OpenCast Mining

Drilling & Blasting

Learners Guide

Design of Blast in Opencast Mining

There are two types of variables in blasting design

- **Controllable variables**
- **Uncontrollable variables**

Controllable Variables

- Hole diameter
- Hole depth
- Sub grade drilling
- Stemming Distance
- Stemming material
- Burden and Spacing
- Number of holes in the blast
- Direction of movement
- Delay Timing
- Types of Explosives and initiation System

Uncontrollable Variables

- The Variables over which we donot have much control such as geology ,rock-characteristics,and regulations or local specifications (such as distance to the nearest structures)etc.

Burden

In practice,Burden= ½ to 1/3 of bench height

- Burden is defined as the shortest distance to relief at the time of blast.
- Fixing proper burden is one of the most important decisions made in any blast design.
- If the burden is too small,rock is thrown at a considerable distance from the face ,air- blast levels are high and the fragmentation may be excessively fine.

- If the burdens are too large ,severe-back break occurs behind the last row of blast holes.
- Excessive burdens cause over –confinement of blast holes which result in high levels of ground vibration per weight of explosive used.
- Rock breakage can be extremely coarse ,often causes bottom or toe problem, when burden is kept at large.

Spacing

Spacing = 1.0 to 1.5 of Burden

- The distance between adjacent blast-holes ,measured perpendicular to the burden ,is defined as the spacing
- Spacing calculations are a function of burden.
- If spacing are sufficiently less than the burden ,it tends to cause early stemming ejection and premature splitting between blast holes due to rapid release of gases to the atmoshphere ,and result in noise and air blast.

- When the spacings are too large ,the fragmentation of rock may be poor,and may cause an uneven floor
- Consequently ,burden and spacing decisions are made by careful analysis of geology ,explosives condition at the site and experience.

Stemming Distance

Stemming Distance = 0.7 to 1.0 of Burden

- A stemming distance of 0.7 to 1.0 of burden is adequate to keep material from ejecting prematurely from the hole.
- But if the blast is poorly designed ,the above stemming distance may not be adequate to keep the stemming from blowing out.
- A delicate balance exists between no tenough or too much stemming.

- Fly-rock and excessive air blast can be caused when there is not enough stemming
- Too much could lead to excessive vibration and poor fragmentation.

Optimum size of stemming material

- The most common material used for stemming is the drilling cuttings ,since they are economic and conveniently located at the collar of blast site.
- If we want to minimize the stemming distance in order to break cap rock we should use the proper size of stemming material.
- Very fine drilling dust will not hold in the blast hole and is easily ejected; very coarse material tends to bridge the holewhen loading and may be ejected ;round gravel or sand from river will not function as crush stone.

- The optimum size of stemming material would be the material that has an average diameter of approximately **0.05 times** the diameter of the blast hole.
- Material must be granular or function properly ,never use a coarse,large,or sharp rock that could damage the initiating system.
- If the drill holes are wet to the collar ,the use of crushed stone can result better fragmentation and control.

Sub-grade drilling

- Blast holes may not break to full depth ,especially when blastng takes place in dense rock.
- Too much sub drilling is wasteand may cause excessive ground vibration because of the increased confinement.
- Insufficient subdrilling can cause a high bottom ,ultimately causing excessive equipment wear and the need for secondery blasting.
- As per rule of thumb ,sub drill holes depth equal to 20% TO 50% of the burden ie sub grade drilling =0.2 to 0.5 of Burden
- Sub grade drilling J = 0.2 to 0.5 of Burden
- **Sub grade drilling is approximately 0.3 of Burden**

Inclined hole drilling

Advantage of angle drilling

- Less back break
- Les problem at grade ,i.e bench stability is better.
- More throw ,especially on low benches.
- Better fragmentation on low benches.
- Loose rock better held on face by gravity.

