

Enabling better blasting

Ailbhe Goodbody examines how the efficiency of blasting at mining operations can be improved or optimised



Surface Mining > Development

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At mine sites, the primary aim of blast optimisation is to achieve the optimum fragmentation for downstream operations and processes with a minimum cost.

However, improving the efficiency of blasting means different things to different mines at different times. Vicente Huélamo, advance applied solutions director at Maxam, says: "Each mine is unique, with its particular set of challenges which keep changing. Therefore, our first task is to listen to our customers, and explain how drilling and blasting can be tailored to address their priorities."

Russell Lamont, national consulting manager at Dyno Nobel, states that the optimisation of blasting efficiency is a process which occurs continuously at most mine sites. He says: "The 'perfect' blast design will never be achieved, in large part due to the constantly variable geology encountered during the mining process, as well as the high number of variables and constraints inherent to any single blast.

"Seeking to identify, characterise and address each of these factors in a way which enhances a site's successful operation is the process of blast optimisation. Technology advances have given the mining industry extremely improved capabilities to perform this function, particularly over the last few decades."

Adrian Imre, drilling and blasting senior consultant at Metso, notes that optimisation studies around the world have proven that feeding the process plant with the optimum fragmented run-of-mine ore is the most important source for savings in mining operations.

According to him, the principal techniques to improve blasting efficiency are:

- Increasing the accuracy of the information on rock blastability, including structural and rock mechanic properties and ore domain definition based on blastability - these are key factors for a successful blast;
- Carefully planning blasting activities. In open-pit mining, the use of blast-masters, by designing the shape and size of the blasting polygons for the whole bench in the initial planning stages, is essential to increase efficiency;
- Blast design optimisation by adapting the drill and blast parameters to the blasting polygon conditions will achieve the fragmentation target in a continuous and sustainable way;
- Increasing the accuracy of drill and blast design implementation and establishing a reliable blast reporting system;

Collecting and analysing the information related to blast performance including fragmentation and outcomes such as flyrock, ground vibration, back break, etc. Constructing a blasting database, including a complete set of data for each blast, represents the foundation for continuous improvement by 'fine tuning' the blasting operation; and

Feedback from the process plant (changes in different operational parameters linked with different plant feed) is also important and a driving factor for continuous improvement, allowing for maximum operational benefits.

Imre notes that blasting optimisation is a complex process that perfectly illustrates how a multifaceted problem can be solved with teamwork. He says: "I would like to stress the importance of collaboration between all professionals, from various departments, for a successful blast."

Angus Melbourne, chief commercial and technology officer at Orica, explains: "The downstream impact of variable and poorly controlled blast outcomes today can impact as much as 80% of the total mine processing costs; this, combined with the current non-digitised and manual practices involved with the drill and blast segment of the value chain, presents a significant opportunity for the industry to digitise drill and blast."

Additionally, he points out that as mines go deeper, and orebodies become more remote, automated and digitally enabled better blasting presents a significant productivity opportunity for the industry.

Explosive and detonator suppliers have focused on electronic detonator systems for more precise blasting delays, as well as advanced software programs to optimise blast patterns and delays for various rock structures.

In addition, technology providers such as MST Global have concentrated on the remote initiation of the blast using various communication technologies. Denis Kent, product manager, mining at MST Global, says: "In particular, our underground PED 'through-the-earth' transmission system and our AXON digital networks."



Precharging using Orica's WebGen 100 system eliminates the need for personnel to work in hazardous

areas

Downstream

processes

As noted earlier, better blasting can strongly improve downstream mining processes. "As one of the first steps in the mining process, blasting is widely understood to bear considerable influence over subsequent stages," suggests Dyno Nobel's Lamont. "The degree and manner of this influence depends largely on the type and configuration of a specific mining operation. In fact, 'better' blasting is often defined by downstream functions."

For example, the ideal size distribution for a quarry is substantially different from that of a copper operation. Lamont says: "The mine-to-mill concept has been widely accepted by the industry for decades, but the implementation of blasting principles to maximise this benefit is woefully behind in many cases."

