Technology Initiatives for Efficient Blasting Operations and Improved Environmental Control

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1. Introduction

Blasting is one operation which impinges on efficiency of entire operation and results in poor image due to environmental impacts. Adverse environmental effects of blasting ranging from ground vibration, air blast overpressure, dust, fumes, fines and the potential for fly rock may make entire operation as harmful to environment and society. It is important to control all these effects while carrying out blasting operations as increasingly projects are being subjected to scrutiny and at times closure. Conventional blasting practices and techniques in mining and infrastructure construction industry are unable to improve efficiency and mitigate environmental hazards. Poor blasting design and execution not only has negative economic consequences, but is also a safety and environmental hazard. Efficient blasting with reduced environmental effects requires suitable planning, good blast design, accurate drilling, the correct choice of explosives and initiation system, blast execution, adequate supervision and considerable attention to details. With the development of new explosives systems and initiation devices, blast design and execution software tools, the blasting process has now become more efficient and safer. Blasting operations are utilizing technology systems that underpin rock blasting in open pit and underground mine operations, such as predictive modelling, blast design, radio-controlled detonation, real-time monitoring of drilling, charging and post-blast data analysis. Across the blast lifecycle, Information Technology (IT) systems are being used to record, manage and analyse data being generated.

Basic considerations such as choice of explosives, maintaining intended hole spacing in drill patterns, and selection of correct delay timing are good starting points for blast-improvement efforts. Another economical approach is to employ blast design and analysis software currently available, including those that allow pre-blast bench face profiling and post-blast analysis of fragment size distribution. Most are frequently updated to accommodate new technology and data-collection capabilities. It is worthwhile to look at some technologies which are being adopted in the mining industry to make blasting operations efficient and reduce the environmental impact.

2. Efficient Blasting and Environmental Control Strategies

Essentially, the energy released by the explosives is useful for fragmentation, displacement and movement of broken rock whereas wasteful part of energy causes
adverse impacts such as ground vibration, airblast, flyrock, dust and fumes. Operators need to adopt strategies to control the adverse environmental impact of blasting operations (Figure 1). The diagram explains a systematic manner which considers geology and mine planning information, blast block location and environmental information for design of blasts. Based on the blast design, drilling operations take place and measurement of actual drill hole position is recorded. Accordingly, explosives management is carried out which involves delivery, loading and priming. Based on this information environmental impacts can be predicted, which allows explosive and initiation can be changed at the execution level. Several monitoring tools can be used to evaluate blasting results and analyse outcomes to improve overall operations and control subsequent blasting. Key performance indices (KPI) can be determined and continuously monitored by management at different levels.

![Diagram of blast management strategy](image)

**Figure 1** Strategy for optimum blasting operations.

All the information about blast needs to be recorded in an appropriate manner to plan subsequent steps.
3. Information Technology Applications in Blasting

Information technology can be used in every step of drilling and blasting operations. Based on customized blast design tools for any operation blast design, charging and execution can be planned. The design can incorporate environmental restrictions and result goals. After holes are drilled, measurements regarding burden, spacing, hole depth need to be made either by using GPS or manually. There would always be a difference between designed hole location and inclination and actual holes drilled. After actual drilling and blasting parameters are available, predictive tools may be used for fragmentation, vibrations, flyrock and dust. Information can be used for simulation of firing sequence and for checking any unfired holes. If a blast is likely to exceed the respective limits then charging, initiation timing and sequence can be changed to keep adverse environmental impacts within the prescribed limits.

Drilling and blasting data management system ensures information storage and also acts as an intelligent system as an aid for blast design, prediction of impacts and analysis (La Rosa, 2001; Bhandari and Bhandari, 2006). Data is obtained from blast hole face profiling tool, vibration prediction tool, and direct data link to a database incorporating all the major manufacturers products and an interface allowing the user to add new product ranges and create custom products. Misfire and accident details can be recorded.

If data is continuously recorded, then a large number of data will be available, the system can update the scaled distance relationship, based on location variations and ultimately provide the blasting engineer with an interactive means to assist with planning of future blasts.

Another technology that has great importance for drilling accuracy and the integration of drilling and blasting operations is Global Positioning System (GPS) applied to drill positioning on individual blastholes. These systems allow the blast plan with hole locations to be downloaded to the drill. Some form of moving display is used to guide the drill onto the designed hole location. The drill can be positioned to within one third meter of the designed location. Some systems provide for azimuth as well as coordinates in order that the drill can be accurately located on angled holes. If the elevation coordinate is provided for, hole depths can be adjusted for variations in bench topography.

