THE EFFECTS OF AIR-DECKING TECHNIQUE OF BLASTING IN SURFACE MINE- A BRIEF REVIEW

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Abstract: ***Blasting is the most important activity in mining operation from the concept of "From Mine to Mill" which talks about the production and productivity at the mill but production operation starting from the mine. This signifies that the results of the blasting which is measured in terms of fragmentation, muckpile profile, throw…etc. affect the efficiency of loading and hauling equipment, and crushing and milling efficiency of the processing plant which in turn affect the costs involved in these operations. Since the objective of mining is to produce the best quality at minimum cost with due respect to safety of manpower and environmental concerns, several technological developments related to blasting have taken place for the purposes. Air-Decking technique of blasting is one of them in which air-spaces are created by dividing the entire column of charges into a number of decks which not only gives the better fragmentation by facilitating better utilization of explosives energy but also reduces the ill effects of blasting on the surrounding rock. This paper enlightens a brief review on the effects of air-decking technique of blasting.***

Keywords: Blasting, From Mine to Mill, Air-Decking, fragmentation, Explosives,

1. INTRODUCTION

Air-decking technique is used to create air-gap in blast hole by separating the column charge into a number of decks. This technique is used for the purposes of better fragmentation quality by extending the induced fracturing, control of back break reducing the fracturing and reducing the generation of fine. This technique of blasting was identified as the revolutionary changes and provided a totally new mechanism for the breakage of rock in a blast hole (Mel'Nikov, 1940). There is a long history of the application of this technique in rock blasting since 1891, when the technique of air-decking was invented and patent in German (Saunders, 1891). The copy of original drawing was depicted in Foster (1897) as shown in Figure 1, where the section A is representing black powder, the section B is representing the air-gap and the section C is representing the stemming portion of the blast hole. This technique facilitate the better utilization of energy of the explosive with reduced ill effects of blasting terms of less fine generation and ground vibration. It was reported that air decking technique of blasting not only reduces the amount of explosive consumption but also provides better degree of fragmentation of the blasted rock (Mel'Nikov and Marchecnko, 1971; and Mel'Nikov et al., 1979). It reduced the consumption of explosives by 15-30% in comparison to that of the blasting of full column charge. The main objective of the technique of air-decking is to enhance the utilization of the energy of explosive in a blast hole to achieve better fragmentation of rock and better powder factor of the blasting. Apart from that the efficiency of loading and hauling equipments has been reported to be doubly increased (Sazid, and Singh, 2012).

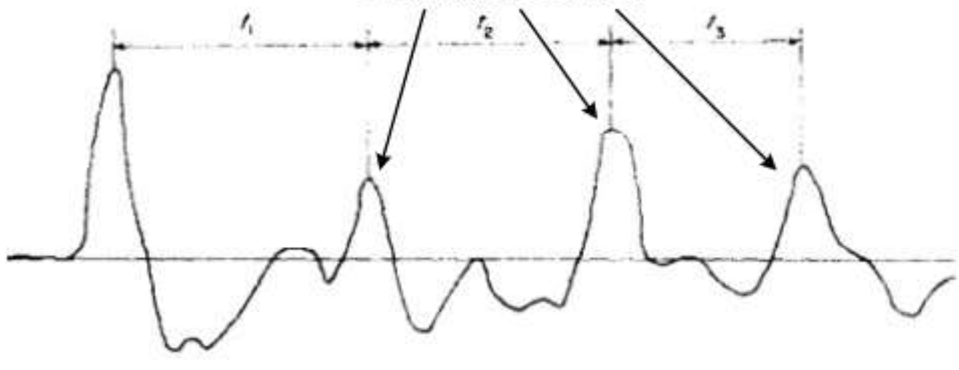
Fig 1 Original drawing of Saunders used by Foster (1897)

