EXPLOSIVES ENGINEERING

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What are the important of explosives?

Most raw materials, from which our modern society is built, are produced by the use of explosives in mines throughout the world. The construction of highways, canals and buildings are aided by the use of explosives. The plentiful food, which is available in all countries, would not exist without explosives to produce the fertilizers and the metallic ores, which ultimately become tractors and other equipment.

Illustrate a brief history of explosives until 1950?

The use of explosives in mining and construction applications dates back to 1627. From 1627 through 1865, the explosive used was black powder. Black powder was a different type of explosive than the explosives used today. In 1865, Nobel invented nitroglycerin dynamite in Sweden. He invented gelatin dynamites in 1866. These new products were more energetic than black powder and performed differently since confinement of the explosive was not necessary to produce good results, as was the case with black powder. From 1867 through the mid-1950, dynamite was the workhorse of the explosive industry.

Illustrate a brief history of explosives after 1950?

In the mid-1950 a new product appeared which was called ANFO, ammonium nitrate and fuel oil. This explosive was more economical to use than dynamite. During the decades of the 1970's and the 1980's, ANFO has become the workhorse of the industry and approximately 80% of all explosives used in the United States were ammonium nitrate and fuel oil.

Illustrate a brief history of new explosives?

Other new explosive products appeared on the scene in the 1960's and 1970's. Explosives, which were called slurries or water gels, have replaced dynamite in many applications. In the late 1970's a modification of the water gels called emulsions appeared on the scene. The emulsions were simple to manufacture and could be used in similar applications as dynamites and water gels. Commercial explosives fall into three major generic categories, dynamites, blasting agents and slurries (commonly called water gels or emulsions).

Illustrate the important of explosives design?

Blasting problems generally result from poor blast design. Poor execution in drilling and loading the proposed design and because the rock mass was improperly evaluated.

Blast design parameters such as burden, stemming, sub drilling, spacing and initiation timing must be carefully determined in order to have a blast function efficiently, safely and within reasonable vibration and air blast levels.

Illustrate the important of controlled blasting?

Controlled blasting along highways must be done to reduce maintenance costs and produce stable safe contours. Those responsible for the execution and evaluation of controlled blasting must be aware of the procedures used to produce acceptable results and must understand how geologic factors can change the appearance of the final contour.

Illustrate the effects of geological structures to the rock explosion?

Rock strengths change over both small and large scale. Geologic structures such as joints, bedding planes, faults and mud seams cause problems. These variations in structure require the blaster to change his patterns and methods to obtain reasonable results. Therefore, one must assume, from surface indicators, what the rock mass will be at depth. The drilling of blast holes provides information as to what type of structure intersects those holes. To enable the blaster to make enlightened judgments, when adjusting his blasting pattern to compensate for rock structure, he must have a thorough understanding of exactly how the explosive functions during blasting. Without that understanding, blasting is just a random trial-and-error process.

When the high explosives react, which types of energy are released?

Two basic forms of energy are released when high explosives react. The first type of energy will be called shock energy. The second type will be called gas energy. Although both types of energy are released during the detonation process, the blaster can select explosives with different proportions of shock or gas energy to suit a particular application.

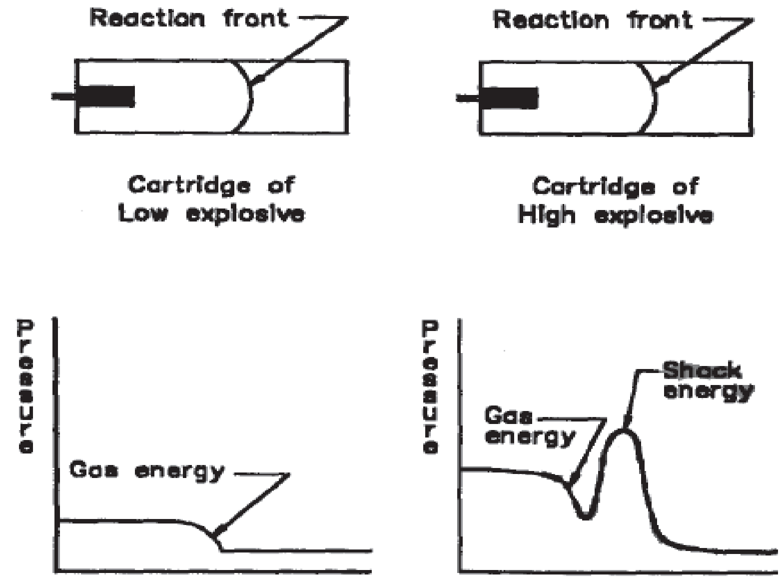
When the high shock and high gas energies are useful?

If explosives are used in an unconfined manner, such as mud capping boulders (commonly called plaster shooting) or for shearing structural members in demolition, the selection of an explosive with high shock energy would be advantageous. On the other hand, if explosives are being used in boreholes and are confined with stemming materials, an explosive with a high gas energy output would be beneficial.