Use of a drilling machine with a GPS guided system can accurately locate the planned location and can determine the exact collar elevation at each drill location. Normally, the drill pattern file containing the designed hole numbers, northing and easting coordinates for each hole and the defined horizon to which all holes should be drilled is sent to the drill via a radio network from the planning office. The drill monitoring system precisely calculates the depth of the drill hole and it significantly reduces over and under-drilling (Rodgers, 1999). After drilling the data of actual drill hole positions and length can be uploaded from the drill to mine planning office via the radio network. The
knowledge of actual locations and spacing between holes facilitates comparison between actual and planned blast design.

Equally important, the system records exactly where the hole is drilled. This is essential for data transfer to blasthole loading operations, because it provides the way to access hole depth and rock strength profile information in the monitoring database (Figure 2). If the elevation coordinate is provided for, hole depths can be adjusted for variations in bench topography. Thus, GPS technology is the key to integrating drilling and blasting operations, and to the possibility of providing for effective quantitative feedback. New technology is helpful in generating good blast designs for transfer to field operations. For example, target less laser survey equipment provides a means to accurately determine the bench faces profile. The laser profiling system provides full-face information including undercutting, back-break irregularities and the nature of toe conditions. This system provides considerably more detailed information than the traditional crest and toe surveys.

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Figure 2. Monitoring Technology at different stages of rock excavation

Proper placement and loading of the front row holes is absolutely essential to good blasting. The laser profiler helps the blasting group design effective front row blasthole locations, or to design explosives loading requirements that reflect actual conditions. The laser systems can also be used to survey the muckpile after blasting. The volume of rock broken by shot can be obtained. The swell of the blasted material can be determined. Swell is a measure of the looseness and therefore, diggability of the blast. Swell can be correlated to excavator productivity and this information can be fed back to blast design for use in designing subsequent blasts in the same area.
Ideally, the blast will be designed with computer assistance using information from laser surveys, geotechnical and other data. The hole locations are placed on blast plans. The final design is downloaded to the drill equipped with GPS capability. The drill machine can then drill the blastholes accurately on the designed locations.

Explosives bulk trucks equipped with on-board computers and suitable communication make it possible to download blast design data. The trucks can then use this information and data from the drill to properly load the individual blastholes.

The overall success of a blast is usually assessed by the speed and efficiency of subsequent digging operations. Thus the fragmentation, position, shape and looseness of the rock pile must be suited to the equipment available. These parameters and equipment productivity can be measured by various techniques, to make a more objective overall assessment of blast performance. Image analysis is now usually used to assess the size of fragmentation.

Mine to Mill concept quantifies and models blast fragmentation and applies this knowledge to optimize the combined performance of mine and comminution circuit. Online image analysis system provides measurement of the size distribution of the ore. Fragmentation and comminution models allow management of optimization and control to increase productivity. Modelling of blast fragmentation and comminution together use ore characterization, blast simulation and mill simulation of mill has been demonstrated by number of case studies. Substantial benefits in improved performance and reduced costs have been achieved.

4. Explosives and Accessories

If the mine is new, selection will have to be made between cartridge and bulk explosives depending on the proposed volume of excavation per month. Once this is made, the choice can be exercised amongst ANFO, HANFO, slurry and emulsion depending on the characteristics of rock vis-à-vis its response under dynamic loading during blasting.

The most significant changes in the blast technology have taken place in product-delivery systems. One factor is the continuing trend away from the use of cartridge products in favor of bulk products for both surface and underground operations: new surface and underground delivery-vehicle technologies that boost blast accuracy and safety: high-precision pumps and blending and measurement devices, robotic arms that place the product in the hole, and remote controls. The blasting agent throughout the industry would continue to be ammonium nitrate fuel oil (ANFO) mixture or ammonium nitrate-based emulsions, and this basic explosive chemistry is unlikely to change in the coming decade. When considering blasting technologies, operating companies tend to be highly cost conscious, which mitigates opportunities to develop value-added or innovative products.
Electronic detonators are now commercially available (Cunningham, 2004). Advantages include precise delay timing (resulting in increased blast efficiency and control) and greater compatibility with remote-controlled loading of explosives and wireless detonation. However, these initiating systems have higher costs. Whilst most of the efforts by the manufactures are being directed towards enhanced fragmentation, there are undoubtedly areas relating to environmental control that, with more directed research, can bring benefits to operators, regulators and local residents. The successful use of electronic detonators to control ground vibrations from blasting is a classic example of research leading on to commercial deployment for the benefit of all the stakeholders (operators, regulators, consultants and local residents). The trend towards use of electronic detonators has not been to replace other systems as signal tube or shock tube which has its own advantages.