The technique air decking was used in pre-splitting and found that there was 10-45 % reduction in cost of production (Chiapetta and Mammaele, 1987), 25% reduction in the cost of drilling (Bussey and Borg, 1988) and 50% reduction in the cost of blasting (Bussey and Borg, 1988). The technique of air-decking reduced the amount explosive consumption by 15-20% along with improving fragmentation (Rowland, 1989). As per Mead et al. (1993) experimentation, the amount of explosives was reduced by 15-35% by along with better overall blasting result with least ill effects by this technique. According to field observation of Jhanwar and Jethwa (2000) and Jhanwar et al. (2000) air-decking technique provided improved the fragmentation along with reduced cost of explosive by 10-35%. The technique of air-decking also helps to control the profile of blasted muckpile and back break (Jhanwar et al. 2000). Sastry and Chandar (2001) reported reduction in vibration, throw and back break by 35-50%, 20-35% and 16-25% respectively. It was claimed to reduce the subgrade drilling by the technique of air-decking Chiappetta (2004). Better breakage and heave were obtained by air-decking technique in crater blasting (Singh et al. 2012). From the above references it is obvious that air-decking technique is very useful method of rock blasting. Several researchers have got different views about the mechanism and effects of air-decking technique of rock blasting which will be covered in subsequent headings.

2. MECHANICS OF AIR-DECKING TECHNIQUE

There are a lot of literatures available enlightening air-decking technique, its associated mechanism and beneficial effects. Mel'Nikov (1940) was the first to explain the mechanics of air-decking technique. He observed from his experiments that air-deck allows the expansion of explosion pressure and hence reduced the internal pressure of blasthole which results into generation of week blast wave and prevents the excessive crushing of rock letting the redistribution of energy of the explosive thereby increasing the increased utilization of the explosives energy. Since air-decking reduce the crushing so equivalent amount energy is transfer to the surrounding rock for improved breakage. In another experiments of Mel'Nikov et al, (1979) observed strong secondary stress waves are generated from the air-deck region which act on the surrounding rock repeatedly for longer period thereby transferring more explosives energy to the rock. It is observed from oscillograhic outputs of movement of medium for full column charge and air-deck charge (Figure 2) that a single stage loading of rock takes place in case of full column charge. But in case of air-deck charge, a quite different pattern of rock loading was observed. Several secondary waves were observed which propagated through rock and developed several micro-cracks in rock surrounding the blast hole. The air-gap first accumulates the energy of explosives and then releases that as separate stress pulses rather than instantly acting on to the rock as shown in Figure 2 (Mel'Nikov et al. 1979). The longer action of energy of explosive on surrounding rock mass resulted into better fragmentation.

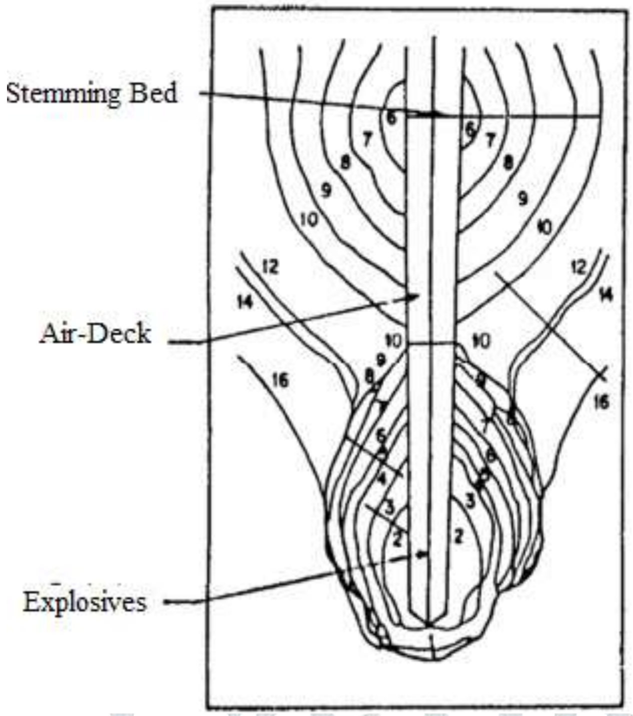
(a) Full column charge



(b) Air deck charge

Fig 2 Oscillograhic records of velocity of movement of medium using (a) full column charge (b) air deck charge (modified after Mel'Nikov et al. 1979)