Maxam's Huélamo thinks that mines are recognising that while drilling and blasting constitute a tiny portion of the mining costs, they have a significant influence on the safety of the mine, on the impact to the environment and on the performance of all downstream operations.

He says: "For us it is instrumental to work with our partners on customising the drill and blast solutions for each specific requirement. Controlling how and when the rock is produced affects the performance of excavation, hauling, crushing and milling.

"At Maxam we are already working with our partners on mining optimisation projects developing downstream productivity initiatives aligned with their KPIs. Thanks to this collaboration, we are becoming not just a blasting solutions provider but a productivity enhancer partner."

In many mining methods, a significant portion of the material blasted is waste, which is removed to expose the mineral deposit. Simon Tose, global manager - mining optimisation at AEL Intelligent Blasting, explains: "This needs to be blasted to a fragmentation size to ensure maximum fill for the bucket of the loading equipment and the optimal fill factors for the haul trucks. As the global industry looks to conveyors, hydro systems to take the blasted material out of the pit, to reduce waste-to-ore ratios, the design of blasting and managing the fragmentation curves becomes increasingly more important."

The shape and looseness of the muck pile also have an immediate effect on loading and hauling productivity. Metso's Imre says: "Nowadays, blasting can be conducted to achieve the desired shape and looseness to guarantee the maximum productivity for specific loading equipment."

However, improved blasting results can have the biggest impact in the processing plant. "Blasting operation is the first stage of comminution," notes Imre. "Pushing the fragmentation as close as possible to optimum will cut costs in the process plant by reducing the energy consumption and cost of wear parts."

By increasing throughput, the cost per tonne will decrease since fixed costs remain constant. Huéllamo says: "The mining process plants, once designed, installed and commissioned, have either little flexibility or high cost in terms of changing operational parameters."

Imre adds: "In addition, as mineral processing involves considerable water consumption, feeding the plant with optimum fragmentation can contribute to reducing this, therefore reducing the overall environmental impact of the mining operation."

MST Global's Kent suggests: "The key is consistent fragmentation, and hence why the major explosive suppliers have put so much effort in electronic detonators over the last 10 to 15 years."

Lamont says that Dyno Nobel is collaborating with customers in all mining industry sectors to ensure that training and tools applied on the bench or in the heading translate to cost savings and productivity improvements throughout the downstream processes.

"Achieving customer understanding and buy-in from ops managers, procurement specialists and even drill and blast personnel that the lowest blasting cost rarely translates to the lowest operational cost, is a difficult but key undertaking to our business," he comments. "The digital tools, physical products and drill and blast expertise within Dyno Nobel allow us to deliver minimised overall operating costs when accepted and engaged as a true business partner with our customers."



A screenshot from AEL's Designer software showing tailormaking the fragmentation of the blasted material, matching design to that required to improve shovel or haul truck or process plant efficiencies

Trends

Blasting professionals are strongly oriented towards increasing blasting efficiency. Metso's Imre says: "Blasting will continue to be the main means for rock excavation despite increased performance and applicability of mechanical excavation tools."

Explosive suppliers, working closely with the mines, are continuously expanding and improving their offerings with a wide range of more versatile explosives. Imre notes: "This enables mines to choose the best explosives for the local conditions (rock characteristics and blasting targets) and to maximise efficiency. At the same time, innovative explosives have increased flexibility, covering a wider range of conditions."

"Professionals working in R&D, using new digital tools and instrumentation, are progressing faster towards a better understanding of explosive-rock interaction in blasting, rock blastability characterisation, damage and fragmentation evaluation. The results will allow for improved explosive selection and advanced blast design tools."

Beyond explosives, there has been a step change in initiation systems as well. Imre says: "Electronic detonators are currently being used in many operations, providing more accuracy in controlling blasting results."

AEL's Tose states that the new generation of electronic detonators opens the ability to better understand each blasthole and its impact on the overall blast design through GPS positioning. He adds: "The mass of explosives and the rest of the design such as stemming allow the further development of the tools to control the blast vibrations, potential airblast and flyrock."