Selection of initiation system and timing need to be made keeping in view the environmental constraints. The site-specific relation between burden and burden response time can determine the delay between different rows. The time delay should be selected on the basis of response time and the desired throw of muck pile. For proper fragmentation and throw, the time delay should be higher than the response time so that by the time the next row detonates, the front row has just started getting detached from the rock mass causing movement to take place in order that the row under detonation gets proper relief for movement to avoid choke blasts and severe back break.

Another trend is outsourcing of blasting-related services, ranging from consulting on safety to providing comprehensive packages priced according to the volume of “rock broken” on the ground or ore processed. Explosives are a mature technology. As a result, providers are shifting their business focus from products to service.

5. Surface Blast Design Software

Optimum blasting just does not happen. It requires suitable planning, good blast design, accurate drilling, the correct choice of explosives and initiation system and sequence and proper supervision. An approach is needed that considers the factors that interact with one another during blasting. The rock type and structure; size, length and inclination of blast holes, drilling pattern and accuracy, type, quantity and distribution of explosives; charging and initiating techniques all play a significant role in the overall efficiency of a mining operation (Bhandari, 1997). During the design stage environmental constraints such as vibration limits or flyrock restriction with respect to any structure can be prescribed. Blast design software can be used as a tool to assess the likely impact or effect of a particular design on results in terms of fragmentation, movement and other environmental impacts. This is in conjunction with field observations, experimentation and monitoring. Blasts can be designed while using scaled distance tools so that ground vibrations and airblasts are within the limits. Information Technology can be used to design blasts based on historical data collected over a period for each geotechnical strata and to provide optimized drilling and blasting patterns. There are several blast design software tools. For example Surface Blast Design Software (BLADES) provides
design of blasting pattern according to rock conditions, rock structure, and results required for optimized results, considering explosive properties, drilling, environmental restrictions and equipment and subsequent operations. The software helps to calculate and draw blast parameters. The software has the ability to generate a firing pattern for a blast. It allows to vary delay timing and sequence and the pattern drawn can also be saved and blaster can be provided with charging sheet. It also provides the first movement of rock. The software shows the simulation (animation) of ignition sequence. The program provides output, charts and graphs, as well as reports in real-time and allows output of data via customizable printing capabilities. Figure 3 provides a typical blast designed by this software.

Figure 3 Surface Blast Designer software BLADES provides design for a blast block

BLADES software has modules which predict approximate vibration values, fragment size and approximate danger zone. Initially the software uses empirical constants. However, after historical data have been accumulated, the software can be used to determine specific constants for each pit/bench. Software has drilling and blasting cost analysis capabilities. Software can import/export drill hole data, GPS data, total station records, face profiler records in excel or .csv file. The software can give charging sheet for blaster for loading explosive in each hole and also provides initiator connection. Other blasting software use information to create charge standards to design specific hole by hole explosives loading and create load sheets according to geotechnical zone characteristics and required results. Users can view the animation and subsequently
make changes in both the order and firing pattern before the pattern is released. The software provides the ability to calculate the true volume of a blast as planned.

The software allows users to set pattern burden and spacing by rock, allowing greater control over a blast involving different material types. For reporting purposes, each material may have a different specific gravity. The different material can also be assigned different drilling costs per meter, allowing greater accuracy in budgeting for drill and blast and more ability to anticipate areas of higher cost. The software also provides reports as needed for individual operations or as per format of regulatory authorities.

6. Blast Information Management System (BIMS)

Blast Information Management System (BIMS) provides information to meet the strategic and operational needs for planning, controlling and decision-making for optimizing mining operations (Bhandari and Bhandari, 2006, Bhandari, 2011). It provides methods to store, manage, document and retrieve drill and blast related information. The system stores blast details, actual blast parameters, blast pattern, face profile, explosive consumption and charging details (Figure 4).