What are the difference in reaction of a low and high explosives?

Low explosives are those which deflagrate or burn very rapidly. These explosives may have reaction velocities of two to five thousand feet per second and produce no shock energy. They produce work only from gas expansion. A very typical example of a low explosive would be black powder. High explosives detonate and produce not only gas pressure, but also energy or pressure which is called shock pressure. Figure 1.1 shows a diagram of a reacting cartridge of low explosive. If the reaction is stopped when the cartridge has been partially consumed and the pressure profile is examined, one can see a steady rise in pressure at the reaction until the maximum pressure is reached.

Low explosives only produce gas pressure during the combustion process. A high explosive detonates and exhibits a totally different pressure profile (Figure 1.1).



During a detonation in high explosives, the shock pressure at the reaction front travels through the explosive before the gas energy is released. This shock energy normally is of higher pressure than the gas pressure. After the shock energy passes, gas energy is released. <u>The gas energy in detonating explosives is much greater than the gas energy released in low explosives</u>. In a high explosive, there are two distinct and separate pressures. The <u>shock pressure</u> is a transient pressure that travels at the explosives rate of detonation. This pressure is estimated to account for only <u>10% to 15%</u> of the total available useful work energy in the explosion. The <u>gas pressure</u> accounts for <u>85% to 90%</u> of the useful work energy and follows thereafter. However, the gas energy produces a force that is constantly maintained until the confining vessel, the borehole, ruptures.

Illustrate the pressure form in high and low explosives?

In high explosives, a shock pressure spike at the reaction front travels through the explosive before the gas energy is released. There are, therefore, two distinct separate pressures resulting from a high explosive and only one from a low explosive. The shock pressure is a transient pressure that travels at the explosives rate of detonation. The gas pressure follows thereafter. The shock energy is commonly believed to result from the detonation pressure of the explosion. The detonation pressure is a function of the explosive density times the explosion detonation velocity squared and is a form of kinetic energy.

Why the determination of the detonation pressure is very complex?

There are a number of different computer codes written to approximate this pressure. Unfortunately, the computer codes come up with widely varying answers. Until recently, no method existed to measure the detonation pressure. Now that methods exist to produce accurate measurements, one would hope that the computer codes would be corrected. Until that time occurs, one could use one of a number of approximations to achieve a number that may approximate the detonation pressure. As an example, one could use:

$$P = \frac{4.18\text{x}10^{-7}\, SG_e\, Ve^2}{1 + 0.8\, SG_e}$$

where:

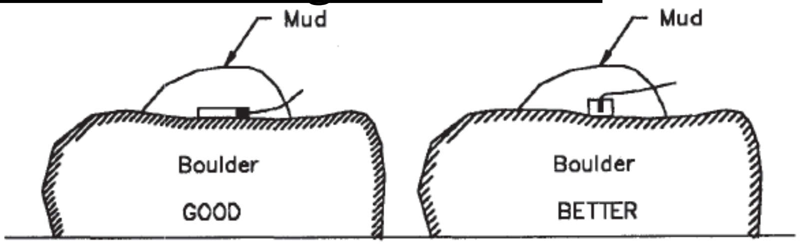
P = Detonation pressure (Kbar, 1 Kilobar = 14,504 psi)

SGe = Specific gravity of the explosive

Ve = Detonation velocity (ft/s)

Explain the detonation pressure and the shock energy in an open explosion?

The detonation pressure or shock energy can be considered similar to kinetic energy and is maximum in the direction of travel, which would mean that the detonation pressure would be maximum in the explosive cartridge at the end opposite that where initiation occurred. It is generally believed that the detonation pressure on the sides of the cartridge is virtually zero, since the detonation wave does not extend to the edges of the cartridge. To get maximum detonation pressure effects from an explosive, it is necessary to place the explosives on the material to be broken and initiate it from the end opposite that in contact with the material. Laying the cartridge over on its side and firing in a manner where detonation is parallel to the surface of the material to be broken reduces the effects of the detonation pressure. Instead, the material is subjected to the pressure caused by the radial expansion of the gases after the detonation wave has passed. Detonation pressure can be effectively used in blasting when shooting with external charges or charges which are not in boreholes. This application can be seen in mud capping or plaster shooting of boulders or in the placement of external charges on structural members during demolition

