BLASTING TECHNOLOGY BY NON-EXPLOSIVE

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Abstract:

Non-explosive blasting technology has emerged as a promising alternative to traditional explosive methods in mining operations. Unlike conventional explosives, non-explosive agents are silent and do not generate vibrations, making them ideal for use in sensitive environments such as urban mining or areas with strict noise and vibration control requirements. These agents are cost-effective compared to explosives, which are more expensive and subject to stringent regulatory controls. Non-explosive methods also have the advantage of being environmentally friendly, as they do not produce harmful pollutants or gases. These technologies are already widely used in applications like tunnel excavation, sand and rock quarries, and foreign mining operations. While their adoption in Indian mines has been limited, non-explosive blasting methods are expected to gain traction in the future due to their lower cost, ease of use, and environmental benefits. This paper highlights the advantages and growing potential of non-explosive fragmentation methods in the mining industry.

Keywords: Non-explosive, blasting technology, mining, environmental benefits, cost-effective, vibration-free, safety.

1.Introduction

In mining the basic aims is to achieve maximum extraction of minerals keeping in view the environmental, economic and lease constraints. Drilling and blasting are the major unit operations in mining. Rock breaking by drilling and blasting is the first phase of the production cycle in most of the mining operations. Without drilling and blasting there is no excavation process is take place. In mining industry, for blasting of rocks we use explosive for fragmentation. Due to use of explosive causes accidents it leads to loss of life, collapse of normal activities of mine and surface. In some case, blasting done with use of explosive may cause several damage to mine workings and surrounding areas by producing vibration, fly rock, noise, and air blast, etc. Due to various concerns such as nearby infrastructure, sensitive environmental areas, legislation etc., blasting is also not permitted. So, blasting research unit are increasingly required to break rock without using explosives. Blast Quest has tried and tested various methods and found that chemical rock breaking and non-explosive cartridge blasting has the desired results. Non-explosive is cheaper than the explosive. Non-explosive is free from the disadvantages of explosive. In olden days non-explosive method of rock fragmentation is used for secondary blasting. But nowadays, it is used primary blasting in critical areas (i.e.) where blasting is

not permitted. Rock breaking technologies and equipment has developed after 1960 in Romania which led to important changes in this field of forest roads building.

Problems By Use Of Explosive:

The basic objective of drilling and blasting program is to achieve optimum fragmentation. Blasting in overburden is mainly done either to fragment and shatter the rock or to displace the rock in the mine area by casting of overburden. In mining industry, for rock fragmentation explosives used are Gun powders, slurry explosive, ANFO, Nitro glycerine, T.N.T, Emulsion explosive, liquid oxygen explosive.

By use of above explosive in varies places of mine, problems faced by us is

- It causes fly rocks, noise, air blast, etc.
- There is no controlled blasting occurs.
- Operation is not in safety.
- Storage of explosive needs high security.
- A licence is needed for using explosive.
- Cost of explosive is high.

2.Literature Review

The traditional use of explosives in mining operations has long been integral to the extraction of minerals, including coal. However, the environmental and safety concerns associated with explosive blasting, such as air pollution, ground vibrations, and risk to personnel, have led to the development of non-explosive blasting technologies. One of the most prominent non-explosive techniques is expansive cement, which works by forming a large volume of gas upon setting. This expansive force fractures rock without causing shock waves. According to Amin and Goktan (2006), expansive cement-based methods are highly effective in soft to medium-strength rocks, providing controlled, low-velocity cracking with minimal environmental disruption. However, the technique may require longer time periods for the process to occur and its effectiveness is somewhat limited in very hard rock formations.

Another non-explosive method is chemical agents designed to induce rock fractures. These agents are usually applied in drilled holes and then activated to generate a pressure that causes the rock to crack. Lee et al. (2012) explored the use of chemical-based blasting agents, such as potassium nitrate compounds, which produce a controlled fracture pattern. This technique is particularly advantageous in areas where conventional blasting is restricted due to environmental concerns or proximity to urban areas. While these agents can be effective, their use often comes with higher costs and limitations in terms of the scale of application. Hydraulic fracturing is another non-explosive method that involves injecting high-pressure water into a borehole to induce fractures. Kumar et al. (2015) demonstrated that hydraulic fracturing could be successfully applied in coal mines to break hard rock formations without the need for explosives. This method offers precise control over the fracture process and can be monitored in real-time. However, the method's success depends on the geology of the area, and it requires specialized equipment and expertise. Microwave energy blasting is a relatively new, non-explosive method that has shown promise in laboratory settings. In this technique, microwave energy is used to heat rock formations, causing thermal expansion and stress that leads to fracture. Research by Li et al. (2018) indicates that microwave energy can effectively break rock with minimal environmental disturbance. However, its application remains limited due to the high energy consumption and lack of widespread practical implementation.

