CRUSHING IT!

Dusty Jacobson and Stuart Baillie, Metso, outline what to consider when it comes to choosing, maintaining, and further optimising a crushing operation over time.

Given the broad range of different crushing technologies available today, it is critical to find the right crusher to suit the application. However, getting the most from the equipment does not end there — factors like chamber selection and optimisation, and additional services, can make all the difference.

Materials, methods and equipment

Before selecting an exact crusher, it is important to first consider what crushing technology is needed for the feed material. The two main methods used for crushing are fracture by energy or impact and compression or shear breakage. From an operating costs perspective, horizontal shaft impactors (HSI) are feasible in low abrasive and typically soft material applications.

Even from a CAPEX perspective, the HSI's high throughput capacity can make it an interesting option in some cases. Barmac vertical shaft impactors (VSI), by virtue of being an impact crusher, can also be

economically feasible with rather abrasive feed material. This is especially the case when crusher duty is focused on improving product quality in aggregates applications, or the target is to reliably produce -2 mm materials from soft to medium rock.

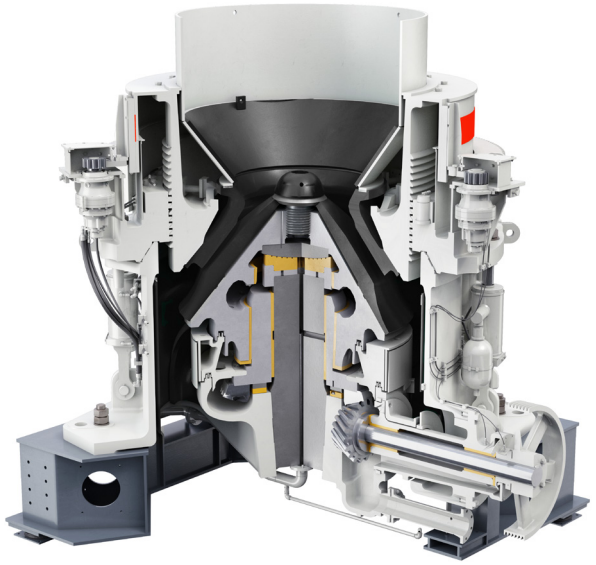

Figure 1. Understanding your specific crushing application is one of the first steps in selecting the right equipment.

Figure 2. Getting more out of your crusher depends on choosing the right wear parts.

Figure 3. Extra wear parts on site can help prevent unnecessary service breaks.

With medium-to-hard rock or ore that also has abrasive qualities, a compression crusher is often the most economical choice, especially in cases where a high reduction ratio is required. Once the first choice of technology is determined, other factors then need to be evaluated.

The right crusher for every stage

The primary crushing stage generally breaks down the material into pieces of max 200 – 300 mm. The aim is to achieve the right balance between feed size (capacity) and throughput (speed). Reaching this balance is important, as focusing on one aspect, while neglecting the other, could lead to an unsuitable choice of equipment. For example, focusing on accepting a large feed size could mean ending up with an oversized and hungry crusher that can actually handle more material than the plant can provide. Certain adaptations are possible, such as adjusting the machine settings or using a special liner to re-size the crushing chamber, but it is still important to choose a machine with a chamber size range that best fits the application.

Another factor that needs to come into consideration is machine reliability. As with most equipment, there is a trade-off between initial investment costs and long-term operational costs and reliability. As a rule of thumb, the higher the production requirements and the longer the equipment is set to operate, the more important reliability and low operating costs are.

For example, primary gyratory crushers (based on hydraulic floating shaft technology) are often the first choice of larger mining projects with a throughput of 1500 tph or more. Although these crushers demand a relatively high initial investment, they offer payback in the form of better total plant production and a lower operating cost per unit.

There are jaw crushers which carry lower upfront costs and are often preferred by small-to-medium size mining operations. Jaw crushers work well for reasonably hard and abrasive feed material and can handle a large feed size. Maximum throughput, however, is typically only 1500 tph even with the biggest units. When processing sticky materials with low-to-medium hardness, or if there are restrictions on installation headroom, the addition of a primary sizer can be helpful.

Also there are cone crushers which are not generally used for primary crushing, but there are some notable exceptions, such as gravel plants, river gravel or screening the feed to eliminate over-sized material.

Choosing secondary, tertiary and fine crushers

Cone crushers have long been the preferred choice for processing of hard or abrasive materials. This category includes hydraulic supported cone crushers which offer dynamic gap fluctuation and are therefore well-suited to coarse crushing applications.

Other secondary crushers are the highly versatile pedestal-shaft (based on fixed shaft technology) and

Symons™-style machines, which typically have a higher power and crushing-force while also achieving higher reduction ratios and finer product sizes. Such machines are also suitable for tertiary, quaternary and pebble crushing. To generate very fine fractions i.e., product sizes below 2 mm, modern roll crushers (high pressure grinding rolls) or vertical shaft impactors are recommended.