Drilling of inclined holes depend mainly on availability of Drilling Machines in the mines

Selection of Blast hole Size and Bench height

- For selection of blast holes size following points to be considered.
- Drilling economies
- The effect of fragmentation
- Air blast ,fly-rock, ground vibration
- The larger diameter of blast holes tend to be more economic ,but would cause more problems with air blast ,fly-rock ,ground vibration and fragmentation

- To gain the best result of blasting with the best fragmentation and the least result of unwanted effects ,the operator would consider the stiffness ratio.
- Stiffness Ratio is the ratio of Bench height to Burden

Stiffness Ratio must be between 2.5 to 4.0

Decking

- The technique of decking is to divide the explosive column into two or more charges .
- This is accomplished by loading inert material such as drill cuttings or crushed stones ,between the explosive charges .
- The purpose of decking is to give confinement of explosive gases where a soft seam/strata or void is encountered ,or to ensure a better energy distribution.

- This technique is also used to to reduce the explosive weight per delay when blasting in an area of vibration constraint .
- The decision is often made upon analysis of scaled distance calculation or analysis of seismic records.

Minimal deck thickness Td= 6times D,Where Td =decking thickness(mm) and D = borehole diameter (mm)

Powder Factor or Explosive Factor

- Powder factor is the mathematical relationship between the weight of explosive(kg) and a given quantity of rock (Cum).

To calculate cubic mt=metres per borehole,the following formula is used:

- V=B*S*H;
- Where B=Burden(m),S =Spacing(m).H=bench height (m)and
- V= rock volume (cubic metres).

- To calculate tons of rock per borehole ,multiply V by the density of rock (tons/cubic meter).

Powder Factor = Quantity of rock broken per kg of explosive.

Explosive Consumption

- The amount of explosive required to break the rock into an average size is called the explosive consumption.
- There are many factors in the value of explosive consumption as the types of rock(rock strength) to be blasted ,geometry &geology of rock ,kind of explosives to be used, size of borehole, delay systems, initiation systems, product size,etc.

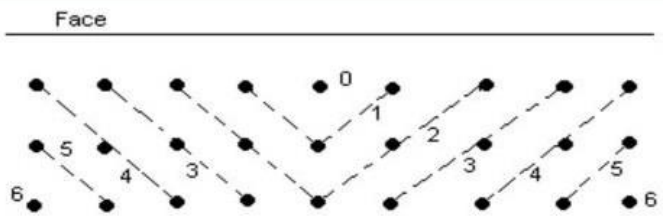
- Blasting with more free face consumes less than blasting with less than free face,loose rock needs less explosive than dense rock and so on.
- In any blasting ,the operators need to try and adjust the amount of explosive to achieve the optimum product size.
- One must consider crushing and grinding cost with blasting cost.
- In some operations ,particularly when blasting inrock,drilling cost also must be considered.

Blast hole initiation system

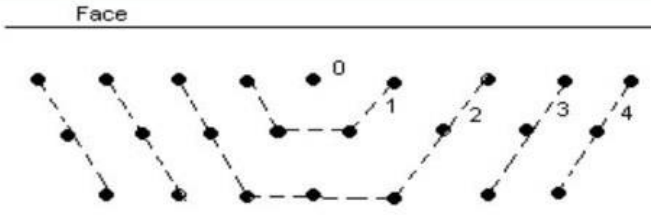
- In this system each charge is given sufficient to break its quota of burden from the rock mass before the next charge of detonates.
- By using proper delay sequence ground vibration,air blast and fly rock are minimized and the fragmentation is increased.
- If sufficient free face is not availabe ,an inner blast hole may crator upward ,resulting in poor fragmentation,little forward displacement ,and increase in the possibility of fly –rock &over-break ,while increasing ground vibration and air blast.