The expansion of explosion gas in air-gap results into the reduction of initial pressure of the blast hole. From this it is understood that explosion product is incapable to generate powerful shock waves just immediately after the explosion unlike full column concentrated charge. The secondary stress waves propagated in opposite directions through the air medium and reflected back due to collision with blasthole face and bottom of the stemming region. The reflected shock waves again interact in air medium. This process of multiple collision and reflection continued until the process rock blasting completed. Fourney et al. (1981) conducted experiment of air deck blasting on a thick Plexiglas and observed the process of crack formation (Figure 3). He observed that shock wave moves reflected back after the collision with the bottom of stemming region. The time period for which explosive energy work on to the rock was longer by 2-5 times due to the coalescence of reflected pulses and primary waves which lead to more fracturing in surrounding rock. Fourney et al. (1981) observed more fracturing in rock surrounding the air medium and stemming zone than that of surrounding the explosive charge zone (Figure 3).

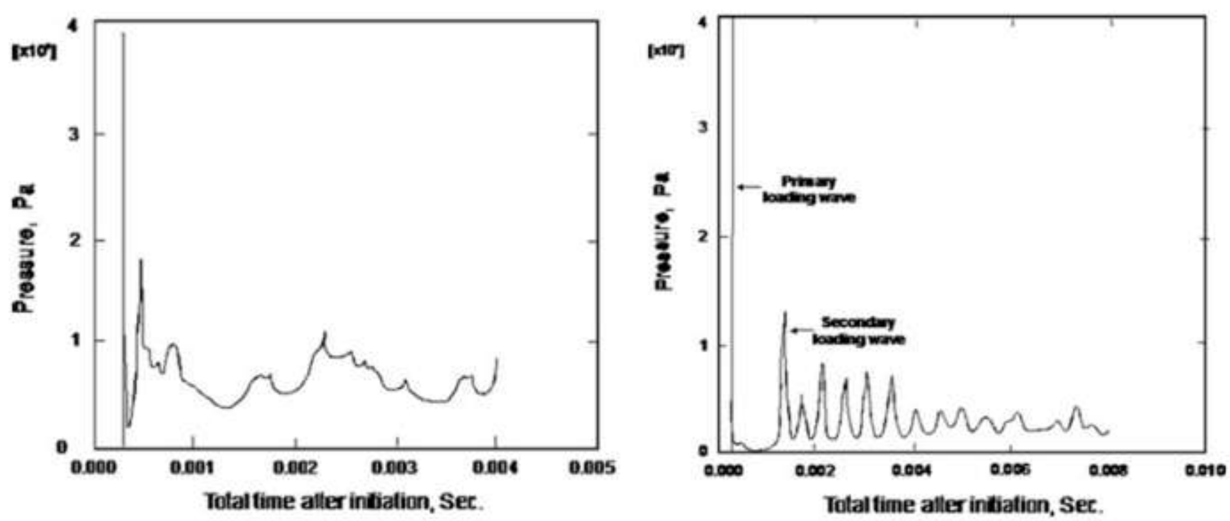


Frame No.	Time µ sec.
1	13
2	34
3	57
4	81
5	90
6	113
7	140
8	164
9	191
10	215
12	247
14	272
16	323

Fig 3 Crack propagation from air decking in Palxiglass (after Fourney et al. 1981)