![Figure 4 Blast Information Management System (BIMS)](image)

The stored blast information data can be retrieved quickly and easily. Performance and cost of blasts can be monitored and appropriate blast designs for particular areas or different zones can be identified. The data management and retrieval is easy and simple to use which can be carried out in a few minutes which helps in optimizing various operations. Readily available past data in a logical format and blasting data analysis tools are the key features of the database. The database can be extended to integrate with other systems such as ERP, CMMS etc. If the software is operated in conjunction with a comprehensive monitoring program, it can contribute to the efficient
running of an operation and reduce environmental effects to a minimum. Importing data from .csv file, Excel and other mining software makes it is possible to reduce input work. Entered data can be edited through edit parameters functionality. The database can be tailored according products and practices, to customer requirements and can be maintained. This database also has searching options using which the user can look for the records of blasts as per his defined criteria. The software can use several criteria for the search option: between dates, by performance of explosives or initiating system, by vibration limits, by fragmentation size, by location of blasting zone or accident etc.

Protection and regulatory authorities are increasing their expectations for strict accounting of inventory and blast documentation. Using BIMS, presentation of analysis of data, compliance reports suitable for regulatory bodies, archiving and viewing of data at distance location, costs can be developed. Reports suitable for Occupational Health and Safety (i.e. incident reports) can be compiled. Key performance indicators are derived. Thus BIMS provides a way of trapping the experience of drilling and blasting personnel to better control critical parameters such as dilution, vibration, fragmentation, and flyrock and fines generation. Integration with other software such as those used for vibration monitoring and analysis, fragmentation analysis etc is possible to provide simplified management system. The system also provides defensible data that can be provided to regulatory authorities to illustrate the mine operator’s compliance with regulations.

7.0 Assessment and Audit of Existing Blasting Practice

While planning each blast, accurate assessment of past performances need to be made. An audit of existing blasting practices is suggested to be carried out with video camera, face profiler, borehole location and deviation measurements. Further, assessment should look into the variation between the designed and actual charge distributions. The drill hole deviation alters the planned burden, spacing and depth of holes thus resulting in suboptimum results. After holes are drilled it is important to know their deviations so as to suitably alter the charge distribution in the holes or initiation system. It is considered prudent, if not essential, to regularly monitor and audit blasting performance against design criteria and anticipated results.

8. Prediction and Control of Environmental Impacts

There is often difference in designed and actual drilled holes. Actual drilled data need to be checked whether the resulting blast will result in exceeding the set environmental limits by using predictor software. In case the environmental limits for vibration and flyrock imposed by regulatory authorities or by the management exceed then explosive charge quantity, distribution and initiation timing and sequence can be changed so that limits are not exceeded. These software can be used on desktop and are web based are also available. It is also possible to collect blast data through iPad or smart phones and analyse data before and after blasting.
8.1 Blast Vibration Prediction and Compliance

Comprehensive blasting vibration predictor, analysis and reporting software meets the needs of both operators and regulators (Birch et al, 2002). It supports and improves compliance with blasting related planning conditions and contributes to improved blast performance and blast design. Key features include:

Regular updating of predictions using ongoing site data, providing minimum instantaneous charge (MICs) to the operator that ensure compliance with vibration level restrictions by design rather than by accident. The system’s advanced analysis also allows blasting on individual benches or areas to be assessed (Figure 5).

![Figure 5 Determining Scaled Distance](image)

8.2 Wave Reinforcement Predictor

Wave front reinforcement has been found to cause substantial increases in both air and ground vibration from both surface and underground blasting operations (Richards and Moore, 2004). Simple alterations to firing patterns can prevent wave front reinforcement which can be used to control vibration (ground and airblast) levels in many situations. Pattern Analyser is a graphical software program for the design and editing of blast
designs. With the help of this software, engineers and blasting personnel can optimise the layout and initiation sequence of blasts. Analysis of data imported from other blast design software can also be carried out.

By change of delay timing or sequence, wave reinforcement can be avoided thus lowering of vibration levels Figure 7.

![Figure 6](image_url) (a) Wave reinforcement (b) Non-reinforcement by change of delay timing

### 8.3 Flyrock Prediction Software

Inputs to the software are charge mass, burden or stemming height, and a site constant that lays within a general range that can be fine-tuned by site calibration and the output is flyrock distance (Richards and Moore, 2004). This 'design your own flyrock' quantification can be used to establish both safe clearance distances, and the critical range of burdens and stemming heights. The zone of flyrock travel is indicated by this tool. Using safety factors, danger zones for machinery and person are indicated respectively. If it is not possible to remove any structure or person, then one can modify the charging of holes.
8.4 Dust Plume Movement

Blasting operations can generate large quantities of fugitive dust. When this dust is released in an uncontrolled manner, it can cause widespread nuisance and potential health concerns for on-site personnel and surrounding communities. Though the blasting dust plume is raised for a few minutes but most of the dust settles in and around mining area and some of it is dispersed before settling down. Depending on meteorological conditions, the dust dispersal can travel to substantial distances endangering health of communities. Generation of fines and dust is influenced by several blasting and rock parameters (Bhandari et al, 2004).

