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Blasting Misfire: A Review of Causes, Economic Effect, Control and Handling Techniques

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ABSTRACT

Mining consolidated ore deposits require the fragmentation of the host rock to liberate concentrate minerals for further processing. Blasting operation as the most common approach used for rock-bearing minerals size reduction, it involves the use of explosive. Explosive as an energetic and highly sensitive chemical compound requires great caution during usage, storage, and handling to avoid any form of unexpected initiation. Therefore, a proper understanding of explosive misfire causes and possible control and prevention measures will assist in improving industrial explosive usage and storage. Misfire is always a major source of potential hazards in the mines. Misfire from the surface and underground mining blast operation has caused serious injury and death of mine workers and other persons. Damage due to misfire and lack of proper handling accounted for over two-thirds of all blasting-related accidents in the mine and likewise in explosive magazine and manufacturing companies. Consequently, blasting misfire cause several adverse economic, environmental, and health (Triple-Helix) effects such as; ground vibrations, air blast, flyrock, generation of fines, fumes and mud, crush injuries, asthma or COPD exacerbations. It's important to regulate these effects while completing blasting operations as increasingly projects are being subjected to scrutiny and sometimes closure Selected accidents due to misfire are presented in this paper. Causes and occurrence of misfire are described. Techniques to prevent, mitigate, and handle misfires are also discussed.

Keywords: Blasting, Explosive, Mine Accident, Misfire, Triple-Helix Effect

1. INTRODUCTION

Ren et al, (2013) noticed that universes steel mines and non-steel mines, tremendous earth, and stone exhuming, or unloading initiatives primarily use blasting and deep hole blasting procedures to interrupt rocks formation into fragments. As indicated by way of Stretec, (2001) perfect blasting operation is what yields the downstream required fragment length appropriation affirmation of protection introduction, financial system, and in an environmentally pleasant manner. Likewise, an inadequately directed blast could ordinarily end in helpless discontinuity and might produce unfriendly influences like fly rocks, floor vibration, air blast, and again spoil (Neaupan et al 2006). Moreover, he discovered that blasting hobby is capital concentrated due to the accompanying; requirement for rock mass lower to greater modest length tiers, effective utilization of unstable energy at excessive well-being level; and manipulation of impacting to keep away from oversize materials. As indicated by using Guttmann, (1892), the utilization of Explosives in rock breaking commenced on February 8, 1627, inside the Oberbiberstollen of Schemnitz in Hungary which was deliberate and terminated through Caspar Weindl the usage of black powder. at the fulfillment of this first blast, the Hungarian Mine Tribunal hastily depict this fact at some point in Hungary and the usage of explosives in underground mining spread with the quit goal that via 1673 the innovation had unfolded in the course of the Hungarian underground mining enterprise (Brown, 1673). As of then basting spread everywhere. The utilization of Explosives usage was presented in Germany in 1700 and Sweden in 1724 for blasting inside the mining business. With the sizeable upgrades in rock discontinuity, especially in tough rock, which couldn't be mined before everything except with blasts, the construction industry additionally started out making use of the execution of black powder blasting for rock fragmentation. the first underground construction tunnel created with the aid of blasting become archived to were built in 1679, known as Malpas Tunnel in Languedoc, France, and with the aid of 1696 blasting had begun to be utilized for floor impacting in the development business for the development of streets on the Abula pass in Switzerland (Guttmann, 1892). Blasting as according to Phifer, (1972) is the most, not unusual manner of breaking material with the aid of the use of a decided and measured degree of explosive price all collectively that a foreordained volume of Rock is broken. precise blast design and execution are crucial for effective mining activities. Beside the point or helpless practices in blasting can adversely have an effect on the profitability elements of a mine. Essential times of contemporary explosives applied for impacting in surface mines contain ANFO (ammonium nitrate and gas oil), Slurries, and Emulsions. Blasting operations cause several adverse environmental effects: ground vibrations, air blast, flyrock, generation of fines, fumes and mud. It's important to regulate of these effects while completing blasting operations as increasingly projects are being subjected to scrutiny and sometimes closure. An improper blast can change the record of a mine, thanks to public litigation cases and payment of heavy compensation. Efficient blasting with reduced environmental effects requires suitable planning, good blast design, accurate drilling, the right choice of explosives and initiation system and methods, adequate supervision and considerable attention to detail.