Marchenko (1982) concluded that intensity of stress was reduced significantly in air-deck zone thereby reduced zone of crushed rock around the explosive charges and increased stresses in farther regions by 25%, which facilitated improved fragmentation. Chiappetta and Memmele (1987) acknowledged that there required secondary pulses and repeated loading of rock for better utilization of explosives energy and improved fragmentation. Hence, technique of air-decking stood suitable for the above requirement. Liu and Katsabanis (1996) carried out numerical simulation and inferred that air-decking feeble the initial loading and accumulate the energy of the detonation. This accumulated energy was transformed into kinetic energy and then kinetic energy in the form of strain energy and elastic dissipation created rock mass collision. This process facilitated improved rock breakage. In this connection, two numerical models were used to observe the pressure profile curves, which distinguishe

d the breakage mechanism (Figure 4). It can observed from pressure profile curves of top most portion of explosive charge that value of pressure reaches the highest value after detonation and then drops down quickly whereas, action of secondary pulse was observed in case of air-decking simulation. This additional loading by secondary pulse showed the more fracturing of rock. Liu and Hustrulid (2003) inferred from his experimentation that the propagation of rarefaction pulse and reflected rarefaction pulse formed the pressure releasing process on the rock which is the major response for improved breakage. In case of concentrated continuous charge, only single pressure loading was observed for rock fracturing unlike that of air-decked charge where repeated loading and unloading by secondary pulses facilitated substantially improved rock breakage. The review paper of Jhanwar (2011) explained in his review paper the theory and practices of air-decking technique for blasting in surface mine.



(a) Full stemming model (b) Air deck model

Fig 4 Pressure history curve of top element of explosive (after Liu and Katsabanis 1996)

So, it can be noticed from all the above references that the air-decking technique of rock blasting followed a different mechanics for transferring energy from the explosive charge to the surrounding rock in which air-decking facilitates the longer working time by the generated secondary pulses on to the surrounding rock rather than sudden release of energy as in case of concentrated continuously charged blast hole. There requires further detailed understanding of the mechanism of air-decking technique of blasting through latest and advanced practices of this technique. In this concern, Singh et al. (2012) simulated the air-decked blast model through the tool of latest finite element in order to further understand the destructive behavior of shock pulses in air-decked region. There were tried to differentiate the blast of full column charge and air-decked charges through two crater blast models with axisymmetricity. It was observed that energy relationship is quite different in air-decking (Figure 5). In case of full stemming, the entire kinetic energy is transferred to stemming portion of the blast hole in the form of fly rocks whereas in case of air-decking, energy is retained and transferred to the rock surrounding the column in the form of repeated loading (Figure 5). It can be observed from pressure profile curves of different target points that air-deck marked the different phenomena of pressure in the form repeated loading and unloading (Figure 6). These repeated loading and unloading invoked the efficient fragmentation rather than instantly shattering of the rock. It was also observed that the stemming capability is improved due to the decay of pressure in air-decked region whereas, there can occurred the premature ejection of energy of explosive due direct contact of explosive energy with bottom of stemming column. The tope element of stemming in Model-2 marked the premature ejection of energy of the explosive due to sudden intense loading pressure.

3. DISCUSSION

It can be obvious from the available references that air-decking technique completely changes the mechanism of energy transfer from explosive charges to the surrounding rocks. Accumulation of energy of the explosives into the air medium and releasing the same in the form of separate pulses which appear in the form of repeated loading and unloading of surround rocks by secondary shock and substantially improve the fragmentation quality rather than instant shattering of surrounding rock and resulting into huge crushed rock as in case of full column concerted charged blast hole. Advanced numerical modeling tools can be used to further understand the mechanism involved in air-decking technique of rock breakage.

