ISSN (online): 2349-784X

Parameter Affecting Blast Hole Drilling in Coal Mines

Harsh Wardhan Bhatia
Department of Mining Machinery Engineering
Indian School of Mines, Dhanbad

Tripti Sahu
Department of Electrical Engineering
Indian School of Mines, Dhanbad

Abstract

This paper deals the monitoring of blast hole drilling which can be used to measure drilling parameters and the difficulties encountered when using various condition. The analysis inspect the technologies used before, during, and after drilling rotary rig operation which shape everything into accounts productivity results. The research also reviews the parameter as well as reasons to increase efficiency of drill and where the industry is headed in the future. When there is a difference in drilled hole diameter or fragmentation detailing, changes in the blasthole design parameters are required affecting the cost of a drilling operation. Finally, the paper provides information aimed at resolving a problem for analysts and modelers when it is applied to make more efficient drilling operation.
Keywords: Blast Hole Drilling, Penetration Rate, Specific Energy, Drill Bit, Rotary Speed, Rock Characteristics

I. INTRODUCTION

Blast hole drilling is an essential part of production process in mining as well as civil engineering. As we see today, has developed through need. For all the years in the past, the needs were ever increasing and in future also their trend will remain increasing. The need of drilling holes in the ground existed in prehistoric times, in those days mining activities certainly excited but the ore was excavated. Blast holes are obviously drilled for charging them with different types of explosive and eventually firing them, so a different occurs and formation is fragmented. In this paper many more terms related to blast hole drilling and surroundings have been described with relevant illustrations wherever possible.

Drilling process can commence, continue, and complete only when the following essential technical requirements are fulfilled.

- The drilling bit meant for disintegrating the formation must be sufficiently hard so that it formation must be sufficiently hard so that it disintegrates the formation over long period of time to form small cuttings.
- The cutting formed in the process of formation disintegration must be taken out of the hole as soon as possible, so they do not waste energy in getting crushed once again.
- The drilling tool must be advanced in the intended direction of the drill hole.
- The walls of the hole, formed a the drilling progresses, must e prevented from collapsing in the hole.
- After completing the drilling to the desired depth, the drilling string formed by drill bit and other accessories must be withdrawn from the hole.

Besides the above technical requirements it is also necessary to fulfill environmental and economic needs. These are,

1) The cuttings of very small size – in the form of dust – generated during the process of drilling, should be prevented from mixing with the atmospheric air and polluting it.
2) The process of drilling should continue at optimum speed so as to keep the cost of operation to bare minimum.

There are many means of fulfilling these requirements. Combination of means to fulfill the essential requirements gives rise th different drilling methods. Obviously, before turning to blast hole drilling methods, it is essential to take a closer look at the means of fulfilling the essential requirements.

II. ANALYSIS OF DIFFERENT PARAMETER

A. Bit load:

In order to drill formation, it is necessary to apply bit load which is above the compressive intensity of the objected stones and rocks. According to the test, the increases ratio of penetration rate by load application shows that when the load is applied within the compressive intensity, the penetration rate increases linearly.

Relation between weight and penetration rate can principally be shown as follows:

$$R = KL^n$$

Where, R = penetration rate
L = Bit weight
K , n = constant determined by kind of stone.

B. Rotary Speed Penetration Rate (Fixed Load):

In the rotary method, a method of drilling with the use of bit rotation, the relation between rotary speed and penetration rate is principally linear as in the following equation:

$$R=KN^n$$

Where, R = penetration rate
K= fixed number by compressive intensity of stones.
N= rotary speed (rpm).
n= fixed number (soft formation =1 & hard formation = 2-3)

C. Vibration of Rotating Drill Pipes:

Vertical self-vibration having affixed circle, and horizontal vibration by wave pressure due to bit resistance and mud water circulation, will be generated, and if both resonate each other, there is danger of the drill pipe breaking due to "bending moment" if the hole diameter is extremely large.
The effect of vibration will be as follows when rotary speed and hardness are constant:
Resonance vibration will be increased when the total length of drill pipes is long.
Compressive stress which effects drill pipe axially reduced number of vibration.
As mud water of high gravity increases its inertia oscillation will be expanded.

D. Optimum Rotary Speed:

The increasing proportion of penetration rates which will be affected by rotary speed in the ratio between adding 2/3 of the increased rotary speed before increased and the rotary speed before increasing rotary speed and penetration rate increases according to such proportion. The standard rotary speed ids about 60 to 80 rpm but there must be higher than standard speed for light weight drilling and lower for heavy weight drilling.

