A fragmented approach

Control, prediction, and imaging of rock fragmentation in blasting is ever more important in mining as a way to provide more consistent mill feed and reduce downstream comminution costs with more effective particle size reduction in the pit, reports Paul Moore

In essence, thermal fragmentation replaces or improves the room and pillar (flat or reef), small long hole mining and shrinkage mining methods

This month's issue includes article on both fragmentation and comminution, and the relationship between the two is crucial in the industry due to downstream energy savings with better planned and managed blasting. Professor Alban Lynch felt strongly that mineral processing in the future needed to be linked to mining and as early as 1975 the **JKMRC** extended their comminution modelling research to blasting as it is the first in the sequence of size reduction, or comminution, processes. A feasibility study was carried out with support from the Mount Isa and Mount Newman operation and the blasting study became a large and long running AMIRA project. The research was very useful to blasting engineers but it was still many years before any meaningful development of any integrated approach between blasting and crushing and grinding.

The link between varying n explosive energies and fragmentation has been well addressed in ***IM***, and this year's Coalition for Eco-Efficient Comminution (CEEC) Medal has been awarded to **Orica's** Dr Geoff Brent and his research team for ground-breaking research using a novel method of Ultra-High Intensity Blasting to improve mine productivity. Orica Managing Director Ian Smith said the quest to use the chemical energy in explosives to improve ore fragmentation and deliver a step change in mine processing efficiency was a priority for the global resources sector. "Independent modelling has indicated that increasing the explosive energy by several fold can lead to increases in mill circuit throughput of up to 40% and savings of tens of millions of dollars annually." Speaking on behalf of the research team, Dr Brent said: "By utilising explosive energy in the pit to produce much finer ore we can dramatically increase the efficiency and throughput of the downstream comminution processes of crushing and milling. The overall energy consumption across the mining and milling cycle can be reduced with a consequent reduction in emissions. This is a step-change in ore processing."

Fragmentation and software

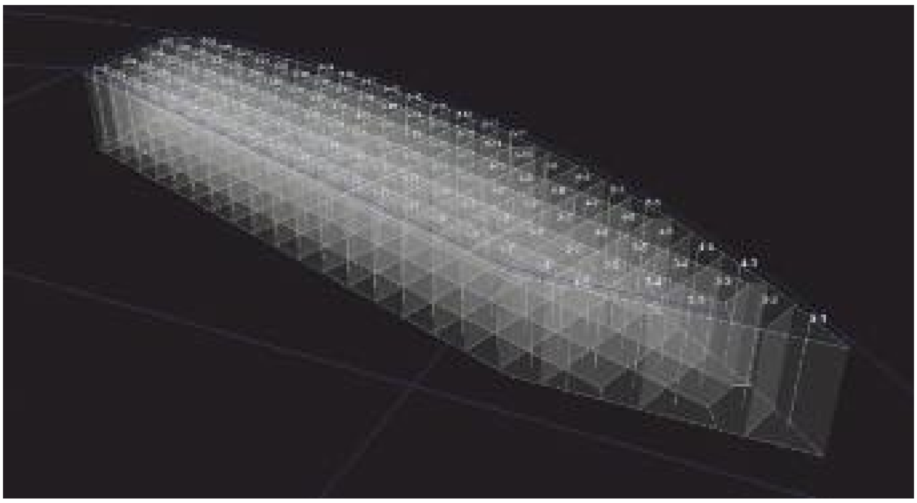
Blasting as stated is the first stage in comminution, the reduction of solid materials to smaller particle sizes, and it requires energy and money. Blasting is an efficient way to reduce the particle size of ore material and, if done well, mines will save significant amounts of money on crushing and grinding costs. **Hexagon Mining** is integrating the design process in MineSight, the drilling process in Leica Jigsaw, and the reconciliation of these in a new product, HxM Athena, to help mining companies close the loop and improve their drill and blast processes.

Hexagon Mining, which unites industry leaders MineSight, Devex Mining, Leica Geosystems Mining, and SAFEmine, told ***IM*** it views the drill and blast cycle as integral to its vision of smart change. The company expects to unveil HxM Blast at MineSight's annual seminar, MineQuest, in Tucson, April 13-17, 2015.

"HxM Blast will bring precision and dependability to one of mining's most challenging steps. Incorporating a modern design interface, HxM Blast will design and manage drill and blast patterns interactively on screen while storing all of the design (and actual) information in a SQL database", says the company.

"Blasting is a critical stage in most mining operations," says Mark Gabbitus, MineSight Senior Product Manager Geology and Operations. "Poor fragmentation of ore and waste material can wipe millions of dollars from the value of a mine. The design of the blast does make a difference and HxM Blast is one of the products we are unveiling at MineQuest 2015 to help. HxM Blast replaces and enhances the functionality of MineSight's ever popular Blast Pattern Editor, and will make life easier for the drill and blast engineer. We plan to add charging, tie-in and blast optimisation features, which will enable operations to blast smarter and more efficiently. HxM Blast will revolutionize the design and execution of drill and blast plans. Within a single interface, you will be able to design drill patterns, apply charging parameters to holes, and do the tie-in of a shot. You can then update the charge based on as-drilled information received from J2Drill or other drill fleet management systems."

