body and height of production block

TABELA 5

Projektu porównania ekonomicznego systemów wierceń pierścieniowego i równoległego w zależności od zmienności grubości złoża rud i wysokości bloku produkcji

Thickness of ore body [m]	Height of production block [m]	Drilling system	Number of stages of economic comparison	Number of economic results
10	30,40,50,60,70,80,90	R1,P	7	14
15	30,40,50,60,70,80,90	R1,P	7	14
20	30,40,50,60,70,80,90	R1,R2,P	7	14
25	30,40,50,60,70,80,90	R1,R2,P	7	14
30	30,40,50,60,70,80,90	R1,R2,R3,P	7	14
35	30,40,50,60,70,80,90	R1,R2,R3,P	7	14
40	30,40,50,60,70,80,90	R1,R2,R3,P	7	14
Total stages			49	147

In all tables, abbreviations are as follow:

P: Parallel drilling, R_1: Ring drilling with one production sublevel drift, R2: Ring drilling with two production sublevel drift, R3: Ring drilling with three production sublevel drift

As it's showed in Table 5 to achieve high range required data to carry out economic comparison between drilling systems, 147 stopes have been designed basis of hypothesized dimensions of stopes. In this section Designation of thickness 35 m and height 90 m are presented as a sample.

In Figure 2 the pattern of ring drilling respecting thickness: 35 m, height: 90 m in a vertical cross section view has been illustrated. In this hypothesized stope due to large thickness of assumed ore body it is possible to excavate 1, 2 or 3 production drifts in each sublevel.

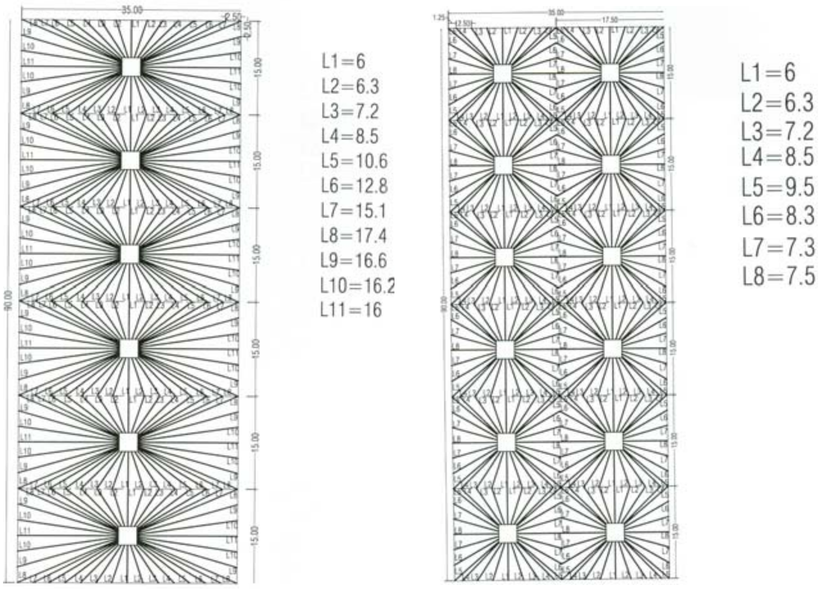

Fig. 2A (left): ring drilling pattern (vertical cross section) in Thickness 35 m and height 90 m with 1 production sublevel drift, B (right): ring drilling pattern with 2 production sublevel drifts

Rys. 2A (z lewej): wiercenie pierścieniowe (przekrój pionowy) o grubości 35 m i wysokości 90 m z 1 produkcyjnym chodnikiem podpoziomowym, B (z prawej): wiercenia pierścieniowe z 2 produkcyjnymi chodnikami podpoziomowymi

In all figures L_1, L_2, L_3,… indicate length of the holes which are illustrated in a vertical cross section on the basis of meter unit. In Figure 3 the ring drilling pattern with 3 production drift in each sublevel (vertical cross section) and parallel drilling pattern (horizontal longitudinal section) with respect to Thickness 35 m, height 90 m and Length of stope 90 m has been illustrated.