E. Specific energy:

The specific energy is calculated by using the following equation:

$$SE = \frac{2.35 * W * N}{D * P.R} \text{ MJ/m}^3$$

Where, W = wt. on bit (kg)
N = R.P.M of drill rod.
D=diameter of hole (mm)
P.R = penetration rate (m/hr)
Estimation of number of blast hole drilling required

The drilling requirement for a given output of rock can be calculated from the formula $T = \frac{v}{u}$

Where , T= total meter age required to be drilled per 8 hours shift.
V= volume of rock(m^3) to be broken per 8 hours shift.
U=the volume of rock (m^3) broken per m of hole.
i.e. $U = \frac{B * S * H}{D}$; B= burden (m)
S= spacing(m)
H= height of bench (m)
D=depth of blast hole (m).

III. SELECTION OF BITS

The subject which has a bearing on the proper selection of bits for achieving optimum penetration speed and longer bit life centers around the design aspects of the bit and its cutting edge, which in turn depends upon the type and extent of insert wear and the incidence of jamming of bits and rifling of the drill holes.

IV. MATERIAL OF CUTTING EDGE

In blast hole drilling in rocks, the cutting edge of a bit which has no perform the primary function of chipping and crushing is required to be wear resistance so that greater depths could be drilled in hard rocks before re-sharping becomes necessary. The heavy stresses that comes to play on the insert also requires it to be tough enough to resist fatigue. Wear resistance (hardness) and toughness are imparted by including two components like tungsten carbide and cobalt in the carbide insert after due control of the grain size of the former. A combination of these material is so selected that a balance of toughness and wear resistance is achieved to suit the majority of drilling condition which vary from mine to mine and in difference parts of the same mine.

Table – 1
Drills bits are made of steels having a wide range of composition, the typical ones among which are given in table:

Particulars	*Composition percent*						
	C	*Si*	*Wn*	*Cr*	*Ni*	*Mo*	*V*
Type 1	*0.4*	*0.6*	*0.6*	*1.2*	*0.2*	*0.5*	*0.25*
Type 2	*0.25*	*0.2*	*0.5*	*1.2*	*0.3*	*0.25*	*-*
Type 3	*0.3*	*1.4*	*1.3*	*0.3*	*1.8*	*0.4*	*-*

V. FIELD WORK AND ANALYSIS

The following data shown in table are obtained from open cast mine relates to blast hole drilling in coal mines. The purpose of this study was to observe the influence of parameters like weight on bits, rotary speed, specific energy, rock characteristics on penetration rate of a rock roller bit.

Table – 2
Rock characteristics:

Mica	
Bulk density	*2.0-2.6*
Uniaxial compressive strength	*100-1500 (kg/cm^2)*
Co-efficient of internal friction	*0.3-0.5*
Shale	
Bulk density	*2.0-2.6*
Uniaxial compressive strength	*100-1000 (kg/cm^2)*
Co-efficient of internal friction	*0.7-1.0*
Sandstone	
Bulk density	*2.2-2.6*
Uniaxial compressive strength	*300-2500 (kg/cm^2)*
Co-efficient of internal friction	*0.7-1.2*

Table – 3
RIG Specification

Model	*SBSH – 120*
Make	*Russian*
Pull down weight	*20000kg*
Air pressure	*5.8 kg/cm^2*
Compressor	*Screw type*

Table - 4
RILL BIT

Type	*Tricone rock roller bit*
Make	*Widia(India), Limited*
No. of nozzle	*One*
Formation group	*Hard*
Size	*250mm (10")*

Table - 5
For Mica

Sr. no.	*Specific energy*	*R.P.M*	*W.O.B*	*W*R*	*P.R.(m/hr)*
1	*308.991*	*65*	*12390*	*805025*	*24.5000*
2	*320.305*	*70*	*12560*	*878850*	*25.80192*
3	*350.875*	*75*	*13090*	*981375*	*26.30121*
4	*357.421*	*70*	*14510*	*1015350*	*26.71241*
5	*295.181*	*65*	*12960*	*842075*	*26.82612*
6	*375.545*	*70*	*15360*	*1074850*	*26.91258*
7	*357.435*	*65*	*15860*	*1030575*	*27.11111*
8	*343.521*	*65*	*15510*	*1007825*	*27.58671*
9	*439.995*	*80*	*16260*	*1300400*	*27.79015*
10	*480.885*	*85*	*16860*	*1432675*	*28.01325*