Blasting by non-explosive mechanical means, such as impact hammers or rock-breaking machines, has also gained attention as a method to avoid the environmental drawbacks of explosives. Zhou and Zhang

(2013) reviewed the development of mechanical rock-breaking technologies and found that they offer high precision and control, especially in smaller-scale operations or areas where environmental constraints are stringent. These machines, however, may be less effective for large-scale or deep excavation projects due to the limitations in their force generation compared to explosives. Fracturing by ice-based techniques has been explored for specific mining applications. Yang et al. (2010) suggested using liquid nitrogen to cool rock formations, causing thermal stress that leads to fracturing. This technique provides an eco-friendly and non-toxic alternative, although it is mainly suited for specific types of rock and requires precise control over temperature. Laser-induced blasting is an innovative method that uses lasers to heat rocks to high temperatures, creating fractures through thermal expansion. According to Sharma and Singh (2017), laser-induced blasting has the potential to provide highly localized and precise fractures. However, the technique remains in the early stages of development and faces challenges related to energy consumption and cost-effectiveness for large-scale operations. Finally, the environmental benefits of non-explosive methods are undeniable. Zhang et al. (2016) emphasized that non-explosive techniques significantly reduce the environmental footprint of mining operations by eliminating ground vibrations, air blasts, and toxic dust emissions, which are typically associated with conventional explosive blasting. These methods also improve the working conditions in mining areas by reducing the risks to human health and safety.

3.Methodology

Non-explosive is cheapest and simplest method of rock fragmentation. To avoid disadvantages of explosive (i.e.) vibrations, fly rocks, dust, etc, we using non-explosive methodology. Non-explosive is convenient to use in the area of critical zone (like geological disturbances, faults, folds, etc.) for extraction. Non-explosive methods does occur any ventilation problems.

Non-explosives technologies are:

- Plasma Blasting Technology
- Cardox
- Chemical Blasting Technology
- Hydraulic Fracturing
- In plasma technology we use ionised ions, electrons, atoms for rock fragmentation.
- In cardox we use liquid carbon dioxide for rock fragmentation.
- In chemical technology we use chemicals (like crackamite, dexpan, etc.) for rock technology.
- In hydraulic fracturing we use water mix of sand and small quantity of chemicals for rock fragmentation.

Plasma Blasting Technology

Plasma blasting technology is an innovative and advanced method for rock fragmentation that utilizes high-energy plasma to break rocks, offering an environmentally friendly and precise alternative to traditional explosive methods. This technology generates a plasma arc or jet, which is a highly ionized gas created by electrical discharges. When directed at a rock surface, the intense heat and energy from the plasma cause rapid thermal expansion, inducing fractures in the material. This process is effective in breaking hard rock formations without the use of conventional explosives, which can cause significant environmental disruption. Plasma blasting technology offers several advantages over traditional blasting methods. One of its key benefits is the reduction of environmental impacts. Unlike explosives, plasma does not produce harmful shock waves, ground vibrations, or toxic fumes, making it a safer option for mining operations near populated areas or sensitive ecosystems. Additionally,

plasma blasting allows for precise control over the fragmentation process, which is crucial in applications where the size and quality of the rock fragments are critical, such as in ore extraction.

Figure 1: Plasma Blasting Technology for Precise Rock Fragmentation

CARDOX

The Cardox System was first developed in 1914 and was used in the coal mining industry. It is developed over 60 years ago for use in explosive coal seams in the UK. Cardox was used by Millennium Mining and Construction. Cardox was an ideal solution as it uses liquid Carbon Dioxide (CO2) which is an inflammable gas that poses no harmful risk to the highly flammable environment inside the coal shafts. As the years progressed, so did the Cardox System. Today, the Cardox System is used in more than 150 countries worldwide across a variety of applications in the Civils, Cement and Silo industry. Cardox is not classified as an explosive, but rather as a high-pressure gas generator. Cardox provides good fragmentation and breaks the rock into large, easily managed pieces with minimal fines.