HxM Blast will feature direct links to drill fleet management and explosive vendor systems, which will enable easy automation of data transfer between the design tool and the operators. Users will see what's happening in the pit in near real time and make intelligent business decisions.



Viewing volume of influence solids and polygons will be among the compelling display features in HxM Blast

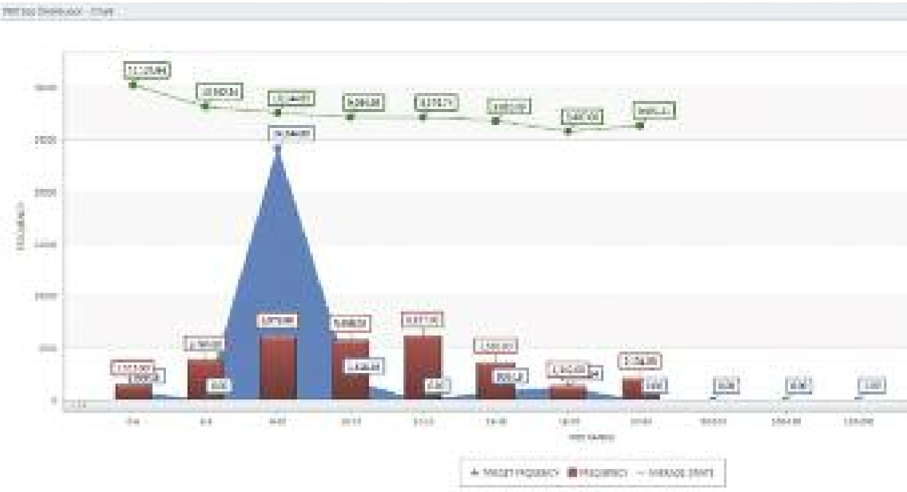


Chart in HxM Athena showing the digrate falling as the fragment size increases. It also shows the difference between the predicted or planned fragment size vs the actual fragment size. This shows how not blasting to plan can affect the mining plan downstream

Several factors affect the quality of a blast. The geology and geotechnical characteristics of the rock are unchangeable, but the blast pattern parameters, such as hole spacing, depth, diameter and amount/type of explosive used, can be modified. The ability to change these parameters dynamically in response to as-drilled information is critical to achieving good fragmentation.

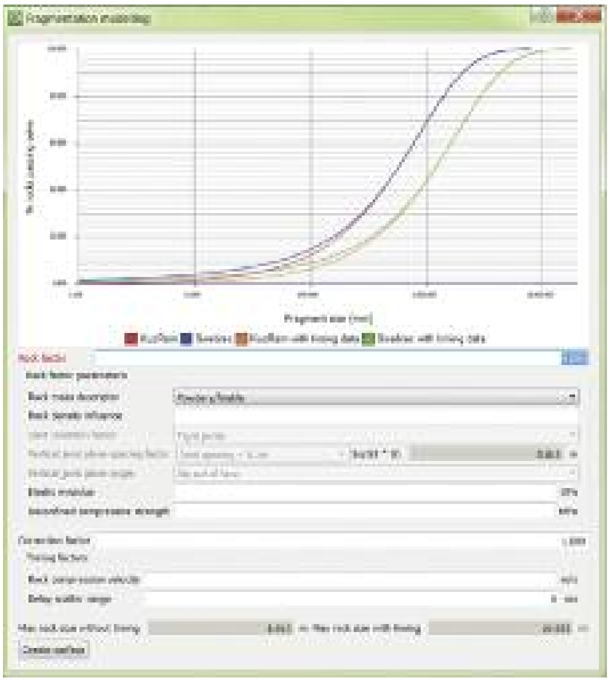
Future releases of HxM Blast will include blast simulation, and analysis and optimisation to reduce the workload on drill and blast engineers, enabling them to change or optimise blasting parameters at critical stages.

"HxM Blast will redefine blasting," says Gabbitus. "A bad blast can undo all of the good work done by geologists and engineers to develop a robust block model and mine plan.

Beyond HxM Blast, Hexagon Mining is also investing in HxM Athena for production reporting and analytics. HxM Athena is designed to gather data from multiple sources into a single data repository, analyse the results, and present them in easy to use dashboards. One such dashboard compares the predicted rock fragment sizes to the actual rock fragment sizes and most importantly to the production dig rates. This way, managers and operators can track how a bad blast affects mining productivity and will hopefully be able to change methodologies and processes to improve the results next time.

The technical mining systems landscape changes almost as quickly as an advancing mine face. Mines are looking for more connected, efficient and integrated systems to fine tune their processes for performance improvements. **Maptek** told *IM* that its BlastLogic blast accuracy and management system provides a platform for achieving optimal fragmentation for each blast while minimising the loss and dilution of minerals. "Getting the fundamentals of drill and blast right every time is crucial," said Maptek Product Manager for BlastLogic, Mark Roberts. "Better blast performance ensures optimised fragmentation, which in turn leads to easier handling and processing of excavated material. Improving fragmentation for example has a direct impact on 'diggability' and can lead to shovel gains of over 9%," he added. The release of BlastLogic 2.0 at the end of 2014 allows mines to track a wider range of metrics for achieving overall productivity gains.