Table - 6
For Shale:

Sr. no.	Specific energy	R.P.M	W.O.B	W*B	P.R.(m/hr)
1	218.959	65	15005	975325	41.8711
2	298.7503	90	15005	1350450	42.4911
3	236.0635	70	16005	1120350	44.6121
4	308.7426	90	16405	1476450	44.9521
5	226.1529	65	16705	1085825	45.1321
6	260.4384	75	17005	1275375	46.0321
7	280.4966	80	17405	1392400	46.6621
8	280.6468	80	17455	1396400	46.7711
9	313.6116	85	18405	1564425	46.8911
10	338.2979	85	19905	1691925	47.0121

Table – 7
For Sandstone:

Sr. no.	Specific energy	R.P.M	W.O.B	W*B	P.R.(m/hr)
1	106.5709	50	11000	550000	48.5123
2	113.1911	50	11900	595000	49.412
3	124.5832	55	12400	682000	51.458
4	143.2095	65	12200	793000	52.051
5	133.1688	60	12695	761700	53.7662
6	135.8435	60	12950	777000	53.7663
7	155.9807	65	13900	903500	54.4484
8	175.4066	70	14800	1036000	55.519
9	169.8063	65	15700	1020500	56.492
10	186.4712	70	16100	1127000	56.8120

Table – 8
At constant weight on bit: 15000 kg

Sr. no.	R.R.(m/hr)	R.P.M	Formation
1	26.9125	70	Mica
2	26.9125	65	Shale
3	56.492	65	Sand stone

Table – 9
At constant R.P.M: 70

Sr. no.	W.O.B (kg)	P.R.(m/kg)	Formation
1	15355	26.91258	Mica
2	16000	44.6121	Shale
3	15600	56.8120	Sand stone

VI. ANALYSIS OF RESULTS

A. Rock Characteristics:

The penetration rate depends on the rock characteristics, the main being compressive strength. Figure shows the effect of weight on bit on penetration rate of sand stone, shale & mica. It is found that penetration rate is more in sandstone than shale, and in shale it is more than mica, for a given set of operation parameters. This shows that the penetration rates dependent on weight on bit for different strata.

B. Weight of Bit:

As shown figure, the drilling rate is directly proportional to the weight of bit. The relationship is almost linear. However, bearing life was found to be adversely effected by weight of bit.

C. Rotary Speed:

The effect of rotary speed on drilling rate is shown in figure; the results obtained are in conformity with many researchers. The relationships in linear one. However, the rate of change of penetration with change in rotary speed is found to be more at small value of fixed weight. Suggesting that for better drilling efficiency weight on bit should be reduced at higher rotary speed. So is true for the better life of bit. As the bit life affected by high speed.

D. Specific Speed: (Penetration Rate Vs Specific Energy)

The specific energy first increase, attains a maximum value, and then again starts decreasing. As the specific energy is less at higher value of penetration rate.

E. Penetration Rate Vs Rotary Speed:

Penetration rate increases with increases in rotary speed. But the rate of penetration does not increases as much as in sand stone as in others at the same rotary speed but it decreases with shale & mica. This is due to the fact of the compressive strength of the drilling formation.

F. Penetration Rate Vs Weight of Bit:

Penetration rate increases with the increases in weight of bit. This is because of the fact that the penetration rate increase with the effective load increases on bits. But the bit load is again an influencing parameter for the better performance of the bits. So the bit load should not be increased drastically, although the penetration rate will increases as found by the experiment, but the wearing of bit will be more.

G. Penetration Rate Vs Product of Weight Of Bit & R.P.M:

As found from the data the penetration rate increases with increases in the product of the weight on bit and rotary speed of the drill. The effects is in then included in calculating the specific energy consumption.

VII. CONCLUSION

The present study established that:
1) Penetration rate increases with increases in weight of bits.
2) Penetration rate increases with the increase in the rotary speed of the drill.
3) Penetration rate increases with the increases in the product of weight of bits to rpm.
4) Specific energy consumption increases with the increases in the penetration rate.
5) Penetration rate depends on very much on the compressive strength of the formation over which it has to drill.
6) By increasing the weight on the bit the rotary speed should be lowered.

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