MECHANISM:

The Cardox system consists of a high-strength, reusable steel tube filled with liquid carbon dioxide, a chemical energiser, and a rupture disc. When the Cardox tube is ignited, the carbon dioxide is almost instantaneously converted from a liquid to a gas. Pressure is released from the gaseous CO2 up to 300mpa (3000 bar), it expands through micro cracks and fractures the rock. The pressure can be regulated between 1200 and 2800 bar by using rupture disks. The body is filled with liquid CO2, a safety heater inserted in the firing head, a rupture disk in the discharge end of varied thickness to regulate pressure. A nylon collar is used to hold the cartridge in place so no stemming is required. The chemical energiser is activated by a small electrical charge which causes detonation. All Cardox tubes are of a standard size requiring a 57mm diameter hole, differences in pressure are altered by the rupture disks only. The standard tube size reduces the flexibility of hole size, and due to the collar instead of stemming allows very little tolerance in hole diameter.

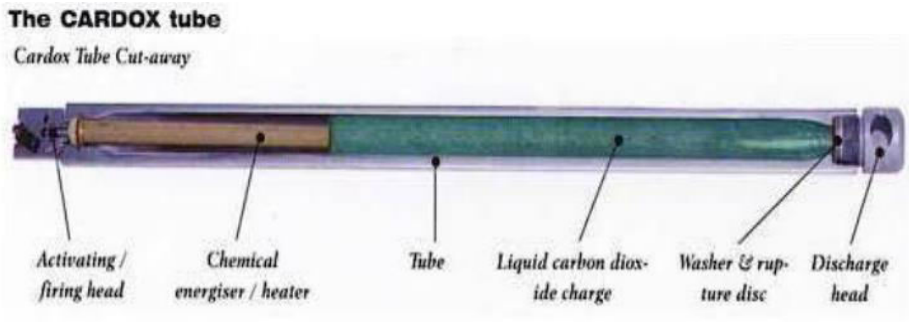

Fig: Schematic Diagram of Cardox Tube

There is no risk of igniting any gas present in the area of use as all combustion is carried out within the sealed Cardox tube. When the gas is released at such high speeds, it has the additional advantage of a refrigeration affect, which brings the temperature low enough as to ensure that any gas/air mixture could not ignite.

CHEMICAL BLASTING TECHNOLOGY

Chemical demolition agents were first introduced in the early 1970s but failed to gain widespread for selective removal of rock. Nearly 40 years later, a large number of competitive products have entered the market due to factors that their potential environmental benefits have greatly expanded their usage. Don't waste too much time, and effort in breaking huge boulders or concrete structures. You can effectively use hard rock breaking chemical complete the huge task in just few minutes. Easy blast, one of the leading non-explosive demolition agent suppliers in Bangalore, offers high- quality chemicals for rock breaking in India. The hard rock breaking chemical from easy blast is made of natural minerals such as oxides of calcium, silicon, aluminium, etc. Stand back and watch hours of natural demolition work being completed in just a few minutes.

CRACKAMITE:

Crackamite, a non-explosive, is a highly expansive powder for stone breaking, granite and marble quarrying, concrete cutting and demolition. Crack mite consists of oxides of calcium, silicon. Crackamite is a safe environment friendly and good a viable alternative to explosives and other traditional methods of quarrying and demolition. Crackamite is mixed with clean water and poured into pre-drilled holes on rock and concrete. The diluted Crackamite swells and exerts significant expansive thrust on the hole- wall, fracturing the wall and splitting the rock across the line of drill holes. This method is mostly used to break boulders in quarry. These agents are much safer than explosive, but they have to be used as directed to avoid steam explosions during the first few hours after being placed.