Maptek states: "Only BlastLogic supports blast-by-blast analytics, allowing comparison of



Maptek BlastLogic distribution curve

blasts across the mine to correlate design, execution and results. For example improvements in fragmentation can be targeted and tracked using the blast modelling tools. Fragmentation model produce two formats for analysis – a distribution curve of fragment size and a coloured grid for easy identification of variation across blasts." Together with the vibration and airblast/overpressure models in BlastLogic 2.0 this helps mines determine if the design will produce the desired outcome.

"BlastLogic effectively provides a live window to what's happening in the field," continued Roberts. "Immediate access to production data, analysing results in real time and making changes on the fly mean all teams involved in the drill and blast process are working in sync."

The easy to use new tie up tools where users can quickly create and compare multiple design scenarios, before finalising blast designs are another example of this.

"Sharing and analysing data instantly at critical stages helps clarify priorities. BlastLogic puts operations in a prime position to make decisions which ensure they get the best drill and blast performance for their outlay."

This performance can be analysed to ensure that every aspect of the drill and blast process is fine tuned to reduce costs in downstream processing and continuously improve overall mine productivity.

Electronic non-electric detonator based on shock tube and detonator cap with electronic delay is used during surface blasting , as well as underground blasting in gas- and dust-safe mines.

Continuing a 140 year-old tradition, **MAXAM** says it continues to develop solutions to improve drilling and blasting. MAXAM has launched RIOBLAST, an integrated blast design and management software suite. RIOBLAST can be customised, helping productivity and communications. Advanced versions of RIOBLAST offer "unmatched analytical capabilities, seamlessly integrating data from laser profilers, topographic surveys, satellite photos, explosive characteristics and rock properties" says the group. It can also be used to match explosive energy to rock, creating differentiated geotechnical sections in a single blast. Recently, RIOBLAST has been used to design and track drilling and blasting performance in hard rock (dacite). The goal was to improve crusher throughput. Previously, ANFO was used for blasting this rock. As part of a comprehensive redesign with RIOBLAST, ANFO was substituted by RIOFLEX and drill patterns changed to reduce fragmentation by 20% (x80 reduced from 5 in to 4 in, as measured by photo analysis). RIOBLAST was used to successfully predict reduced fragmentation sizes, vibration levels, and safety clearance zones. It helped design and track a complete drill and blast program with new explosives, drill and loading patterns and tie-up schemes. RIOBLAST consists of eight integrated modules which permit the user plan, design, implement and track individual blasts as well as long term drill and blast projects. "Working with RIOBLAST is easy and intuitive – blasters, explosive engineers and mining technicians can start using RIOBLAST immediately after a short training period."

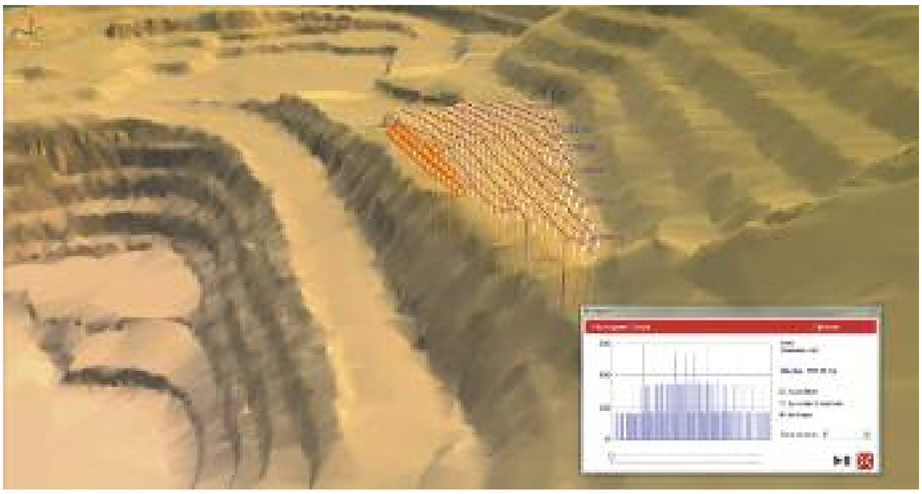
Orica's high intensity fragmentation

Global mining explosives leader **Orica Mining Services** offers Ultra High Intensity Blasting (UHIB) – a novel blasting technique that safely utilises blast energies or powder factors that are up to five times higher than those used in conventional blasting delivering much more intense fragmentation of the ore. In product terms, the company states that its customers continue to see fragmentation improvement with Orica's High Energy Bulk Systems, its high energy range of bulk explosives, Vistis™ and Vistan™.

The company also highlighted what it calls a multifaceted approach to fragmentation: "The Orica suite of products and services, including Electronic Blasting Systems, sophisticated blasting techniques, fragmentation measurement and interpretation, blast modelling, and quality control, help customers to improve fragmentation at their operations."

In February 2015, Orica's Chief Mining Engineer Stephen Boyce delivered a *Mining thought leadership presentation* at the 2015 Mining indaba in South Africa to demonstrate a new advanced blasting technique called 'Ultra High Intensity Blasting'. UHIB ensures controlled delivery of fragmentation, movement, flyrock and vibration and is a dual layer blast with the first layer providing a protective "blanket" or buffer for a second blast layer of higher powder factor. It requires advanced design and modelling with electronic delay timing. As already stated, this technique won the 2014 CEEC Medal.