In Table 6 the final results of designation and calculation of designed stopes in thickness 35 m, height 90 m and length 90 m have been mentioned. Following designation of the hypothesized stopes and running calculations, final results have been showed. In fact these results are required data to reach economic comparison result between drilling systems.

In the next stage of economic comparison basis of comparison of possible designations results in each assumed thickness of ore body and height of production block, 49 comparing geometrical condition is resulted. In each comparing condition with respect to specific height and thickness possible drilling systems are seen. Also the amount of dissimilar cost of viable

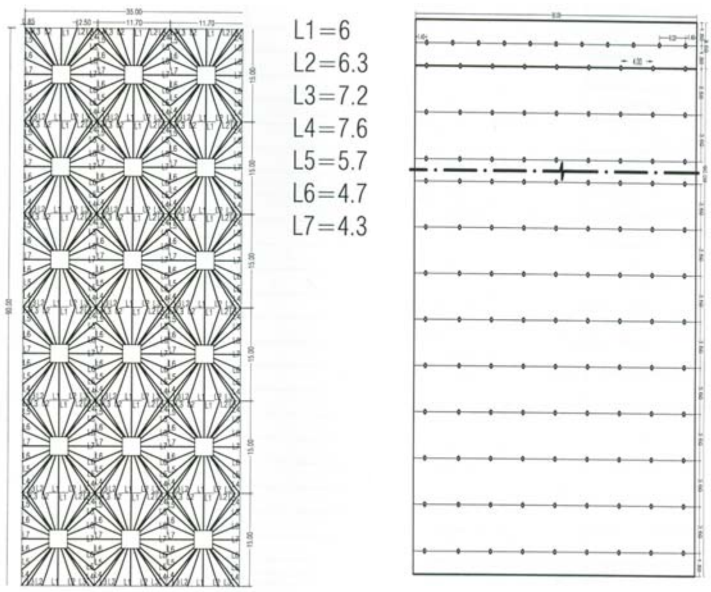

Fig. 3A (left): ring drilling (vertical cross section) in thickness 35 m and height 90 m with 3 production drift in each sublevel, B (right): parallel drilling (horizontal longitudinal section), Thickness 35 m and length of stope 90 m

Rys. 3A (z lewej): wiercenie pierścieniowe (przekrój pionowy) o grubości 35 m i wysokości 90 m z 3 produkcyjnymi chodnikami na każdym podpoziomie, B (z prawej): wiercenie równoległe (przekrój poziomy podłużny), grubość 35 m i długość przodka 90 m

TABLE 6

Economic comparison of drilling systems in thickness 35 m, height 90 m

TABELA 6

Porównanie ekonomiczne systemów wierceń o grubości 35 m, wysokość 90 m

Parameter	R1	R2	R3	P	Unit
1	2	3	4	5	6
Number of production drifts in each stope	6	12	18	1	–
Vertical distance between sublevel drifts	12	12	12	–	m
Number of production drifts in each sublevel	1	2	3	1	–
Horizontal distance between sublevel drifts	–	14.5	8.7	–	m
Production drift Cross section	3 × 3	3 × 3	3 × 3	4 × 35	m^2
Length of each production drift	90	90	90	90	m
Total internal volume of production drifts	4 860	9 720	14 580	12 600	m^3
Cost of excavation of production drift	12.7	12.7	12.7	12.3	$/$m^3$
Total cost of excavation of production drifts	62 000	123 400	185 200	155 000	$
Hole diameter	51	51	51	152	mm
Drilling rig	Ring Drilling J.			HP DTH J.	–

TABLE 6 cont.

TABELA 6 cd.