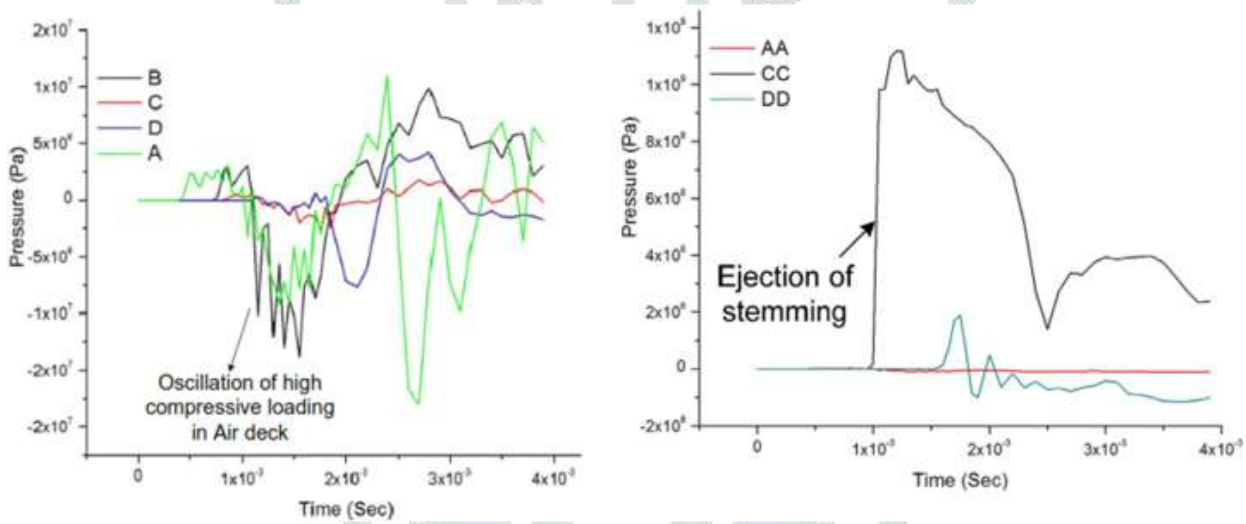


Fig 5 Kinetic energy distribution curve in case of (a) model1- full stemming (b) model2- air-decking

(a) Air decking model (b) Full stemming model

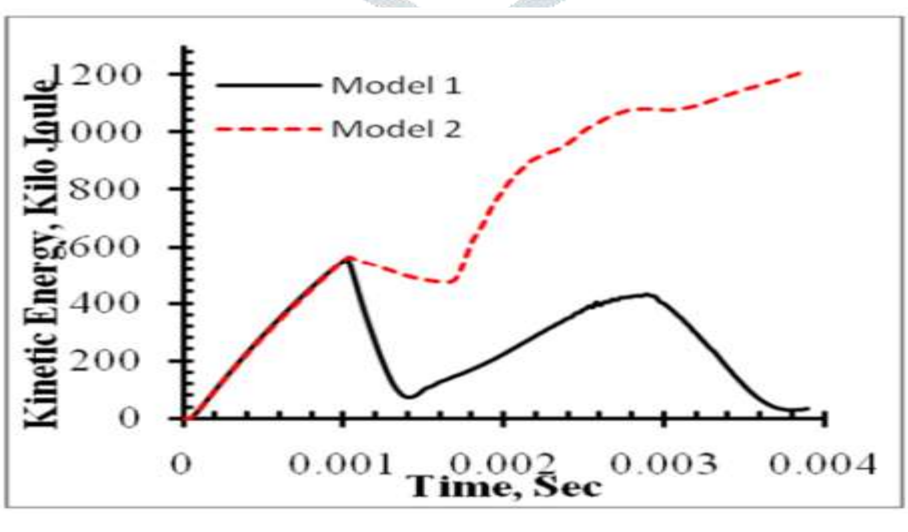


Fig 6 Pressure history curve of different target points (Singh et al. 2012)

4. CONCLUSIONS

It can be concluded from the above literature reviews that air-decking technique of blasting follows a different mechanism of transferring energy from explosives to the surrounding rocks. This unique phenomenon not only increases the utilization of explosives energy but also it has several productive effects on blasting results. Improved fragmentation due to oscillation of secondary pulses in air-decked region for longer time, substantial reduction in blast induced ground vibration, reduction in back break and over break, reduction in explosives consumption, reduction in the demand of subgrade drilling, reduction in the boulder generated from stemming region and many more are such commendable results of this technique. Hence, air- decking technique can be categorized as the best technique for rock blasting. But there is need to understand the mechanism associated with this technique through latest and advanced tools used for numerical modeling.

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