As in so many other areas of the mining industry, automation is a big trend in blasting; it will continue to be an important area for companies to focus their research and development on.

Some of the benefits of automated blasting include making hazardous work safer for miners, as well as increased efficiency that will help blasting overcome the hurdles presented by decreasing ore grades as well as increasing deposit complexity and depth.

Adam Mooney, vice president - EBS, wireless & automation at Orica, says: "Blasting is one of the few processes in the mining value chain that remains largely untouched by automation, and as mines go deeper, and orebodies become more remote, the case for blasting automation becomes clearer."

"Ultimately, it is about transitioning manual blast operation processes to automated blast processes, unlocking billions of dollars for the industry by granting access to ore reserves and reducing waste and operational delays that exist today, while keeping people out of harm's way."

For example, with electronic detonators becoming more mature, companies have been putting effort into automating the entire blasting cycle. MST Global's Kent explains: "Drilling and explosive delivery (loading) is close, but the process of wiring up a face is still difficult to automate due to the complexity of wiring. MST sees the reduction or elimination of wiring as a key to allowing a fully

automated drill-blast-muck-support cycle to become a reality."

Dyno Nobel's Lamont says: "Blasting practices must embrace the efficiencies offered by automation. Automated drilling on both the surface and underground is becoming more and more prevalent, and Dyno Nobel is actively pursuing avenues to expand that trend into other blasting-related functions.

"Our newer bulk delivery systems already incorporate aspects of automation, and we anticipate developing that further to decrease equipment and manpower requirements, improve safety and streamline the overall process.

"Ultimately, Dyno Nobel envisions automating a large portion of the design process as data feedback from various sources may be continuously fed into the blast model and used to modify blast parameters at each stage of the undertaking. Human oversight will continue to play a crucial role, but the ability to almost instantaneously update blast design to achieve optimal performance will be an area of great opportunity in the future."

Mooney believes that wireless initiation systems are the gamechanger of modern blasting and a first step towards full automation of the drill and blast process. He comments: "[This is] a long-term goal shared by both the mining industry and Orica.

"By eliminating much of the intricacies involved, completely wireless initiation systems deliver a step change in safety, productivity and efficiency for customers today. Importantly though, customers are identifying and validating the value of this game-changing technology to their operations."

Maxam's Huélamó says: "This automation trend requires application technologies interconnected together with a new generation of products that can be dynamically adjusted in real time to the requirements of the rock to be blasted, ensuring the right amount of energy is used where is needed."

Other technological innovations that are important trends in blasting include user-friendly, large-scale ground vibration monitoring to better protect areas in close proximity to the blast location, both in and out of the mining perimeter, according to Imre. In addition, the use of combined technologies in blasting are being explored.

"Ore tracking devices like the Metso SmartTag allow the ore to be tracked from mine to mill," explains Imre. "This offers a tremendous opportunity to connect the geological information and blasting results with process plant operational parameters, including grade reconciliation and final confirmation of optimised blast designs."

He also cites fragmentation measurement tools, not only for run-of-mine material but for the product of different comminution stages. He says: "The continuous improvement in fragmentation evaluation, mainly to increase the accuracy in difficult and variable conditions of mining operations, is another important activity to uphold."

In addition, increased data mining capabilities will allow extracting, interpretation and detection of correlations between significant data from massive databases generated in mining operations. Imre states: "This contributes to a deeper understanding or insight into the complex connections among the various factors involved and providing support for operational decisions."

Finally, there is the digitalisation of blasting and the integration and delivery of downstream value to the entire mining value chain. Huélamó says: "New tools backed by emerging digital technologies integrated across the mining process are also driving mines to be more sustainable and better able to withstand volatile prices for the minerals they produce and reducing their impact to the environment."



Maxam's RIOBLAST blast design and simulation software package can import actual data from the topography of the terrain/bench and display them in a 3-D environment

projects

AEL Intelligent Blasting is engaged with students and further education at the University of Pretoria in South Africa on research and development in blasting.