2. Misfire occurrence in the Mine

in step with Fletcher and Zhang, (1985), blasting explosion stages in a mine or production system are based on the result of many uncertain elements, the detonation accessories (detonator and fuse) may be precipitated by means of bonfire blasting or unexploded explosives. as soon as misfires occur, they will effortlessly cause fundamental safety dangers if not detected, identified, and eliminated quickly and successfully. Misfire accidents are severe each in China and at some point in the arena every yr. In 1983, a misfire twist of fate passed off within the Huidong Lead-Zinc Mine located in Sichuan Province, which led to dozens of casualties (Pu, 1985). On October 16, 2008, and October 14, 2009, two important safety injuries related to misfiring explosions passed off inside the coal mine of the Ningxia high-temperature burning vicinity, which caused a complete of 30 deaths and fifty-five injured and/or disabled (Yi, 2008 and Li, and Zhang, 2016).

Consistent with the statistical records of the South Africa Mining and strength branch, as supplied in Stander et al, (2008) paintings, 30 to 40 % of the casualties associated with blasting accidents are due to screw-ups in powerful identifications and wrong managing of misfire conditions. The result of the research of 195 blasting injuries in open-pit mines within the united state between 1978 and 2001, among which eleven (50-64 %) were determined to be misfire injuries (Verakis and Lobb, 2003) and (Kecojevic and Radomsky, 2005). The first step in handling a misfire scenario is to appropriately come across and discover the variety and locations of the misfires. As indicated by Feng and Zhang, (2014), a misfire can be defined in 3 approaches: (i) none of the detonators and explosives detonated; (ii) the detonators detonated, explosives were no longer exploded; (iii) detonators detonated, explosives had been no longer absolutely exploded. Misfire is likewise the deficient or partial failure of blast fee to explode/detonate as designed. Misfire isn't always limited to price failure at initiation but additionally extends to the unintentional detonation of Explosive and other Blasting accessories.

Misfire has been a very hazardous incident; every reasonable means available to the site manager must be taken to avoid its occurrence. After firing, proper checking of the face and muck-pile need to be done to ensure there is no indication of a misfire. This paper provides a quick review of the occurrence and procedures to handling blast Misfire occurrence in the mine.

3. Occurrence of Blast Misfire

According to Marcia et al, (2015) Toxic gases such as CO and NO are produced by the detonation of explosives. The occurrence of misfire during blasting results in the following blast challenges:

1. Production of Noxious (NO_x gas) fumes and toxic dust,
2. Inadequate ground movement,
3. Poor fragmentation,
4. Unusual blast sounds and ground vibration rate,
5. Generation of flyrock,
6. Evidence of undetonated Explosive in bench face or muck-pile,

These are some of the Conditions a Blasting Engineer can use during a blast to at least predict if there is a misfire or not (Kecojevic and Radomsky, 2005). The occurrence of misfire during blasting is dangerous but the post-blast effect is another challenging situation.

3.1 Occurrence identification

3.1.1 Site Misfire Indicator

According to Dick et al, (1983), an explosive is a chemical material that is capable of undergoing extremely rapid combustion resulting in an explosion. A sufficient supply of oxygen can't be drawn from the air, a source of oxygen must be incorporated into the explosive mixture (Sheridan, 1976). As indicated by Sheridan, (1976) some Explosives, such as trinitrotoluene (TNT), are single chemical species, but most explosives are mixtures of several ingredients.

Production of Noxious fumes and toxic gases is a result of alteration in the Explosive oxygen balance due to incomplete detonation (Sheridan, 1976). Oxygen balance is very important in explosive manufacturing requirements and determines the performance of the explosive during usage. It dictates the type of gas, initiation efficiency, and fume produced from Explosive at detonation. Each Explosive has been tested at production and all gases reacting with oxygen had been balanced in such a way that, at detonation, only those gases that are not poisonous are released.

Incomplete or partial detonation of Explosive led to negative oxygen balance and become hazardous to the environment and personnel.

Incomplete detonation produces noxious fumes which are hazardous and a good indicator to identifying misfires from the generated gases from Blasting.