Meteorological conditions such as wind speed and direction, temperature, cloud cover and humidity will affect the dispersion of airborne dust. Atmospheric stability affects dispersion of the emitted plume, determining the extent of the vertical and horizontal, transverse and axial spread of the emitted particulates. Thus, the dispersal of dust plume resulting from blasting is an important area which needs attention. A computer model has been developed to simulate the dispersal of dust (Kumar and Bhandari, 2001, 2002).

Data input is divided in three parts: blast data, atmospheric data and ground contour data.

Blast Data: Total quantity of dust released, Distance from the blast to the point of observation, Angle of top of column of dust of the blast, Latitude of blast site, Height of blast site (above mean sea level).

(ii) Atmosphere Data: Surface Pressure, Variation from mean wind speed: Standard variation of speed in meter per second. This is obtained by observation at the blast site
in the straight line. Wind speed at 850 hPa, Saturation Mixing Ratio, Mixing condensation level: Surface Wind direction: Height of 850 hPa above MSL.

c) Ground Contour Data: This data is collected by the user before the blast with the help of contour map.

Then the software computes the values of the concentration at different distances in the down wind direction at level (zi) at horizontal interval of _____ m and at lateral distances from the central line on either side at the lateral interval of _____ m up to _____ m for all (zi) varying from 2m agl (above ground level) to 24 agl in steps of 2m. 3D axis on the point of blast is drawn and converts the x; y coordinates to 3-D coordinates and plots them on the 3-D coordinate system. Then the movement of plume at different levels is distinctly shown. The software displays 3D movement of plume. A typical display is given in Figure 8.

This prediction allows one to vary delay blasting and/or to avoid blasting during adverse atmospheric conditions.

Figure 8. Dust Plume movement

9. Measurement Before, During and After Blast

Field monitoring and control tools, if properly used, can be valuable in the optimization of blasts. Information must be collected during drilling about the rock strata to decide loading pattern of blast holes. If the field control is poor and implementation of the
design is improper, even a very good design will not produce the desired results. Blast should be executed and monitored meticulously. The measurements which can be used to improve blasting execution include:

### 9.1 Pre-Blast Records

- Geology and rock properties
- Blasthole logging of rock properties
- Blasthole audits (accuracy of drilling)
- Explosive charge verification
- Down hole explosive product densities/pressures

Pre-blast monitoring should also be done cautiously to check deviation in the values of design parameters from the actual ones (Rodgers, 1999). All details like hole position, hole depths, nature and condition of holes, type and quantity of explosives; initiation system, sequence and delay timings are to be recorded. Prior to the introduction of new methods & technologies as working tools in mines, it was not possible to directly measure to inaccessible locations on rock faces. If a person could not occupy the point, only indirect measurements could be made. This led to direct and significant problems with blasting, including fly rock and air blast, excessive vibrations, inadequate fragmentation and tight digging, back break, coal damage (all of which may be caused by excessive front row burdens). Blast planners have increasing capability—and availability—of simplified photogrammetric/stereo photogram- to profile bench faces and other terrain features of interest. A highly automated workflow that begins with the simple task of photographing, say, a bench face from slightly different angles with a calibrated digital SLR camera, then using sophisticated algorithms in software to process the photos into a 3-D image, and applying the resultant information to fit drill-pattern layout to the actual bench face geometry.

In cases where larger areas or complex shapes extend beyond the information available from a single stereoscopic image pair, the area is recorded by several overlapping 3-D images. Once the 3-D image of a bench face is generated, users can employ Blast Planning software, entering basic geometric parameters such as burden, spacing, or inclination of the boreholes and allowing the system to place them accordingly. Each borehole is profiled, and hole locations are viewable in 3-D and plan view.

### 9.2 Monitoring During the Blast

- High speed photography/ videography  
  (initiation, time to first movement, stemming ejection, flyrock movement)
- Velocity of detonation
- Face velocities
- Flyrock
- Airblast
- Ground vibration
As a part of blast monitoring process, utilising modern video technology, which provides high-definition, high-speed (ultra-slow motion) capabilities, makes it possible to calculate first burden movement times and face velocity profiles. A video archive can shed light on a pit’s ‘blastability’, fuming and dust generation propensity, for a quick qualitative overview of many key blast performance indicators—Timing accuracy, face profiles, flyrock and fuming timing and origins, and the final muckpile shape. If the video records are archived, they can be used to identify blasting problems in particular areas of the pit.