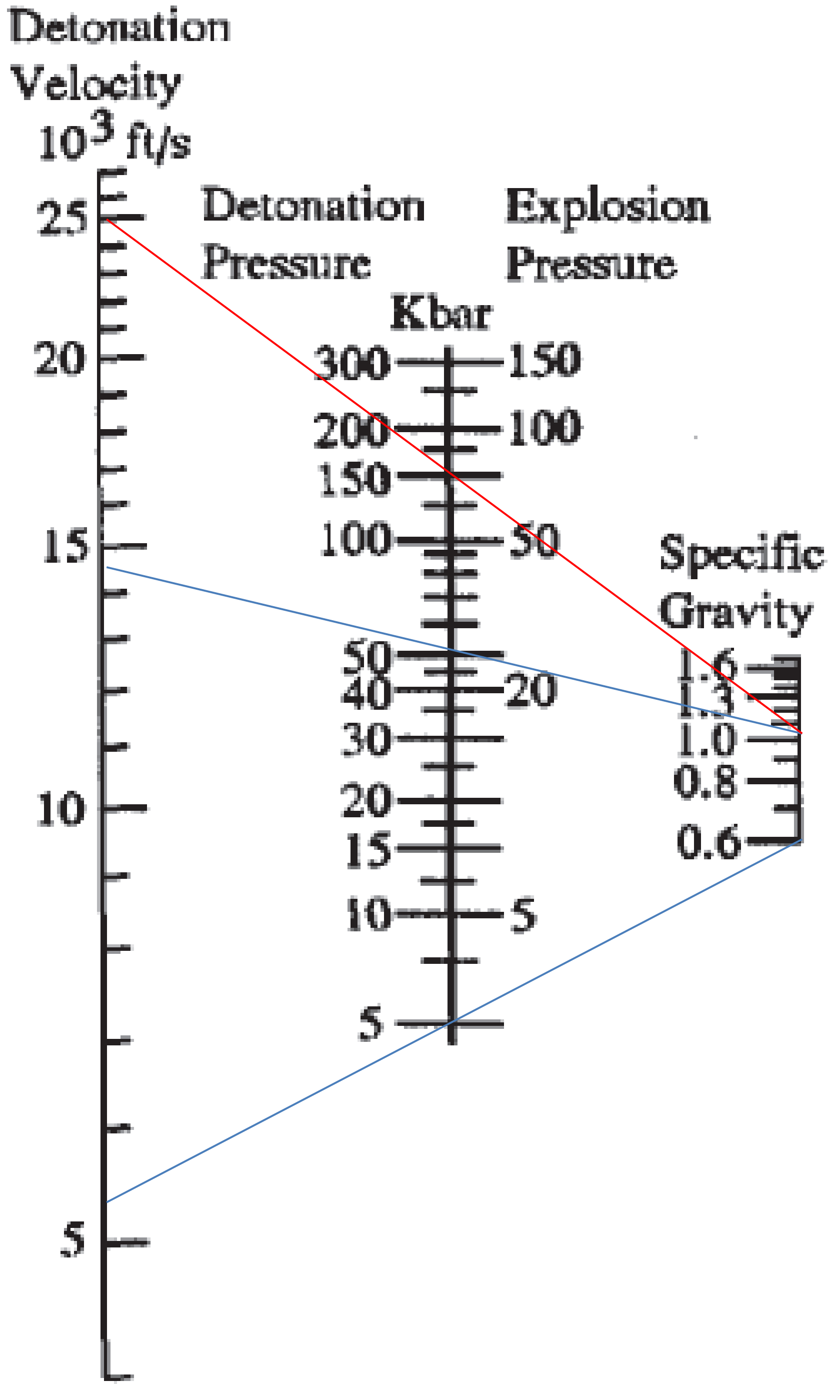


How the engineers maximize the detonation pressure?

To maximize the use of detonation pressure (1) one would want the maximum contact area between the explosive and the structure. (2) The explosive should be initiated on the end opposite that in contact with the structure. (3) An explosive should be selected which has a high detonation velocity and a high density. A combination of high density and high detonation velocity results in a high detonation pressure.

Explain the detonation pressure and the explosive pressure in borehole?

The gas energy released during the detonation process causes the majority of rock breakage in rock blasting with charges confined in boreholes. The gas pressure often called explosion pressure is the pressure that is exerted on the borehole walls by the expanding gases after the chemical reaction has been completed. Explosion pressure results from the amount of gases liberated per unit weight of explosive and the amount of heat liberated during the reaction. The higher the temperature produced, the higher the gas pressure. If more gas volume is liberated at the same temperature, the pressure will also increase. For a quick approximation, it is often assumed that explosion pressure is approximately one-half of the detonation pressure.


Detonation Velocity 10^3 ft/s
25
20
15
10
5
Detonation Pressure
Kbar
300
200
150
100
50
40
30
20
15
10
5
Explosion Pressure
150
100
50
20
5
Specific Gravity
1.6
1.3
1.0
0.8
0.6

When the explosive pressure is greater than detonation pressure?

It should be pointed out that this is only an approximation and conditions can exist where the explosion pressure exceeds the detonation pressure. This explains the success of ANFO, ammonium nitrate and fuel oil which yields a relatively low detonation pressure, but relatively high explosion pressure.

How the explosion pressure is calculated and measured?

Explosion pressures are calculated from (1) computer codes or measured using (2) underwater tests. Explosion pressures can also be (3) measured directly in boreholes; however, few of the explosive manufacturers use the new technique in rating their explosives. (4) A review of some very basic explosives chemistry helps one to understand how powdered metals and other substances affect explosion pressures.

Thank you