- The delay interval necessary for optimum fragmentation varies with the type of rock and burden distances .
- It appears that delay intervals of more than 8 milliseconds between adjacent holes in a row provides the best result in respect to ground vibration and fragmentation

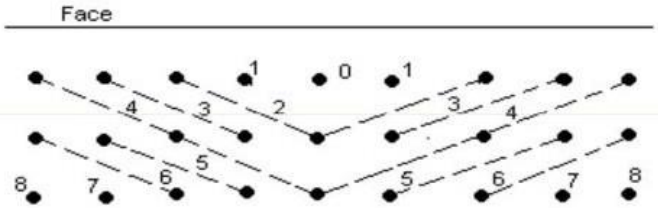
SOME EXAMPLES OF DELAY PATTERN



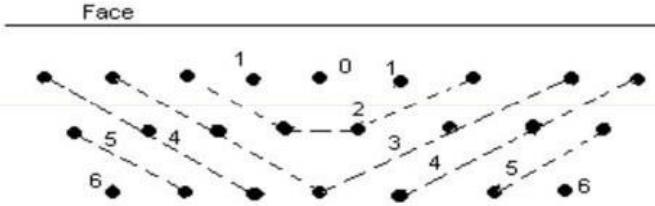
Square 'V'



Staggered 'V'



Square 'V1'



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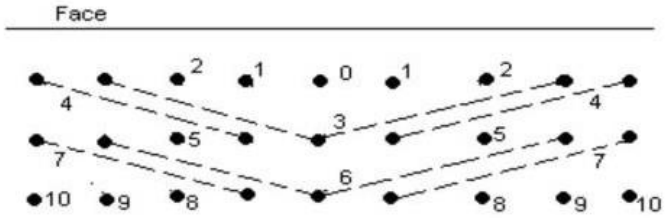
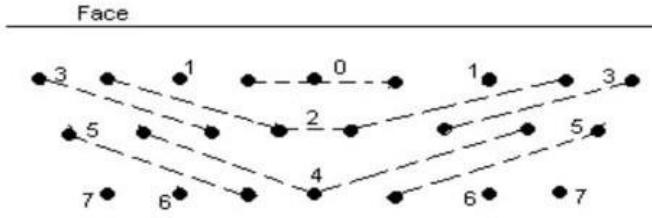


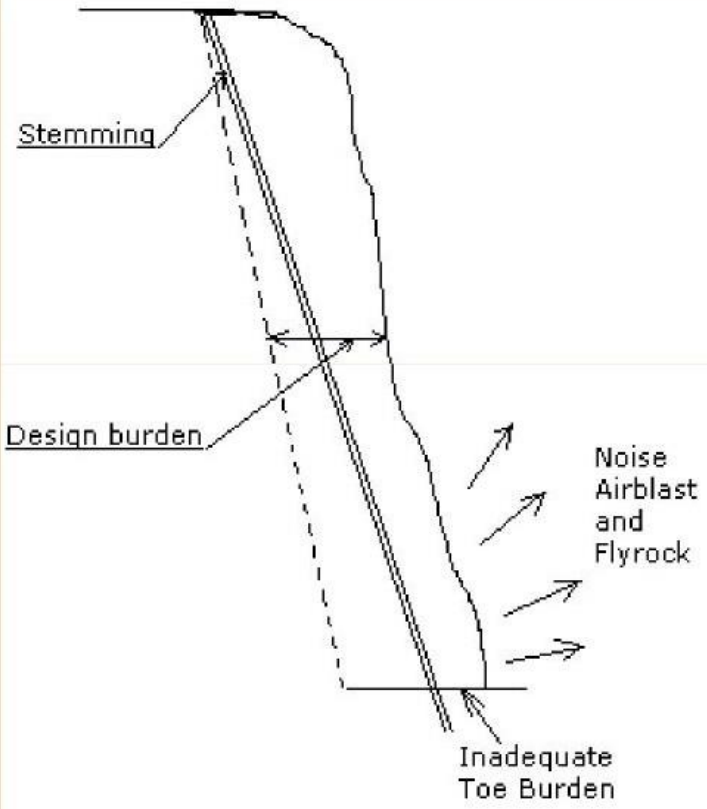
Square 'V2'



