An Overview of Explosive Energy Utilization in Mining

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Abstract – *Blasting is the controlled use of explosive to break rock for excavation. It is practiced most often in mining, quarrying and civil engineering but the use of explosive is much higher in mining rather than any other industry. Breaking of sandstone, limestone, coal or any other rocks in opencast mines is essentially required for ease in excavation. The blasting operation plays a dominant role in the overall economics of opencast mines. The blasting sub-system affects all the other associated sub-system i.e. - loading, transporting, crushing and milling operation. Blasting is used as an economical tool for rock excavation in construction quarry and mining projects. This paper develops an understanding of explosive energy utilization in mining industry. This will help in developing the socio-eco-effective awareness towards the effective utilization of explosive energy in mining industry.*

***Key Words*: Blasting, Sustainability, Socio-economic, Opencast coal mining, Metallic Foam etc.**

1. INTRODUCTION

Explosive is a substance, that when subjected to a suitable stimuli, undergoes a violent chemical decomposition with the evolution of heat and gas and the blasting is basically the technology of exploding explosive material [1]. In general, an explosive have some basic characteristics, It is a chemical compound or mixture ignited by heat, shock, impact, friction, or a combination of these conditions, upon ignition, it decomposes rapidly in a detonation; there is a rapid release of heat and large quantities of high-pressure gases that expand rapidly with sufficient force to overcome confining forces, and the energy released by the detonation of explosives produces the basic effects, are rock fragmentation, rock displacement, ground vibration and air blast. Blasting operation not only restricts all other operations of the mine in vicinity, but it is hazard prone if not carried out with extreme caution [2]. But explosive is the main and cheapest source of energy available for rock blasting in the mining, quarrying and civil excavation operations. Upon detonation of explosives, there is a rapid release of heat nearly at 4500°c and large quantities of high-pressure gases (2500 bar) during detonations. During this process explosive energy is converted into mechanical energy to fragment hard rock and dislocate them so that they can be available for loading, howling and consequently passed for mineral beneficiation/washing stages [3]. The pressure breaks the rock releasing blasting (nitrous) fume, heat, high speed dust and fly-rocks, noise and ground vibrations. Every kilogram of ammonium nitrate in explosive generates 110 liters to 600 liters of nitrate gas and 6to31 liters of CO in air depending upon the quality of explosive their use and situations. Nitrous fume is one of the most powerful greenhouse gases. It bears very high global warming potential [4]. Dust in atmosphere cause health problems to local population. Fly-rock and noise make birds and animal too afraid to return in location. Ground vibration travel long into residential places causing damage to structures, soil, flora and fauna, and creating psychological pressure on habitats. The main aim of this paper is to address an overview of explosive energy utilization in mining works.

1.1 Type of Explosive

Explosive is a chemical substance (sometimes may be a mixture of fuel and oxidizer) which releases huge quantity of shock and gas energy instantaneously on triggering by a detonation. The main explosives are categorized into two types, one is low explosives and another one is high explosives. Low explosives deflagrate rather than detonate, they burn progressively, and the reaction is sub-sonic. The velocity of shock wave is lower than speed of sound. The example of low explosives is black powder and gun powder [5]. The high explosives detonate, and the detonation process is progressive and the shock wave passes through the high explosive at or faster than the speed of sound in that material. The examples of high explosives are ANFO, Slurries, Emulsion, and PETN etc. Explosive can also be classified as – primary explosive and secondary explosive. The primary explosive is very sensitive to flame but not very much destructive and used to initiate secondary/main explosive. Secondary explosive is not sensitive to flame, sensitive to shock but high energy release. Mostly AN based explosive as the main explosive charge. ANFO, Emulsion, Slurry, PETN, TNT as the detonation transmitting device or base charge NG based explosives (dynamites, Gelatins) are NO MORE in use in India but used in European and US mines. [6].