1	2	3	4	5	6
Spacing	0.2–2.5	0.4–2.5	0.2 – 2.5	4	m
Burden	1.5	1.5	1.5	3.6	m
Number of holes in a stope	14 400	20 200	25 900	227	–
Length of holes	6–17.5	6–9.5	4.3–7.6	86	m
Total length of holes in a stope	175 320	156 000	158 400	19 500	m
Cost of production drilling	3	3	3	8.2	\$/m
Total cost of production drilling in a stope	517 000	468 000	475 000	16 000	\$
ANFO consumption	328	292	296	271	Ton
Primer consumption	25 070	22 320	22 660	2 720	Cartridge
Cordtex consumption	270 000	240 000	244 000	48 800	m
Total cost of explosives	561 000	499 500	507 000	155 000	\$
Total costs	1 140 000	1 091 000	1 167 200	470 000	\$
Volume of extracted ore from excavation of drifts	4 860	9 720	14 580	12 600	In situ m^3
Volume of blasted ore	278 640	273 780	268 920	270 900	In situ m^3
Total volume of extracted ore	283 500	283 500	283 500	283 500	In situ m^3
Cost of extraction	4	3.8	4.1	1.7	\$/m^3

drilling system due to \$US/m^3 of in situ ore is seen to create simple situation of comparing of executions (Tab. 7).

TABLE 7

Results of designing with different ore body and production block's condition

TABELA 7

Wyniki projektowania z różnymi zasobami rud i warunkami bloku produkcji

Dissimilar cost [\$US/m^3)]				Height [m]	Thickness [m]
P	R_3	R_2	R_1		
1	2	3	4	5	6
2.9	–	–	3.7	30	10
2.5	–	–	3.7	40	10
2.3	–	–	3.9	50	10
2.1	–	–	3.7	60	10
2	–	–	3.7	70	10
1.9	–	–	3.8	80	10
1.9	–	–	3.7	90	10
2.7	–	–	3.5	30	15
2.3	–	–	3.6	40	15

TABLE 7 cont.

TABELA 7 cd.

1	2	3	4	5	6
2.1	–	–	3.8	50	15
2	–	–	3.5	60	15
1.9	–	–	3.6	70	15
1.8	–	–	3.7	80	15
1.7	–	–	3.5	90	15
2.8	–	3.7	3.6	30	20
2.5	–	3.7	3.6	40	20
2.2	–	3.9	3.7	50	20
2.1	–	3.7	3.6	60	20
2	–	3.7	3.6	70	20
1.9	–	3.8	3.6	80	20
1.8	–	3.7	3.6	90	20
2.8	–	3.9	3.7	30	25
2.4	–	4	3.8	40	25
2.2	–	4.1	3.9	50	25
2	–	3.9	3.7	60	25
1.9	–	3.9	3.7	70	25
1.82	–	4	3.8	80	25
1.8	–	3.9	3.7	90	25
2.7	–	3.5	3.8	30	30
2.3	–	3.6	4	40	30
2.1	–	3.8	4.1	50	30
1.9	–	3.5	3.8	60	30
1.8	–	3.6	3.9	70	30
1.8	–	3.7	4	80	30
1.7	–	3.5	3.8	90	30
2.7	4.09	3.8	4	30	35
2.3	4.13	3.9	4.2	40	35
2.1	4.29	4	4.3	50	35
1.9	4.09	3.8	4	60	35
1.8	4.11	3.9	4.1	70	35
1.72	4.22	4	4.2	80	35
1.7	4.09	3.8	4	90	35
2.7	3.78	3.6	4.2	30	40
2.4	3.84	3.6	4.4	40	40
2.14	3.98	3.7	4.5	50	40
2	3.78	3.6	4.2	60	40
1.9	3.8	3.6	4.3	70	40
1.8	3.91	3.7	4.4	80	40
1.7	3.78	3.6	4.2	90	40

Regarding creation of final result relating to dissimilar cost of execution of the doable drilling system, comparing of drilling systems would be possible in unlike thickness range of ore body. Therefore essential material to select 1st, 2nd and 3rd choices has been obtained (Tab. 8). According Table 8 in all thickness range of ore body, parallel drilling with the lowest cost rate is the 1st choice. Also it is realized that 2nd choice in different thickness up to 30 m would be ring drilling pattern with 1 production sublevel drift. As well in thicknesses over 30 m ring drilling with 2 production sublevel drift would be 2nd alternative.