Tose explains: "The studies include development of the next generation of virtual reality (VR) and artificial intelligence (AI) for training, field simulation, management of equipment and environmental issues. As of yet, that curved ball has not yet arrived to replace the easily managed and controlled explosives and initiating systems used today."

Recent

The company also provides modern emulsions, delivery systems and electronic initiation that allow its mining customers to manage the fragmentation, muck pile position and height to control and improve load and haul, waste removal and mineral processing at their sites.

Dyno Nobel is currently engaged in projects that will allow for varying levels of autonomous loading and blasting. "The loading equipment we use is already doing some automated hole loading based on our DynoLogix systems for bulk trucks on the surface and DynoMiners underground," says Lamont. "The initiation systems are a bit more difficult to load in an automated system due to handling issues and wires or tubes needing to connect to a blasting circuit.

"We are currently coupling these automated abilities with downstream optimisation principles at several operations to provide the greatest overall benefit to customers. Dyno Nobel has numerous examples of the ability to alter fragmentation through product selection, explosive distribution and/or other incoming data sources."

He adds that key to this exercise is the determination of what fragmentation distribution minimises cost in the mill, but to an extent which justifies possible increases to drill and blast costs upstream.

"Each case is unique, but there are times when pattern and product adjustments lead to processing cost savings as well as reduction in drill and blast costs," notes Lamont. "In other cases, increases in drill and blast costs are required to achieve minimised processing costs. The digital tools, physical products and drill and blast expertise within Dyno Nobel allow us to deliver minimised overall operating costs when engaged as a partner with the customer. We have seen cost savings ranging from 5-35% at various customers leveraging our solutions."

Lamont says that Dyno Nobel is working to deliver better explosive product options, improved blasting equipment and advanced designs based on data captured throughout the process to grant operations ever-greater influence over blasting outcomes.

He comments: "Recognising the huge benefit that improved blasting results may yield to a wide range of mining processes, we are committed to providing our customers with the latest technologies in bulk, initiation, design, monitoring and training. As with many aspects of mining, those companies which fail to align themselves to capture benefit from new blasting technologies may find themselves at a serious competitive disadvantage."

Maxam has been partnering with several mines all over the world on blasting projects. Huélamo says: "Whether it was working with a copper mine to increase the SAG [semi-autogenous grinding] mill throughput by more than 25% with no added CAPEX or OPEX, or guiding an iron mine to reduce misfires by more than 90%, Maxam's experts, tools, systems and products are making a difference every day."

Maxam's tools, products and services for blast optimisation include the RIOBLAST blast design and management suite; RIOFLEX, a robust, flexible explosive with a broad range of densities and energies; RIOSPLIT, a product for pre-split blasting; and the Selective Energy Application concept.

Huélamo comments: "[These] help mines exceed expectations for a myriad of ever-changing priorities - digging rates, wall stability, ground vibrations, rock production, SAG mill throughput, energy consumption, water use, etc."



Metso has been involved in blast optimisation projects addressing typical challenges with implementation, performance and fragmentation optimisation for downstream processing

Metso has been involved in run-of-the-mill blast optimisation projects addressing typical challenges with implementation, performance and fragmentation optimisation for downstream processing. "What's new and interesting at Metso is incorporating drill and blast optimisation in performance solutions - a new way of helping customers achieve sustainable results," says Imre.

"Solutions are engineered to individual needs across the entire operation, pulling together elements from Metso's portfolio of specialists. By integrating drill and blast optimisation with other process solutions, operations will develop tools and solutions for continuous improvement and achieve large-scale benefits."

MST Global's efforts have been focused on minimising the amount of physical wiring required in a blast. Kent explains: "Our 'through-the-earth' BlastPED system is still in use at many mines simply because it eliminated the need for large mains firing circuits for centralised blasting of electric and nonel detonators."

However, he says that a number of these customers want to extend the BlastPED functionality to electronic blasting as well; that is, use the BlastPED to remotely initiate the electronic blasting box to automatically run through its routine and fire the faces and stopes.

"To date there has been some pushback from some suppliers, initiating that two-way communications are required," states Kent. "However, recently some suppliers have realised this isn't necessary, and so we have made a new version of BlastPED to remotely initiate their electronic blasting unit to run through its program automatically and initiate the round."