1.2 Significance of Explosive Energy in Blasting

The explosive energy utilization is one of the main dependable factors to select any type of explosive to use in any kind of blasting and to evaluate the blasting results. However the many research scholars ‘studies are focused to get an optimal utilization of available explosive energy. In the present study the above research findings have served as a guideline to understand the various energy components associated with rock blasting. Among all the energy factor has been extensively used to evaluate the blasting result. To understand the various energy components associated with rock blasting and the utilization of explosive energy, have been reported by ouchterlony et al (2003) calculated the amounts of energy transformed into kinetic energy of the rock, fracture generation and seismic wave [7]. Finn et al (2004) undertook studies on energy partitioning of limestone production blasts under well controlled conditions; from rock properties determination, structural mapping and monitoring of drilling and charging, to VOD, 3D accelerometer and bench face movement measurements during the blast to post blast fragment size measurements [8]. Sanchidrian, Segarra et al (2006) in-depth depicted the energy approach, aiming at establishing, through new data vis-à-vis quarry blasting. They have undertaken trials at a limestone quarry using seismographs, high speed video camera and fragmentation monitoring systems to measure the seismic field, the initial velocity of the blasted rock face and the fragmentation size distribution respectively [9].The efficiency of the transfer of energy from the charges to the surrounding rock has been estimated by introducing a new explosive test, the cylinder expansion test. Md. Sazid et al (2012) experimental blasts are enhances the explosive energy utilization with the demonstrations SPARSH (Stemming Plug Augmenting Resistance to Stemming in Holes) is capable in yielding no fly-rock blasting, blasting without boulders formation.

2. Principle of Explosive Energy Utilization

Explosives are the main and cheapest source of energy available for rock blasting in the mining, quarrying and civil excavation operations. Blasting is complex phenomenon and yet to be understood fully. Fig.1shows the sequence of events occurring in rock mass surrounding a borehole during blasting. Upon detonation of explosives, there is a rapid release of heat nearly at 4500°C and large quantities of high pressure gases (250 kBar), during detonations [10]. The gases expand rapidly with sufficient force to overcome confining forces of the surrounding rock formation, on the free face. During this process explosive energy is converted into mechanical energy to fragment hard rock and dislocate them so that they can be available for loading and hauling and consequently passed for the mineral beneficiation stages. The explosive energy is defined in a number of ways obtained either from calculation or from experimental tests in laboratories. The main question of exact amount of explosive energy transmitted to the rock and fraction of has been converted into useful work during blasting remains largely undefined.

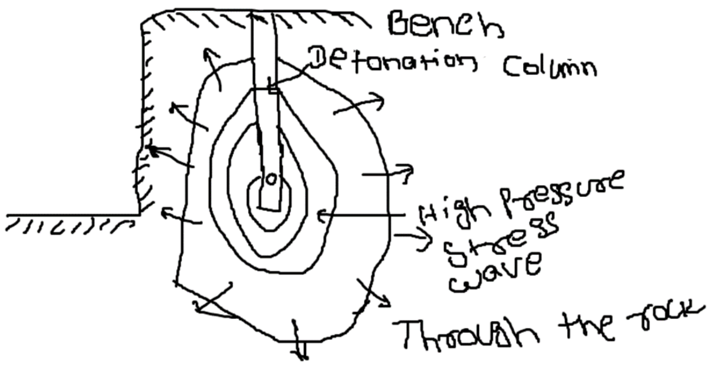

Fig.1: The sequence of events occurring in a blast hole during detonation

2.1 Efficiency Measurement of Explosive

Powder factor was a good indicator of the explosive energy used to break a quantity of rock and normally explosive energy increased with density of explosive. However, with slurries, water gels and emulsions the energy can vary, even though the explosive density remains the same. Consequently a better method is needed to relate the amount of explosive energy required to fragment a given quantity of rock. This is known as energy factor [11]. The energy factor describes the energy distribution within a given unit of rock. Energy distribution within a blast is measured by the energy factor (EF) a ratio of the explosive energy (kcal) to quantity of broken rock (m3).