Dr Geoff Brent at Orica states: "This buffer avoids flyrock while allowing us to use powder factors in the lower layer that are up to five times higher than those used in conventional blasting, delivering much more intense fragmentation of the ore. Meanwhile, independent studies have found that increasing these powder factors in the range of 2 to 5 kg per cubic metre of rock can produce much finer rock fragmentation and



MAXAM RIOBLAST has been used to track drill and blasting performance to help improve crusher throughput increase mill throughput by 20 to 40%." Dr Brent added that blast modelling and field trials had also shown that control of surface ejection and vibration levels were better with the UHIB method. "These results are quite remarkable, given the large increases in explosive energy, and reveal that highwall damage as well as vibration and potential damage to key mine infrastructure can be safely controlled when using this method."

Over the past four years, Orica has been trialling UHIB at copper mines in Latin America, working closely with mine operations. "The trials have shown that blasthole patterns as tight as 4 m by 4 m, with hole diameters of 250-300 mm can be drilled, loaded and fired successfully, and no explosive or initiator malfunctions have been observed. They have also shown that UHIB blasts can control flyrock and vibration better than conventional blasting methods. The early results from the field trials had also indicated that rock fragmentation from UHIB was finer. For example, a fragmentation vision system installed at a mine's SAG mill feed recorded a 7% point increase in the size fraction under 25 mm entering the mill from the UHIB trial section. Another series of full scale production blasts at a mine in Central America showed increases of 10 to 15 percentage points in the size fraction under 50 mm.

To date, Vistis™/ Vistan™ bulk systems have been deployed in four countries (Australia, Chile, Peru and Canada), across 10 sites, in more than 130 blasts, 30,000 blastholes and 20,000 t of explosives. At Codelco Andina in Chile, Orica provides a Rock to Spec service with KPIs to supply broken rock to agreed specifications. Combining the expertise of Orica technical services team, with the higher energy of Vistan™ 225 and the accuracy of the i-kon™ II Electronic Blasting System the mine has seen signification improvements in fragmentation. Averaged across the trials of Vistan™ 225, there was a 5% increase in mill throughput and an 8.5% reduction in specific energy consumption. This equated to incremental revenue of $2.2 million per month for the customer.

Thermal fragmentation

Rocmec Mining as of April 2014 has been operating under its new name of **Nippon Dragon Resources**, and continues with its work on thermal fragmentation as the holder of an exclusive license for the thermal fragmentation mining method for exploiting narrow-vein ore deposits. The extraction process allows thermal fragmentation with an accuracy of 2 cm to quickly extract mining corridors in hard rock wider than 110 cm using soft blasting between a pattern of thermal fragmented holes.

In essence, thermal fragmentation replaces or improves the room and pillar (flat or reef), small long hole mining and shrinkage mining methods. "With this precision, high grade precious and base metal veins can now be extracted without dilution. The thermal unit can be set up to extract a specific corridor." The major advantages of this process as described by Nippon Dragon include production of highly concentrated ore which results in 400% to 500% less dilution compared to shrinkage mining methods. The process simply requires regular diesel fuel and compressed air.

A 150 mm pilot hole is required to guide the thermal head for which an ordinary mining drill is sufficient. For production purposes, the pilot hole must be within the mineralised structure. For openings and development work, the fragmented hole will serve as space for rock expansion after blasting.

The lance head is inserted into the pilot hole then the head is ignited and compressed air is added to create a thermal 'cushion.' The lance head is inserted for 4 minutes during which time the pilot hole enlarges to 300 mm. The maximum width is 1,200 mm in approximately 10 min. There is no angle limitation and little or no wall damage that can be caused by blast vibrations.

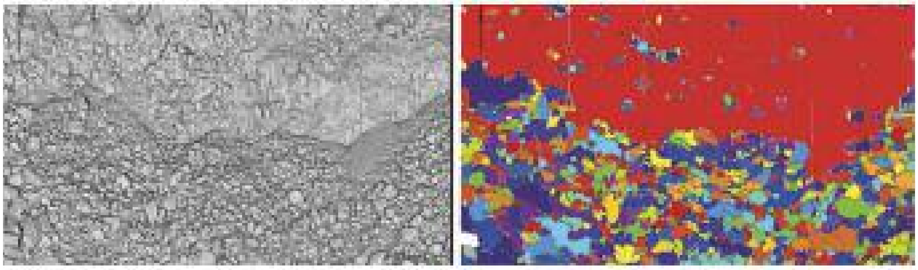
Since less rock is extracted, important savings are realised throughout the entire chain of production. The compact size of the ore (0-13 mm) and concentration of the material brought to the processing plant increases the production capacity of existing installations and output of ounces.

The thermal fragmentation mining process requires a three person team including the pilot hole driller. The thermal unit is fully mechanised reducing the risk of physical injury traditionally observed in labour intensive shrinkage mining methods.

Since less waste rock is extracted and development is performed directly into ore, the process produces significantly less mining waste (1:5). Therefore, fewer chemical products per ounce mined are needed and fewer alterations are made to the terrain, making for smaller tailings and waste piles.