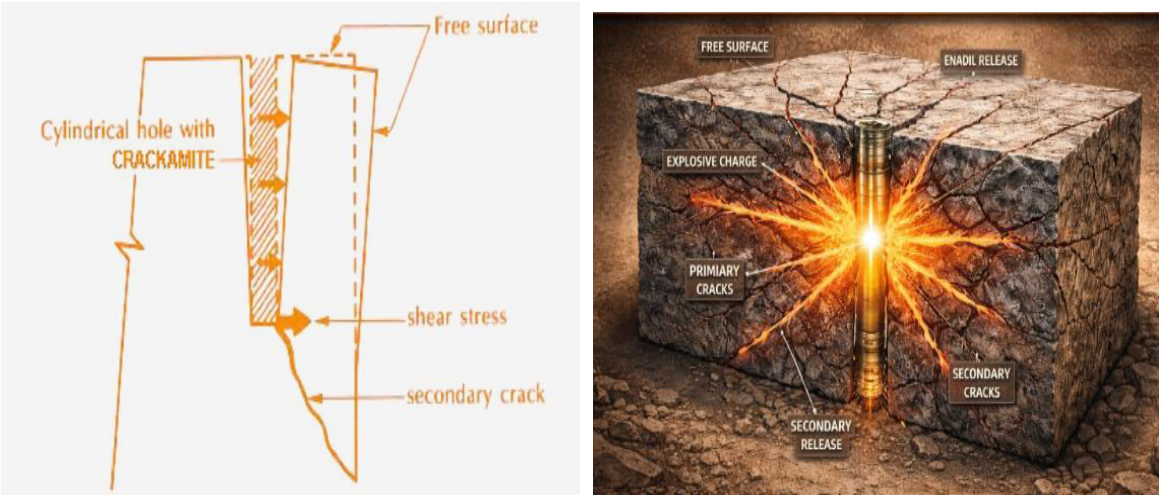

Fig Sectional View of the Crack Formation

Cutting and secondary breaking:

When the cracking gap is around 3 to 5 cm, you can carry out further demolition work. After crack initiate, secondary breaking is carried out with a hand-breaker, a pick hammer, a giant hydraulic breaker, a ripper etc.

Fig: Stages Of Chemical Blasting

Hydro Fracturing Technology

In 1865, col. Edward Roberts and his brother developed a technique known as 'superincumbent fluid-tamping' later in 1953 advancing of this method by use of water with sand and called as hydraulic fracturing. This technology is about the using of water as external source at certain pressure to make the fall of rocklike the induced caving in longwall goaf. The water is mixed with mud and chemicals. This method is obtained from the process of the extraction of natural gas from shale. From this method the drilling and crack formation is applied to the hydro fracturing technology.

Table: Comparison of Explosive and Non-Explosive

COMPONENTS	EXPLOSIVE	NON-EXPLOSIVE
COST	More costly than the non-explosive	Low cost for (2-3) mg/kg
TRANSPORTATION	Transportation involves the logistical challenges and risks	No permit is required for transportation

	associated with moving dangerous goods	
USE AND SAFETY	Requires highly trained professionals to work with explosives	Safe and easy to use by trained personnel
POLLUTION & HARMFUL GAS	Explosive blasts produce dust and gaseous pollutants harmful to people and the environment	It is environmentally fine and gentle
VIBRATION AND NOISE	Generates significant noise, vibration, and shock waves that can affect surrounding structures	No detonation; it's achieved through a controlled fracture, reducing noise, vibration, or risk
RISK OF GASES	Spark can cause flammable gases to ignite, which may spread rapidly in the vicinity	There is no risk of igniting gases since it does not involve explosives
MAGAZINE	Needed to store explosives safely	No need for a magazine
ACCIDENT	Chance of a serious accident is high	Low chance of accidents due to controlled use
HUMAN POWER	High human power required for operation	Less human power is required, as it involves simpler operations
POWER	High power consumption for blasting explosives	Non-explosive methods require less power
WORK PROGRESS	Work is dependent on explosives and requires time to achieve optimal conditions	More consistent progress without waiting for explosive reactions
FLY ROCKS	Higher chance of flying rocks during blasting	No chance of flying rocks as there is no explosion
TIME PERIOD	Time-consuming due to delays in setup and safety procedures	Non-explosive methods can be faster and safer
DAMAGE	High damage potential to surrounding areas, including the environment	Minimal damage due to controlled use

CONCLUSION

Now we are concluding that, non-explosive agents offer many advantages including that they are silent and do not produce vibration the way a conventional explosive would in some applications. Conventional explosive are more costly than non-explosive agents. In many countries these are available without restriction. Unlike explosive which are highly regulated. Non-explosive method of fragmentation is applicable in tunnel excavation, sand and rock quarries and it's also applicable in many foreign mines. Nowadays it is used in one or two Indian mines, in future it come to applicable in many mines.

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