The thermo-chemical energy (Q) is expressed in terms of cal/unit volume or weight of an explosive. The Absolute Bulk Strength (ABS) of a given explosive is the amount of thermo-chemical heat energy expressed in terms of cal/gm.

EF= Q/ vol. of rock

Where Q = AWS×Wt. of explosive in hole

By obtaining the various energy factors, charge distribution in a borehole can be calculated. Based on the properties of cartridge explosives, the energy factor values for different rock types are established. Energy factor has been used as a useful tool in selecting type of bulk SMS or SME explosives, since this has been achieved with packaged explosives without changing existing burden and spacing values.

3. Discussion

To identify various energy parameters associated with rock blasting, it is practically it is not possible to measure various energy type, involved in blasting. Explosive selection in majority of mines has been based on landed cost of explosive, or by the powder factor achieved basis. This system has been widely accepted. With the passage of time, when blasting became a major cost and efficiency centre, new approaches have been adopted. With the growing number of explosive manufactures exceeding half century mark to supply explosive to coal India, the selection methodology for explosives incorporated powder factor as one of the sole criteria for explosive performance evaluation. At the initial stage, coal India, fixed powder factor values from the historical data of the each mine. The manufacturers who could not maintain the powder factor values were subjected to heave monetary penalties.

4. CONCLUSIONS

Powder factor plays an important role in the effective utilization of explosive energy. It is a good indicator of the explosive energy that used to break a quantity of rock and normally explosive energy increased with density of explosive. However, with slurries, water gels and emulsions the energy can vary, even though the explosive density remains the same. Consequently, a better method is needed to relate the amount of explosive energy required to fragment a given quantity of rock.

REFERENCES

[1] Khademian, Amir, and Raheb Bagherpour. "Environmentally sustainable mining through proper selection of explosives in blasting operation. "Environmental Earth Sciences 76.4 (2017): 166.

[2] Lyashenko, V., et al. "Improving the efficiency of blasting operations in mines with the help of emulsion explosives." Mining of Mineral Deposits 12, Iss. 1 (2018): 95.

[3] Holmberg, Roger, ed. Explosives and blasting technique. CRC Press, 2000.

[4] hdi Hosseini, Me, and Mehdi Seifi Baghikhani. "Analysing the ground vibration due to blasting at AlvandQoly Limestone Mine." (2013).

[5] Behera, Ramakanta, Trinath Biswal, and R. B. Panda. "Recent Progress in Explosives: A Brief." Current Advances in Mechanical Engineering: Select Proceedings of ICRAMERD 2020 (2021): 305.

[6] Uranchimeg, E., M. Narantsetseg, and L. Purev. "Modification of ANFO detonation parameters by biowaste addition." IOP Conference Series: Materials Science and Engineering. Vol. 1019. No. 1. IOP Publishing, 2021.

[7] Ouchterlony, Finn, et al. "Where does the explosive energy in rock blasting rounds go?." Science and technology of energetic materials 65.2 (2004): 54-63.

[8] Finn, O., Ulf, N., Mats, O., Ingvar, B., Lars, G., & Henrik, G. (2004). Where does the explosive energy in rock blasting rounds go?. Science and Technology of Energetic Materials, 65, 54-63.

[9] Sanchidrián, J. A., P. Segarra, and L. M. López. "A practical procedure for the measurement of fragmentation by blasting by image analysis." Rock mechanics and rock engineering 39.4 (2006): 359-382.

[10] Mertuszka, Piotr, et al. "The effect of the blasthole diameter on the detonation velocity of bulk emulsion explosive in the conditions of selected mining panel of the Rudna mine." Archives of Mining Sciences 64 (2019).

[11] Dhekne, Prakash, Manoj Pradhan, and Ravi Krishnarao Jade. "Assessment of the effect of blast hole diameter on the number of oversize boulders using ANN model." Journal of The Institution of Engineers (India): Series D 97.1 (2016): 21-31.