Most recently the company provided an update on its exclusive agreement with **MaXem** for its patented thermal fragmentation mining method. MaXem successfully tested the Thermal Fragmentation mining method in South Africa in 2014 and is working to secure future work with this technology in 2015 not only in South Africa but also in Zimbabwe, Botswana, Mozambique, South West Africa, Zambia, Tanzania and the DRC. "Our initial tests and surface demonstration conducted in 2014 enabled us not only to confirm the potential of the thermal fragmentation mining method but also to identify various key services which would benefit the industry such as rock distressing and drop & inverse raises. In 2014, we were able to successfully fragment a reef corridor during which time many lessons were learned to adapt this new mining method to the conditions found within our territory. This success has impressed the mining industry and as a result, our exclusive licensing agreement with the thermal fragmentation mining method has now opened new opportunities for us. MaXem is excited to offer thermal fragmentation services to the industry with its ability to solve many problems including productivity, security, environmental and mechanisation in mining operations," stated Mark Van Schaik, MaXem's Managing Director.

In November 2014 Nippon Dragon provided details of a thermal fragmentation demonstration



Example of automatic identification of compressed fines (red area)

conducted at the facilities of Bourgeois & Sons in Val-d'Or, Quebec, at which approximately 40 mining industry participants and investors attended. The first portion of the event was the unveiling of an animation video created by Trellisys Technologies describing, in simplified form, the overall process of extracting mineralised corridors containing high-grade narrow veins. The unveiling was followed by a "live" demonstration of the thermal fragmentation mining method. A block of granite was employed to simulate the underground process on surface.

For demonstration purposes, the lance head remained in the same location within the hole for only three minutes and enlarged the hole from 15 cm to 40 cm. No explosives or mechanical moving parts hitting the rock were used to enlarge the hole. The second portion included an open discussion forum during which attendees asked several questions pertaining to the potential of the technology and also on how it could be implemented within their current and future mining operations. Information was also provided explaining how the technology could be used without interfering with current mining operations. The versatility of the thermal units with regards to additional applications such as: drop and blind raises, ventilation, escape way accesses and even opening cuts in drifts and ramps was also discussed.

Donald Brisebois, Nippon Dragon VP Operations & Technology and the inventor of the thermal fragmentation mining method, stated: "With the recent down turn in gold prices, the mining industry is realising that ever increasing extraction costs need to be controlled and reduced in order to achieve profitability. The attendees clearly understood that the technology is a solution, which has the ability to reduce and even eliminate dilution by extracting only the mineralised corridors, significantly reducing ore extraction, mucking and milling costs by approximately 30%, depending on their operations and local geology."

André Savard, CEO of Nippon Dragon further stated: "This unique technology enables Nippon and its clients to be well positioned by reducing overall costs per ounce. Nippon is aggressively pursuing its global expansion strategy, the exclusive distributorship agreement with MaXem Holdings in South Africa is an example of our strategy. Nippon intends to deploy thermal units to potentially long term clients seriously considering testing the performance of our mining method." A second exclusive distributor agreement is also in place for Japan.

Fragmentation results imaging at Esperanza

A 2014 paper entitled *Measuring blast fragmentation at Esperanza mine using high resolution 3D laser scanning* is being published this year by the Institute of Materials, Minerals and Mining and was authored by Dr Italo Onederra from The University of Queensland School of Mechanical and Mining Engineering and CRC Mining; Matthew Thurley, Principal – Innovative Machine Vision Pty Ltd and Associate Professor Image Analysis – Luleå University of Technology, and Alex Catalan, Geotechnical Expert and VP Operations at Antofagasta Minerals.

The paper states: "Image analysis as a technique for fragmentation measurement of rock piles has been the subject of research since the 1980s and to date, run of mine (ROM) fragmentation optimisation studies have primarily relied on particle size measurement using photographic based 2D imaging systems. Disadvantages of 2D imaging systems include particle delineation errors due to variable lighting and material colour and texture variation; no direct measure of scale & perspective distortion; and inability to distinguish overlapped particles, non-overlapped particles and areas-of-fines. With the development of 3D imaging technologies, there is an opportunity to develop techniques that could improve data collection and overcome the limitations of existing 2D image based systems." The paper describes the first attempt to use 3D high resolution laser scanning techniques to quantify 'whole of muckpile' fragmentation from full scale production blasting. During two monitoring campaigns in 2013, high resolution laser scanning data was collected from production blasts at the Esperanza mine of Antofagasta Minerals Group. Fully automated analysis of the 3D data was possible in all cases where the data was of sufficiently high resolution. Manual pre-processing was required when the data was of low resolution to specify the region of fines. Overall results indicated that run of mine fragmentation requirements were meeting specified targets despite the marked differences in powder factors. This was particularly the case for those blasts conducted in similar geological domains. "This work has demonstrated that high resolution laser scanning can be used as an alternative technique to measure whole of muckpile fragmentation in production blasting."

For a number of years, both researchers and practising engineers have been aware of the importance of being able to tailor blast fragmentation to optimise the overall mineral extraction and recovery processes. In mining and quarrying, there is evidence to suggest that by providing an appropriate size distribution to crushing and grinding circuits, a measurable increased throughput and/or reduced power draw can be obtained. In a process integration/optimisation approach (such as mine to mill), measuring run of mine (ROM) blast fragmentation is necessary for model calibration purposes and their subsequent application in scenario based simulations.