Blasting 100 charge holes will generate more ground movement than 70 charge holes. The production of less ground movement from large charges can be used as an indicator of blast misfire.

Also, poor fragmentation results from misfire. During Blasting, failures of two or more holes affect burden movement create more oversize and poor fragmentation.

3.1.2 Post Blasting inspection of misfire

Inspection of misfire after Blasting is a dangerous task. In all circumstances, this must be done following site rules and explosive regulations, and Acts. The hazard exists not only from the remaining undetonated explosive but also from the post-blast environment. The existence of toxic fumes within the blasting environment is hazardous, it can be as a result of a misfire, therefore adequately trained personnel must regularly check the muck-pile and face during the loading operation. Unchecked misfire is very dangerous, when such is load and transport to the processing plant can detonate during crushing.

From the various study by different researchers, four initiation stimuli cause explosion Detonation, this is placed under this acronyms:

FISH:

F: Friction,

I: Impact,

S: shock and

H: heat

The presence of any of these four results in the initiation of Explosive.

Impact during crushing can initiate undetonated Explosive in Boulder socket.

3.2 Procedure Action on Site

The extent and nature of the misfire must be determined after identification. This must be done as soon as possible after the misfire has been identified. After check and clear, "The All Clear" sign should be given before the mineworkers return to the mine, in other cases if not yet clear the danger zone must be barricaded

3.2.1 How to deal with an identified misfire

Blasting inspection and confirm the occurrence of a misfire can be handled by;

A. Removing stemming and re-priming: These are some precautions to observe when removing the stemming material;

1. When the detonator is close to the undetonated Explosive, stemming removing with force should not be an attempt,

2. In the case of an electric detonator the use of high-velocity air should not be attempted as it can generate static charges sufficient to initiate an electric detonator.

3. Bulk Explosives can be washed out of misfired holes.

4. Special care must be taken in removing the cartridge especially where detonators are involved

5. Under no circumstances should Explosives or detonators be removed from a drill hole by pulling the detonating cord or detonator lead

6. Use suitable extracting tools if required.

Some of the advantages of using high-pressure water to flush Explosive during misfire include;

1. It desensitizes any non-waterproof Explosive and dissolves high concentrations of water-soluble Explosive ingredients

2. It overcomes the mechanical lock of stemming material comprising chippings

B. Drilling and firing relieving holes:

The objective of drilling the relieving hole is to blast explosive remnants in the blast hole, to displace the adjacent Explosive column and also, to break up the rock mass in the region of the misfire explosive to remove undetonated explosive.

According to Hazardous substances class 1-5 controls regulations (2001), where it is not possible to explode a misfire by re-firing a relieving hole should be drilled parallel to the original hole then charged and exploded as follows:

1. Mark the misfired hole clearly or block it by inserting a wooden plug.
2. When the misfired hole is 50 mm or less in diameter and less than 3 m in length, do not drill the relieving hole closer than 600 mm to the nearest point of the misfired hole.
3. When the misfired hole is larger or longer than 50 mm and 3 m respectively, increase the distance between the misfired hole and the relieving hole so the misfired charge will not be drilled into.
4. When an electric detonator is involved, first short-circuit the detonator wires and then tie them to some permanent object to recover the detonator after a relieving hole has been fired.

Precautions to be taken in drilling the relieving holes include;

1. The hole burden and spacing depend on the sensitivity of the Explosive, the inclination of the misfired hole, and the diameter of the hole.

2. The relieving hole must be parallel to the misfired hole and be of the same depth.

Relighting of a misfire safety fuse is highly prohibited and dangerous, enough time should be given before going to the misfire site. Check Explosive before use, blasting environment must be inspected before selection of Explosive. The use of non-waterproof Explosive in a water log environment is bad. Because, as it has been damaged earlier, the Explosive material in it might have been deteriorated or infected which can lead to fire breakage at ignition.