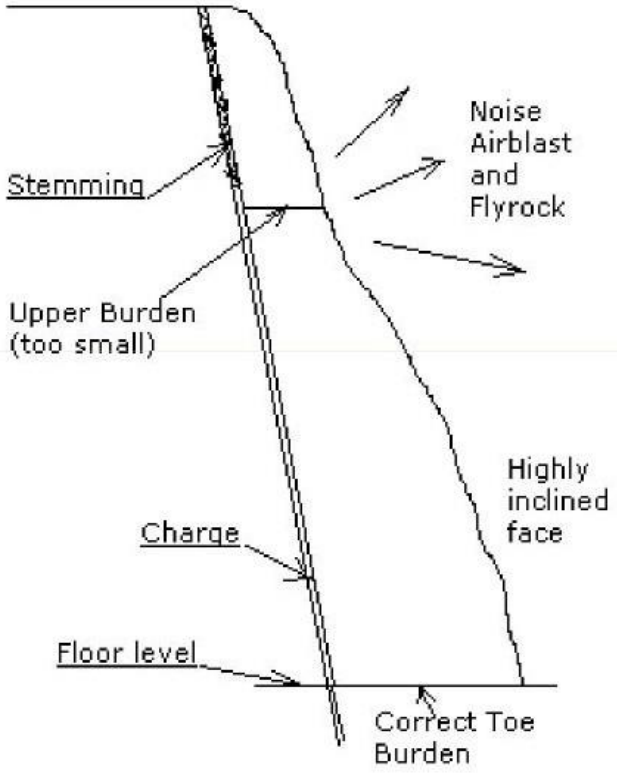
Staggered 'V2'