He says that this works very effectively, but ultimately being able to eliminate the wiring to each individual detonator and control the blast from the surface without any wiring would be ideal.

"MST does not have the explosive or detonator expertise to do this, but we do have the 'through-the-earth' transmission system for this type of remote control to be achieved," notes Kent. "So we will continue to work with mining and blasting companies as they approach us to improve their blasting where our communication technologies allow."



MST Global's BlastPEDs and remote controller

Orica introduced its WebGen technology last year; it is a truly wireless initiation system. Mooney says: "It improves safety by removing people from harm's way, enhances productivity by removing the constraints imposed by wired connections and is fundamentally changing the way blasting and mining is approached by enabling new blasting practices."

Since its release, more than 320 WebGen wireless blasts have been executed globally across four industry segments including quarrying, surface mining, underground mining and marine.

In mid-October, BHP Mitsui Coal's Poitrel mine in Queensland, Australia, used WebGen to fire the world's largest ever wireless blast. This blast shifted 1.3 million cubic metres of overburden in a strata blast fired with 1,920 WebGen 100 units across 534 holes.

Orica has also seen how its WebGen Temporary Rib Pillar (TRP) method has benefited Newmont Goldcorp's Musselwhite mine in Ontario, Canada, with increased ore recovery through a 34% dilution reduction.

Melbourne comments: "The mine also experienced an uptick in overall productivity, achieving 20% improvement in mucking productivity, at the same time significantly improving safety with the removal of operators adjacent to the open stope."

On the back of the success of the TRP method at Musselwhite, Orica has developed new mining methods that can reduce development, reduce dilution, increase ore recovery and eliminate worker exposure to open holes. These include: Temporary Uppers Retreat Pillar (TURP); Reverse Throw Retreat (RTR); Longitudinal Transverse Retreat (LTR); Pre-Loaded Retreat (PLR); Transverse TRP (T-TRP); and Longitudinal Transverse Lifter (LTL).

Mooney says that in underground mining, hang-up blasting poses a major challenge for block and sub level cave mines around the world. "At any one time, up to 30% of all drawpoints can be unavailable due to oversized material," he explains.

"Concerns around safety are also more pronounced in underground mining. In aiming to ensure the safety of every miner and increased productivity for our customers, we have developed the first fully teleremote and mechanised Drawpoint Hang-up blasting solution with MacLean Engineering.

"Underpinned by Orica's WebGen wireless technology, the mechanised units which have been fully tested are capable of charging up to eight blastholes remotely without the need to tie in detonators, removing people completely from harm's way. We expect our units to be commercially available from later this year."

Orica is also working in collaboration with IMDEX, CRC ORE and its customers Anglo American and Teck Resources on a METS Ignited-funded project to accelerate its capability on material characterisation for optimised blasting and material tracking.

Rajkumar Mathiravedu, vice president - digital solutions at Orica, says: "The project involves the co-development of an autonomous system for logging material characteristics of blastholes, which allows automated spatial domaining of physical properties and fracturing.

"We are developing multiparameter logging tools for blastholes in open-cut mining, together with automated near real-time analytics for input into fragmentation modelling, blast execution tools and material tracking workflows. This is a great example of an Industry collaboration, aimed at solving industry level problems that exist today, and we are extremely proud to be a part of it."

In another collaboration focused on better understanding the resource, Orica has invested in and is working with DataCloud.

Mathiravedu notes: "DataCloud's RHINO seismic-while-drilling (SWD) system is a real-time subsurface measurement technology that provides high-resolution rock mass data through vibration measurement on IoT sensors. This enables accurate detection of faults, fractures and joint spacing, in addition to many grade indicators and blast-critical measurements.

"With these collaborations well established, we are now integrating vast amounts of complex geotechnical data into our blast design processes - influencing the overall blast design and ensuring the right explosives are delivered into the right holes and given the right timing to achieve the desired outcomes."



Orica has developed a fully tele-remote and mechanised Drawpoint Hang-up blasting solution with MacLean Engineering



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