TABLE 8

Selection of preferences on drilling choice in different thicknesses

TABELA 8

Wybór preferencji wierceń w różnych miąższościach

Thickness [m]	1st choice	2nd choice	3rd choice	4th choice
10–20	P	R_1	–	–
20–30	P	R_1	R_2	–
30–35	P	R_2	R_1	–
35–40	P	R_2	R_1	R_3
40	P	R_2	R_3	R_1

3. Mathematical modeling

In order to generate an economical model for identification of best drilling choice, the below procedure was applied. This procedure was extracted from the applied economical comparison method and its final results. Height of stope and thickness of ore body are two variables in the model. The objective outcome from the model is dissimilar cost per volume unit of the in-situ ore for each drilling choice. Thus on the basis of the data from economical comparisons between drilling choice in each specific condition of height and thickness, statistical analysis is achieved. Therefore through regression technique required mathematical function is produced. The best fitting on the experimental data was created from nonlinear multiple regression curves. Distribution of the data is an effective item to fit the best regression curve. Accordingly for each equation, an Index of determination (r^2) is concluded which identifies fitting ratio of each curve. Index of determination (r^2) varies between; 0 to 1. The closest Index to 1 shows the best fitting of the regression curve on actual data distribution.

In this research regression was performed through statistical software. Between the concluded curves, the best fitting of each condition has been demonstrated in Table 9. In this table where C_{R1}; cost of ring drilling with one production drift in each sublevel, C_{R2}; cost of ring drilling with two production drifts in each sublevel, C_{R3}; cost of ring drilling with three production drifts in each sublevel, C_P; cost of parallel drilling, r^2; Index of Determination, H; height of production block, T; thickness of ore body.

TABLE 9

Mathematical model for identification of dissimilar cost for drilling choice in different condition of thickness of ore body and height of production block

TABELA 9

Model matematyczny identyfikacji różnych kosztów wyboru wiercenia w różnych warunkach miąższości pokładów rud i wysokości bloku produkcji

Thickness range [m]	Regression Equation	r^2
10–40	$C_{R1} = 4.0659183 - (3.877 \cdot 10^{-4})\, H - (4.65884 \cdot 10^{-2})\, T + (1.37483 \cdot 10^{-3})\, T^2$	0.87
20–40	$C_{R2} = 3.251142 - (2.142 \cdot 10^{-4})\, H + (4.59143 \cdot 10^{-2})\, T - (8.857 \cdot 10^{-4})\, T^2$	0.13
35–40	$C_{R3} = 5.15333 - (7.1429 \cdot 10^{-5})\, H - (8.1904 \cdot 10^{-4})\, T^2$	0.82
10–40	$CP = 3.171173 - (1.57551 \cdot 10^{-2})\, H - (4.561 \cdot 10^{-3})\, T$	0.88

In order to estimate dissimilar production cost of each drilling method for choosing the best drilling choice, the model primarily is suitable for economical calculation. The calculation is executed based on each specific thickness of ore body and height of production block. Therefore by the model dissimilar cost amount of drilling alternatives is calculated for feasibility studies.

3.1. Verification of mathematical model

For verification of the mathematical model some random data include different thicknesses of ore body and heights of production block were selected. Consequently the amounts of dissimilar cost of production were extracted from the results table. Also the same costs were calculated through mathematical model. Then the actual data and estimated date were compared and adaptation ratio was calculated. According to Table 10 adaptation ratio is between 96.64 to 100.20 percent.