4. Indication of a Misfire

Indication of blast misfire can be through;

1. Inadequate ground movement.
2. Undisturbed ground
3. Lack of fracturing
4. Poor fragmentation in areas of a shot
5. Evidence of undetonated explosives
6. Hang-ups on face
7. Unusual blast sound

Upon initiation of an explosive charge in a blast hole, a detonation wave travels through the explosive charge column. The velocity of detonation is a function of explosive characteristics, confinement, and charge diameter. When an explosive charge is detonated in a blast hole, very high pressure is exerted on the wall (Konya and Walter, 1991). Konya and Walter (1991) reported maximum detonation pressures of 140, 90, and 60 kbars (1 kbar = 14,504 psi) for dynamites, emulsions, and ANFO type explosives, respectively. The wall of a blast hole could experience transient pressure of about 500,000 psi for emulsion-type explosives. This high pressure causes expansion of the blast hole, crushing of the rock in the immediate vicinity, growth of cracks beyond the crushed zone, and generation of a seismic wave and air blast. Inadequate ground movement in large hole blasting is an obvious signal that shows possibility misfire occurrence.

5. Causes of Blast Misfires

1. Technical failure

- i. Wrong primer/assembly
- ii. Circuit connection/coupling fault
- iii. Detonator/poor explosive coupling
- iv. Unsuitable explosives
- v. Carelessness – damage to initiation systems
- vi. Wrong equipment, e.g. exploder
- vii. Equipment failure
- viii. Exploder (not serviced)
- ix. Circuit tester
- x. Firing cables

2. Site conditions

- i. Weak ground/movement
- ii. Water presence
- iii. Geological discontinuities – cut-offs
- iv. Product failure
- v. Detonating cord – gaps
- vi. Detonators – Faulty fuse head/delay
- vii. Shock tube – moisture ingress/connection block
- viii. Fuses – Moisture; poor crimping; damage
- ix. Explosives – water ingress; static pressure; decoupling

6. Misfire implications (Safety)

- i. Unexploded explosives and or Unexploded initiation systems
- ii. Unstable/sensitised explosives
- iii. Accidental detonation
- iv. Drilling into misfires (no drilling into sockets)
- v. Struck by LHDs
- vi. Run over by trucks/wheels
- vii. In crushers
- viii. On feeders/screens
- ix. Deposited onto dumps
- x. Taken off-site in tippers

7. Re-entry into a misfired area

i. Where the blast fired successfully all gases and dust must be allowed to clear before re-entry or inspection.

ii. Where multi-blast conditions exist the following guidelines must be adhered to:

A re-entry of 30minutes must be allowed after blasting.

Where the initiator of the blast failed a re-entry period of 30 minutes must be allowed where pyrotechnic systems are used and 5 minutes for electronics.

8. Treatment of misfires

1. Early shift examination
   i. Mark the hole (MF).
   ii. Return the fuse, shock tube, or downlines wire into the hole.
   iii. Plug the hole with a socket plug.
   iv. Barricade the area off with appropriate warning signs.
2. during the shift
   i. Remove the socket plug.
   ii. If ANFEX or Emulsion, flush hole with water.
   iii. If Cartridges, pull out with an approved scraper and wash out with water.
   iv. Remove cartridges and detonators in separate containers to old explosives boxes for destruction in a designated area.

9. Misfire Safety

i. Never attempt to pull a misfire with force out of a hole or muck-pile.
ii. In the case of a shock tube, the tube snap and shoots, and the column charge can go off.
iii. In the case where the detonator is damaged to the extent that the explosives charges in the detonator are exposed, friction especially with a grid in the hole could cause accidental initiation.
iv. Always remember that detonators in a misfired hole have been exposed to extreme external forces during the blast. This means that a detonator retrieved from a misfired hole is not in the state of the original manufacturing and could be potentially more sensitive.

10. Reporting Misfires

Potentially the most hazardous situation to have to deal with misfires.
Correct blast designs
Appropriate initiation systems
Always report misfires to the responsible Miner.
Always report misfires to the relieving shift.

Conclusion

To prevent risk which is the father of accident is greatly important to properly follow the necessary steps required to prevent the occurrence of misfire during Blasting. In addition, Explosive is a very dangerous chemical substance, is as good as proper handling, if out of hand can be highly disastrous. Furthermore, all Explosive related operations must be carried out with great care and consideration, by following all needful precautions and safety policies. Efficient blasting with reduced environmental effects requires suitable planning, good blast design, accurate drilling, the right choice of explosives and initiation system and methods, adequate supervision and considerable attention to detail.

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