Blastholes / Initiation patterns for shot fired to an open face

FORMATION OF FLY-ROCK

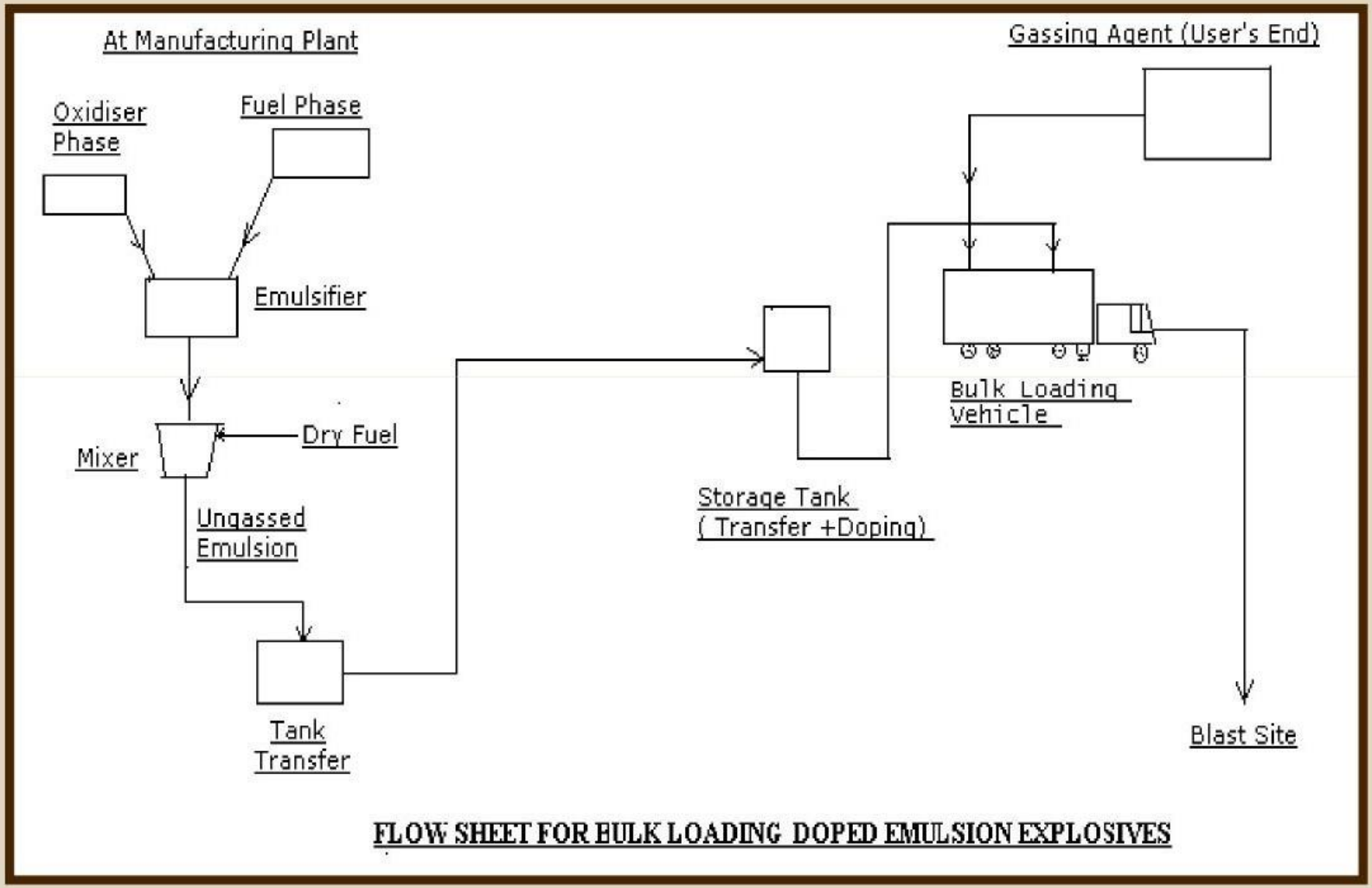


Noise, airblast and flyrock caused by an inadequate toe burden



Noise, airblast and flyrock caused by an upper burden which is too small

FLOW SHEET FOR BULK-LOADING EMULSION EXPLOSIVES



FLOW SHEET FOR BULK LOADING DOPED EMULSION EXPLOSIVES

Summary of Blast Design

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Three Blast Design Keys To Optimum Explosive Performance

1. **The explosive energy must be evenly distributed to achieve uniform fragmentation. This requires:**

- **Proper hole diameter to bench height relationship**
- **Appropriate burden to spacing relationship**
- **Careful implementation of the design**
- **Angle drill in some cases to match existing face conditions**

Summary of Blast Design

Three Blast Design Keys To Optimum Explosive Performance

2. The explosive energy must be confined long enough after detonation to establish fractures and to displace material.

- **The explosive's path of least resistance must be controlled**
- **Blast holes must be loaded according to geology**
- **Use the proper stemming length and stemming material**
- **Match the timing configuration to the existing field conditions**
- **Use accurate delays**