Conclusion

According to reached results it was proved that method of production drilling is effective on sublevels development, drilling rate and explosive consumption costs. thus as to existing high performance production rate of ring and parallel drilling systems against to other conventional drilling system of sublevel stoping, economical comparison is included just mentioned drilling systems. Concerning ring drilling system, optimum length of blast holes and number of production sublevel drifts are the most sensitive parameters relating to cost

TABLE 10

Verification of the mathematical model based on some random data consist of different thicknesses of ore body and heights of production block

TABELA 10

Sprawdzenie modelu matematycznego na podstawie niektórych danych losowych obejmujących różną miąższość pokładów rud i wysokości bloku produkcji

Thickness [m]	Height [m]	Model	r^2	Cost from model [$/m^3]	Cost from design [$/m^3]	Adaptation ratio [%]
10	30	C_{R1}	0.87	3.726	3.71	100.43
25	70	CR1	0.87	3.733	3.74	99.81
20	80	C_{R2}	0.13	3.798	3.84	98.91
35	60	C_{R2}	0.13	3.760	3.82	98.43
40	40	C_{R3}	0.82	3.839	3.84	99.97
35	50	C_{R3}	0.82	4.146	4.29	96.64
10	40	C_P	0.88	2.495	2.49	100.20
40	40	C_P	0.88	2.358	2.36	99.94

effectiveness. Finally main results respecting economical comparison of drilling systems of sublevel stoping are as follow:

In full range of an ore body thickness, using parallel drilling is more economical and cost effectiveness. If applying parallel drilling would be impractical due to technical reasons, ring drilling could be second ideal choice. Ring drilling pattern consist of one production drift in each sublevel, is the most cost effective designation in an ore body up to 30 m thickness. In case of an ore body with thickness over 30 m apply ring drilling pattern include two production drifts in each sublevel is the best designation. With the purpose of apply parallel drilling; generally dissimilar production costs are decreased about 45 percent against execute of ring drilling.

The developed mathematical model identifies dissimilar production cost of each drilling alternatives. Therefore on the basis of thickness of ore body and height of production block economical calculation for feasibility study would be viable step.

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MODELOWANIE EKONOMICZNE JAKO SPOSÓB IDENTYFIKACJI WYBORU NAJLEPSZEGO WIERCENIA W WYBIERANIU PODPOZIOMOWYM

Słowa kluczowe

Wybieranie podpoziomowe, system wierceń, model matematyczny

Streszczenie

Wybieranie podpoziomowe jest metodą górnictwa podziemnego, która cechuje się niskim poziomem kosztów produkcji. Również główna część kosztu produkcji jest związana z wybranym systemem wierceń w każdym przodku. Opracowanie modelu identyfikacji najlepszego sposobu wiercenia z ekonomicznego punktu widzenia w każdym przypadku jest głównym celem niniejszego opracowania. Aby opracować ten model zaprojektowano około 150 przzodków wybierkowych pod kątem hipotetycznych wymiarów i rozplanowania. W każdym przypadku obliczono koszt produkcji z tytułu wydobycia jednostki rudy. Opracowano model matematyczny na bazie nieliniowej regresji wydobycia z obliczeń hipotetycznych, które określały koszt produkcji w zależności od grubości złoża rud i wysokości bloku produkcyjnego. Sprawdzenie opracowanego modelu wykonano na niektórych danych losowych, a wskaźnik adaptacji dotyczy stawek akceptowanych.

ECONOMICAL MODELING FOR IDENTIFICATION OF BEST DRILLING CHOICE IN SUBLEVEL STOPING

Key words

Sublevel stoping, drilling system, mathematical model

Abstract

Sublevel stoping is an underground mining method which has a low level of production cost. As well main part of the production cost is related to the chosen drilling system in each stope. Developing a model for identification of best drilling choice through economical point of view in each case is the main objective of this paper. In order to develop the model about 150 stopes have been designed by hypothesized dimension and pattern. In each case production cost on account of the extracted ore unite has been calculated. A mathematical model was developed on the basis of the non-linear regression on out puts from calculation of the hypothesized designations which provides production cost based on thickness of ore body and height of production block. Verification of the developed model has been carried out on some random data and the adaptation ratio is on acceptable rates.