"With the development and further accessibility of 3D imaging technology, there is an opportunity to develop techniques that could overcome the limitations of existing 2D image based systems. This can include the ability to obtain data without the influence of lighting conditions; shadowing or texture differences, and the ability to automatically delineate particles without the need for manual editing. Furthermore, 3D data provides a direct measure of scale; and....provides the ability to classify delineated regions as overlapped particles, non-overlapped particles, or areas-of-fines, size these different classes of material in different ways, and output size distributions based on volume information."

The latest 2014 paper presents the data collection and analysis to evaluate run of mine (ROM) blast fragmentation. During two monitoring campaigns in 2013, high resolution laser scanning data was collected in two phases of production at Esperanza . Two comprehensive blast performance monitoring campaigns were conducted. The first was carried out during January through to March 2013, focusing on three production blasts with an average powder factor of 480 g/t in 16 m high benches. A total of 58 scans from these three muckpiles were processed in this particular stage. The second campaign was conducted during the months of October and November 2013, focusing on another set of production blasts with an average powder factor of 360 g/t. In this case a total of 37 scans from these three muckpiles were processed.

The data analysis process has been adapted

Typical muckpiles for two blasts from the second campaign at Esperanza

from earlier developments in laser scanning of materials in conveyor belts and LHD buckets by Thurley. This new adaptation used site specific data collection procedures which considered both site access and the main specifications of the laser scanning system available. The data collection described in this paper was performed in collaboration with Esperanza mine personnel; and used the 8810 series I-site Maptek laser scanning system. The procedures implemented at Esperanza ensured that scans were performed at regular intervals during the excavation cycle. The principal aim was to obtain data from the front, middle and back sections of each muckpile. Scanning was conducted immediately after the blast and at intervals that minimised interference with production activities. However, there were few instances where data collection was prioritised in order to maintain sampling consistency.

Overall results have shown the ability of the algorithms to reliably process high resolution 3D laser scanning data. Fully automated results were obtained for the close range data sets.

The analysis showed that if the measurements were taken too far away from the muckpile then the resolution of the data was lower and the algorithms could not identify the areas of fines. These areas of fines were predominately large areas of compressed fines at the top of the muckpile . Therefore these large areas were manually identified in the 3D data before performing particle delineation.

A review of the data collected showed that in some instances, the pre-defined and recommended data collection procedures were not followed. Furthermore, some of these data sets in the second campaign were corrupted with distorted, warped, or missing data due to some error with the sensor or sensor operation and these were manually removed.

A key lesson from the measurement trials was the need to ensure consistent and correct operation of the laser scanner to ensure consistent data quality measured in the expected field of view and range of 8-10 m from the toe of the muckpile. If the rock piles are imaged in this way then fully automatic image analysis of every measurement set can be performed.

Using the higher resolution data, automatic delineation of the areas of fines was achieved. Work is continuing in order to improve the reliability of automated algorithms to delineate regions of compressed fines, but early indications show that by measuring from close range with the expected field of view and appropriate high resolution settings, automated image analysis will produce meaningful particle delineations and consistent results.

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One of the key requirements of mineral processing personnel at Esperanza mine was the ability to estimate the percent passing below 32 mm from the run of mine (ROM) fragmentation. Previous survey data suggested that the grinding stage performed at close to optimal levels when fines (32 mm) were above 40%.

Laser scanning data was collected over a period of 3 months in the first campaign which corresponded to blasts with an average powder factor of 480 g/t. The detection of particles below 32mm was mathematically possible but the output from the process algorithms was not reliable at this smaller size, mainly due to the limitations on the scanning resolution. By applying a lower and upper bound extrapolation in the log-linear space, the combined analysis from this monitoring campaign showed that the expected percent passing fraction below 32 mm was in the range of 50% to 58%; top sizes (99% passing fraction) ranged between 700 mm and 1,800 mm; and the 80% passing fraction (P80) was of the order of 250mm to 300mm.

In the second monitoring campaign laser scanning data was collected across blasts with an average powder factor of 360 g/t. It was evident that the first two blasts approached conditions similar to those measured during the first monitoring campaign with a notable reduction in powder factor. The combined fragmentation output of these two blasts indicated that the estimated % passing below 32 mm was in the range of 49% to 59%. The estimated top size (99% passing fraction) ranged between 840mm and 1,300 mm with the 80% passing fraction (P80) for both blasts being of the order of 30 0mm.

An unexpected coarser fragmentation output was found after analysing data sets from a third blast which was conducted in a different domain. The combined curve for all three blasts monitored in the second campaign indicated that the estimated % passing below 32 mm was approximately 42%. The estimated top size (99% passing fraction was of the order of 1,690mm and the 80% passing fraction (P80) approximately 450 mm.

Overall results indicated that ROM fragmentation requirements were consistently meeting specified targets despite the differences in powder factors. This was the case for those blasts conducted in similar blasting domains. The identified bias from the third blast in campaign two is clear in the coarse end statistics showing a marked increase in P80 and top size.

"This work has demonstrated that high resolution laser scanning can be used as an alternative technique to measure 'whole of muckpile' ROM fragmentation in production blasting. Although limitations were found with the quantification of compressed fines, relative comparisons were possible. Current limitations are being addressed by defining procedures that involve estimating fines with measurements taken from both the source muckpile and the primary crusher product. This procedure will use proven and commercially available laser based measurement systems and material tracking devices. Data collection procedures may vary depending on accessibility and site conditions. Further work is required to standardise data collection procedures to improve processing speed and output reliability."