As part of the blast lifecycle, miners are additionally undertaking ongoing analysis derived from routine monitoring. Monitoring systems, conveying a variety of data via 3G, radio, or satellite links, process information in real-time. In one case, Blast Monitoring Program has six dedicated monitoring units permanently installed at specific locations throughout a coal mine, feeding back into an automated web-based system, providing real-time vibration and overpressure data.

![Continuous Monitoring Blast Vibration meter with GPS included](image)

Utilisation of modern communication and web interfacing can enhance blasting efficiency. Monitoring blasts with modern web enabled blast monitors can save operators a significant amount of time, improve their efficiency and provide near instant feedback on the blasts.

Historically, monitoring of ground vibration and air blasts were performed by monitors which were installed on site and the data were downloaded after the blast event. However, improvements in communication and software technology have now enabled blasting data to be monitored online via a web portal.

Modern blast monitors can now be installed on site which continuously and automatically supervised by a remote software package on a web server. This server software communicates both with the remote monitoring stations and users via the
internet. Blast results can be automatically collected from the stations, collated and are then available to users within minutes of the blast. Users view blast results, produce reports and interact with the server software via the web browser.

Using ‘internet aware’ mobile devices that have GPRS or 3G capability, such as a notebook PC, pocket PC, PDA or mobile phone, blast results can be retrieved from the office, home or vehicle – regardless of the geographical distance of the user to the blast site. This allows the users of these types of devices to retrieve blast results and control the blast monitoring system from virtually anywhere.

The use of this technology provides near real time data to mine operators, enabling them to access the impact of each individual blast and take corrective actions should a blasting campaign threaten to exceed local regulations. The system also provides defendable data that can be provided to regulatory authorities to illustrate the mine operator’s compliance with regulations.

Blast Vibration Monitor permits the measurements of air overpressure and ground vibration resulting from all blasts, with a waveform record that permits the peak levels recorded to be verified. The new blast vibration monitor continuously records full waveform data, and does not require triggering to record an event. This ensures that a full waveform record is available for all blasts. In-built GPS unit provide accurate time and position details. Remote transmission of recorded data is possible.

In another case, consists of five real-time dust samplers, transmitting back to a central database, sending an alarm (on the basis of a rolling three hour average) to environmental personnel when particulate matter levels reach trigger levels at neighbouring residences.

9.3 Post Blast Measurements/Observations

- Muck pile characteristics (Geometry, height and displacement/ swelling)
- Induced cracks and overbreaks (rock damage at blast limits) and toes, floor
- Fragmentation/size distribution; oversize/fine assessment
- Loading performance of excavator
- Crusher performance

The fields of applications of new technologies can be listed: muckpile shape, muck pile profiling to determine throw, cast blasting, muck-pile models to determine swell & blasting effectiveness, flyrock and oversize, new computer aided techniques to better calculate actual burdens at all points on rock face.

Quick and accurate measurement of fragment size distribution is essential for managing fragmented rock and other materials. Various fragmentation measurement techniques are used by industry/researchers but most of the methods are time consuming and not precise. However, several automated image based granulometry system use digital image analysis of rock photographs and video tape images to determine fragment size
distribution are being used by industry. Recently technique has been adopted with video camera and fragmentation size and quality assessment directly on shovel, with continuous, detailed fragmentation results combined with shovel GPS information produces results that are attributed to a specific area of the pit, ore-type and blast. The embedded computer is designed for a high-vibration environment, has no moving parts and is sealed for dust and moisture resistance.

10. Conclusions

Blasting operation limits for vibration and flyrock imposed by regulatory authorities or by management needs to use innovative technology. Blast engineers are ideally trying to predict three outcomes in blast design: fragmentation (the size distribution of the blasted material), movement (where the grade and waste will end up), and environmental impacts.

Use of information technology for storing data, design, analysis and prediction of results helps in better control and optimization of mining operations. Data base helps to quickly respond to information and remain successful in today’s competitive market place. By the use of information technology many projects can reduce complaints and improve efficiency. It is worthwhile to look at some technologies which are being adopted in the mining industry to make blasting operations efficient and reduce environmental impact. Use of a drilling machine with a GPS guided system can accurately locate the planned location and can determine the exact collar elevation at each drill location. The overall success of a blast is usually assessed by the speed and efficiency of subsequent digging operations. Thus the fragmentation, position, shape and looseness of the rock pile must be suited to the equipment available.

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