Summary

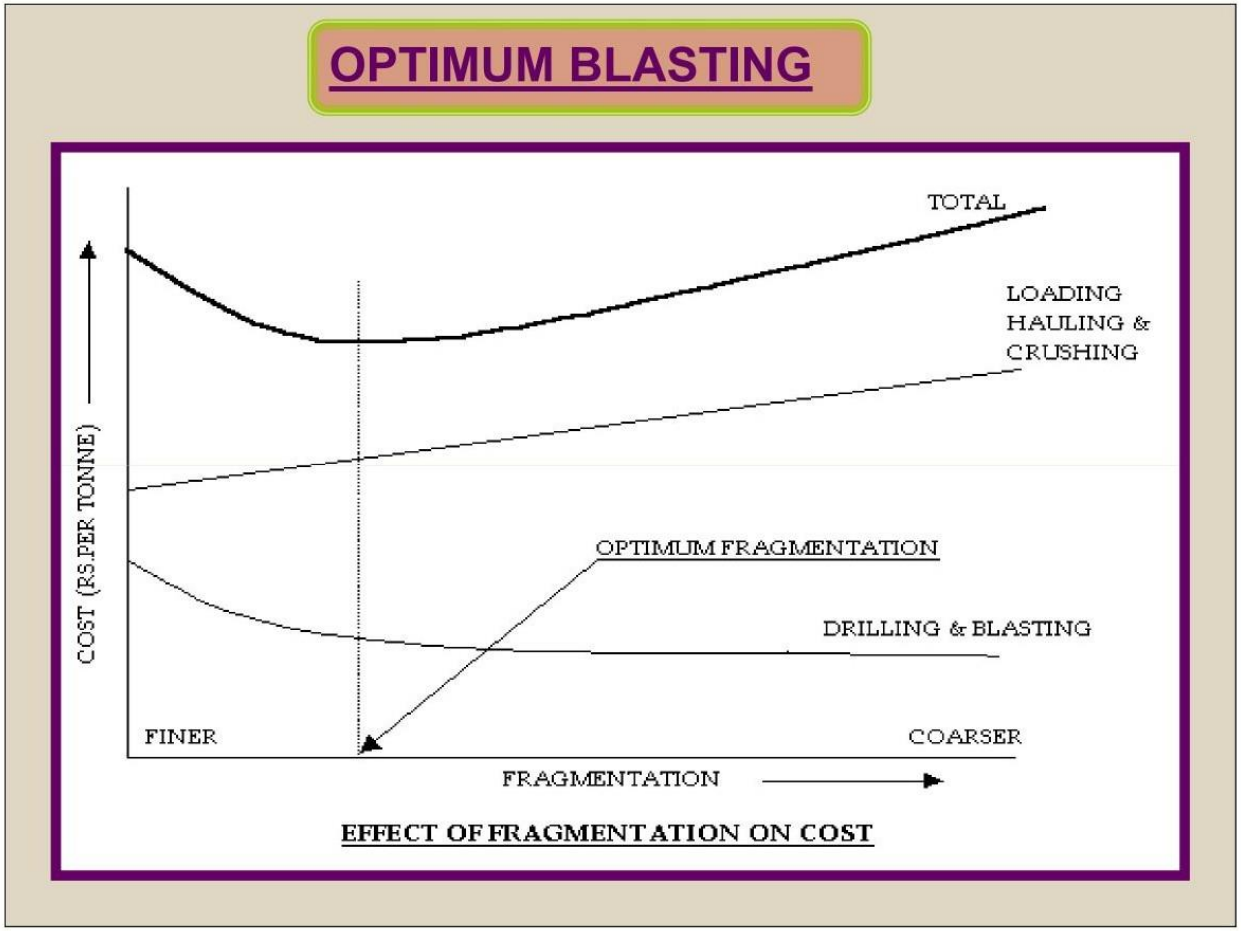
Summary of Blast Design

Three Blast Design Keys To Optimum Explosive Performance

3. The energy level must be sufficient to overcome the structural strength and mass of the rock, while providing controlled displacement.

- **Determine energy level on the degree of fragmentation and displacement required**
- **Account for site sensitivity**
- **Evaluate high energy explosives for special site conditions (i.e. large toes, poor floor)**
- **Maintain explosive quality control with routine testing**

Concept of optimum blasting
Techno economic considerations



OPTIMUM BLASTING

The concept developed by Mackenzie describes the total blasting cost as: $Ct = \frac{Cd + Cb + Cl + \ldots + Cc}{P}$

Where,

Ct = Total blasting cost per tonne of finished product,

Cd = Cost of drilling , Cb = Cost of blasting,

Cl = Cost of loading, Ch = Cost of Hauling,

Cc = Cost of Crushing,

P = Total tonnage of production.

IMPORTANCE OF DEGREE OF PERFORMANCE

- **Fragmentation levels required depend on the type of the excavating and hauling equipment.**
- **Fragmentation coarser than optimum results decreases the loading efficiency and increase in the downtime of loading equipment with added cost of maintenance.**
- **On the other hand, to achieve fragmentation finer than optimum, cost of drilling and blasting may rise disproportionately, which may not be offset by the additional advantage in loading.**
- **The blast design should, therefore, be aimed at optimum fragmentation to economise the overall cost of mining.**

IMPORTANCE OF DEGREE OF PERFORMANCE

- Once the optimum fragmentation requirements for a particular mining equipment is decided, the question arises as to determine which would need secondary breaking.
- Any attempt to produce "Zero Boulder Blast" would severely affect the drilling and blasting cost.
- The optimum ratio of percentage of oversize boulders against the volume of rock may be taken as 1-2%.
- Efficient explosives application is the least expensive method of fragmenting and casting rock. Blast casting the over burden off coal dramatize the economic advantages of using explosive energy to increase production rate and enlarge over all operating profit margins.

END