PortaMetrics point-and-shoot fragmentation imaging

Motion Metrics unveiled PortaMetrics™, "the world's first on-the-go fragmentation analysis device for mining" at the 40th Annual Conference on Explosives and Blasting Technique 2014 organised by the International Society of Explosive Engineers (ISEE) in Denver, Colorado and held February 9-12, 2014. PortaMetrics is a portable tablet "that brings portable rock fragmentation and slope sensing to your fingertips." A major advantage of using PortaMetrics is its ability to provide fragmentation analysis of a desired scene in seconds, without the need for any reference object for scaling. A paper was also presented in 2014 by Product Manager, Bahram Sameti entitled *Portable Rock Fragmentation Sensing Using 3D Imaging*.

Following the 2014 conference, Motion Metrics stated: "We have received a lot of inquiries. This unique point-and-shoot device performs the fragmentation analysis of a desired scene within seconds. PortaMetrics simplifies the complicated and time-consuming fragmentation analysis process commonly required with other products." Since it was first released in late 2014, PortaMetrics has generated very positive feedback from the mining and quarrying community according to the company. "One of the reasons we attend the ISEE conference every year is to hear valuable feedback from some of the industries most experienced experts."

US Steel placed an order for PortaMetrics shortly after seeing the product demo at the 2014 ISEE event. After months of prototypes and revisions, September 17, 2014 marked a significant milestone for the PortaMetrics team, as the first PortaMetrics unit was shipped to US Steel for use in its iron ore operations. Late last year, Motion Metrics stated: "We have been in close contact with US Steel and we are happy to say that they have been quite pleased with the results after a month of using PortaMetrics in the field."

At the 2015 ISEE conference in New Orleans from February 1-4, Motion Metrics also gave a presentation entitled *Bench Face and Quarry Fragmentation Analysis: 3D Imaging vs Scaling References*.

PortaMetrics uses a 3D stereoscopic imaging sensor combined with a powerful processing unit to provide accurate fragmentation information in a matter of seconds. PortaMetrics is described as the first portable, Windows-based, stereo vision device designed for outdoor environments. It uses a large number of 3D points to estimate the slope for a desired scene in real-time. "No assumptions are made about the shape of the scene or the angle between the camera's line of sight and the scene. With a simple click of a button, the system will analyse the 3D images taken and present the information in an intuitive graphical user interface. Users can easily access critical information such as rock size distribution; individual rock size and distance; real-time range measurement; and instantaneous slope measurement."

A major advantage of using PortaMetrics is its ability to provide point and shoot fragmentation analysis of a desired scene in seconds

Electronic non-electric detonators in Russia

Key to fragmentation success is successful blast initiation. Russia's ISKRA in Novosibirsk is the largest plant beyond the Urals producing blast initiation systems, non-electric initiation system, detonating cords, electronic detonators, electric detonators, hunting cartridges, and primers for cartridges. ISKRA's non-electric initiation system is an extra-safe blast initiation system based on shock tube and detonating cap technology.

Since 2014, a series of field blasts have been carried out in the open pits of the Novosibirsk region. Under general conditions, the design of the down hole charge pre-supposes the placing of two duplicating boosters, in the upper and lower part of the down hole charge. Non-electric detonators with pyrotechnic delay are normally used for the purpose of initiation of both boosters. However, taking into account the big delay time variation of such devices, boosters often do not detonate simultaneously, so one of them detonates first, hence the second one cannot initiate the hole charge and is destroyed by the blast of the main hole charge.

The main task set during development of the device was increasing of delay timing accuracy (up to 1 ms) thanks to the application of electronic components and modern technical solutions but with the preservation of simplicity, safety, reliability and ease of handling equal to that of non-electric detonators with pyrotechnic delay. This ensures reliable application in the most difficult mining and geological conditions and permits to create short delay blasting circuits with wide and high accuracy delay ranges.

Delay times range from 10 to 2,200 ms in the temperature range from -50°C to +50°C. A delay time with 1 ms accuracy is programmed during manufacturing with the provision of the factual length of the shock tube. Therefore, delay time is always counted from the end of the shock tube. The device has protection from static electricity, radio frequency, stray current and other factors of an electric nature, as all its elements are placed into a sealed metallic shell which ensures perfect shielding.

The main advantages of electronic non-electric detonators are lowering the explosive rate by up to 10% and widening the drilling grid thanks to strict sequence of down hole blasting occurrence. It also means optimisation of the fragmentary composition of the blasted rock, leading to the increase of efficiency rates of mining and crushing equipment, as well as lowering of oversize output rate; as well as more exact initiation of spread charges; and considerable lowering of seismic and air shock wave effects, and any dust and gassy explosion product outbursts. It also decreases the flyrock ratio. There is no necessity of extra teaching and instruction of the blasting personnel, as the blasting circuit assembly is done in the same fashion as it would be with standard pyrotechnic delay non-electric detonators.

Valeria Gusseva, the Deputy Head of the Marketing Department at **ISKRA** told *IM*: "The application of electronic non-electric detonators is economically efficient thanks to increasing the effectiveness of the explosive materials used, due to the possibility of simultaneous initiation of the two blast hole charges. This allows the user to lower the explosive rate by charge dispersion or widen the blast and drill pattern by 10%, with simultaneous increase of rock output per running metre of the blast hole."

A representative at Russian drilling contractor OJSC Novosibirskvzryvprom stated: "The key positive effect was a more intensive rock fragmentation inside the block which allowed the mine to decrease the time of truck loading by approximately 10-15%, hence increase the efficiency of the whole mining-excavation complex in general.

Dyno successfully trials Differential Energy

Dyno Nobel has announced successful results of a trial taking place at a surface molybdenum mine in the US. The mine agreed to an initial three month trial using Dyno Nobel's Differential Energy (ΔE) technology. The goal was to improve safety, particularly through NOX reduction, along with improving blast performance with fragmentation, oversize and hard toes. To help address the problems the mine was having, Dyno Nobel employed its Titan 1000ΔE technology. Prior to the trial, the mine was loading dry holes with a 30/70 mixture (30% emulsion and 70% ANFO) and wet holes with 100% gassed emulsion.

The Dyno Nobel Differential Energy system allows blasters to accurately vary the density of chemically gassed emulsion as it is being loaded into the blast hole, enabling the operator to load multiple densities of gassed emulsion into the same hole and match the geology characteristics of the ground.

The mine had the challenge of blasting through a variety of different geologies from very hard rock to softer rock. Due to this, the blast crew loaded very high densities in the hard rock and much lower densities in the softer rock to maximise the efficiency of the blast.

The trial period was extended from three months to six months during which over 109 trial blasts were conducted to adequately measure air quality, mine productivity, fragmentation and digability.

The mine was able to meet the goals set forth at the beginning of the trial. Differential Energy "proved to be a reliable and resilient product that provided dependable results where no undetonated blasting agent was found in the muckpiles." The number and severity of NOX incidents were significantly reduced. This allowed the mine to consider revising its air quality permit to allow for larger blast events. Switching to Differential Energy allowed the mine to go from using two bulk trucks to a single truck that can load both wet and dry holes. The Differential Energy truck provided a faster turnaround time and a larger capacity allowing for more holes to be loaded per cycle. Oversized and floor grade problems were noticeably reduced. There were no physical measurements of fragmentation, but drill and blast managers and shovel operators observed a noticeable improvement in dig times.

Since the trial, the mine has fully adopted Differential Energy technology, using 100% Titan 1000ΔE and no longer uses ANFO. Dyno Nobel says its Differential Energy technology enabled the mine to redistribute the explosive energy in the blast hole, distributing the accurate amount of energy throughout the hole, varying the detonation pressure.

Quantifying fragmentation

Achieving better fragmentation can create huge cost savings, with one northern Quebec mining operation seeing a payback over one year of approximately C$32 million. Operations around the world are looking for ways to achieve better fragmentation. But without accurate methods of tracking it, efforts are based on assumptions and guesswork. Automated particle size analysis systems provide a continuous stream of data to allow operators to make informed process decisions based on quantifiable fragmentation results; as image analysis technology company **WipWare** suggests: "you can't manage what you can't measure."

"When investing in particle sizing technologies to track fragmentation improvements, four potential locations are typically considered: the front end of the operation, where significant downstream energy savings can be realised by optimising blast material size; post-primary and secondary crusher locations in order to improve liner life and reduce wear and tear inside of an operation; and pre-SAG, where operations can see significant benefit in controlling stockpile feed conveyors in order to get the perfect blend entering the SAG.

A notably ambitious project took place at a mining operation in northern Quebec, Canada, where the operation was able to automate its crusher gapping control with the use of a

Without accurate methods of tracking fragmentation, efforts are made on assumptions and guesswork

hydraulic toggle, WipWare particle sizing system data, and a PLC. Prior to implementing particle sizing cameras, the operation was manually adjusting its gyratory crusher gap settings, and replacing liners on a fixed schedule. The crusher gap settings were often adjusted based on a perceived increase in material size, and not on any quantifiable data. Although still common place in the mining industry, it can be very challenging to make real-time decisions with regards to gapping control without being armed with particle sizing data.

When installing particle sizing cameras at the operation, a rule was made in the PLC to automate the crusher gap control: when 99% of the running average material is less than 150 mm for longer than six hours, the hydroset adjustment on the gyratory crusher is triggered to step +1 increment every six hours until the condition is satisfied."

The end result of the project was a process improvement of 4.4% during the first few months of implementation, representing a throughput gain of 8 t/h. When the annual value of a of 1 t/h gain is valued at approximately C$4 million the cost savings add up quickly providing rapid return on investment in particle sizing technology.

WipWare says it is taking strides towards better fragmentation in 2015 with the introduction of a new particle-sizing system at the CIM Conference in Montreal during May, launch of a significant upgrade to the company's core software product, WipFrag, and helping operations understand how to leverage savings from fragmentation analysis data with a three-day Big Data seminar. The 6th Annual WipWare Training Seminar is centred on Big Data and making the most of fragmentation analysis. Industry experts including Jack Eloranta of Eloranta & Associates will outline case studies and explain data mining methods to achieve the most significant gains at the event, being held September 15 to 17, 2015, near North Bay, Ontario. ***IM***