Optimisation of wear parts

If choosing the right crusher is the first big decision, the second one is selecting the right wear liners to get the most out of the producing asset. Producers often reorder the same liners that came with their initial purchase, not realising that liners play a significant role in the overall performance of crushing equipment and can make a big difference to the bottom line. Optimising the liner profile can affect the quality and size of the end-product and allow the crusher to work more effectively.

For example, if a cone crusher is not producing the desired end product size, changing or adapting the bowl liner and mantle will bring different results. Similarly, new conditions can be created in the cavity and chamber of the primary gyratory crusher by adjusting the angle, liner alloy or thickness of the mantle and concave liners.

Figure 4. Inspections of your crusher and parts help to spot potential issues.

Figure 5. Achieving the right quality end product means combining the right crusher and liners with the right maintenance.

To get the best results when changing wear parts, it is recommended to consult a process expert who can carry out simulations in the lab and base their decisions on data.

Liners that last

Since liners are worn down by constant contact with the ore, they need to be changed regularly, which can be a big part of the operating costs. To keep costs in check, analysing the crusher chamber and selecting liners with the right profiles, thickness and alloy grade to last as long as possible, is recommended.

Typically, liners are made from a low-grade manganese steel as a base offering. They can also be engineered with different manganese grades or from alloy steel or high chrome white iron, to maximise wear life and/or increase fatigue resistance.

Metso's longer-life range of liners (MX series) is made with hybrid materials and represents a step up in liner lifetime. They have been shown to double the wear life compared to standard manganese steel liners in many applications.

Getting the chamber right

Exploring improved crusher performance, such as with a chamber optimisation programme, is the best option for taking crusher efficiency to the next level. It is a multi-step process which includes gathering data, running simulations and using expert analysis to look at options. From this process, it is possible to create tailor-made solutions and customer-designed wear parts that suit specific processes, applications and equipment, regardless of the brand.

When the chamber is working optimally, it is possible to achieve up to 30% reduction in energy consumption depending on the application, leading to a lower cost per tonne and more sustainable operations. Wear parts can last two to four times longer, reducing the number of liners consumed, as well as resources needed to manufacture and transport them, thus further contributing to sustainability. Longer wear life also means fewer stops in production and fewer change-outs, which in turn also boosts both profitability and safety.

A chamber optimisation programme is not a one-off effort but rather an ongoing monitoring and improvement programme. For example, the development of the liners might start with wear life improvement and continue with tweaking the design to maximise crusher throughput. Moreover, production targets and ore properties at a site can change over time and create an opportunity for further liner development. Each customer journey is unique, and chamber optimisation can be especially beneficial for high-volume production sites and in situations where the raw feed characteristics have changed.

Finding the maintenance edge

Choosing the right crushing technology, machine and liners are all important steps to take. However, every

business wants its crushing equipment to have the longest life possible and this can be a real challenge when operating under harsh conditions. There are several ways to further extend lifetime, maximise performance and achieve a reduction in overall crushing costs through proper maintenance.

As part of a regular maintenance programme, it is recommended to keep a constant eye on the crusher's performance through regular inspections. These should include checking the condition and cleanliness of the hydraulic power units, hydraulic oil tank levels, oil temperatures, cooling fans and oil pressure levels, crusher noise levels, bearing temperatures, crusher vibrations, feed distribution, feed level and electric power draw amongst others.

Customers often find it valuable to get more thorough and specialised inspections at pre-set intervals, such as the 1000 hr operating mark. These inspections often include a review of key wear components and additional verification of critical spare components. Wear replacement inspections are useful to have and involve an inspection of the heads and bowls or concaves and mantle, as well as other components such as bushings, eccentrics, MPS and pitmans, depending on the crusher being inspected.

At an operational level, another often overlooked good practice is the assessment of the size of the rocks entering the feed. Oversized feed could lead to blockages in the crusher cavity which can cause bottlenecks to the entire process and result in unplanned downtime. There are different ways of addressing this issue, but the solution often lies in making improvements to the current drill and blast programme.

Ensuring smooth, safe and successful shutdowns

It is essential that shutdowns come in on-time, on-budget and with minimal downtime. A good shutdown optimisation programme covers all elements of a shutdown, from start to finish. This includes a site evaluation and shutdown planning, as well as the actual execution of the shutdown.

Shutdown optimisation typically begins with experts observing and analysing the crusher relining process and coming up with improvements related to factors such as preparation analysis, concave replacement method (best practices), tooling, training, and safety. A more involved but highly effective time and motion study, often called a single minute exchange of dies (SMED) analysis involves capturing all the actions taken during a shutdown on video, documenting the tasks from start to finish, and creating a timeline with thousands of image and data points for analysis.

Expert support can then make recommendations to help improve the overall workflow and execution of the shutdown event, including removing non-critical tasks and idle periods, introducing better planning and coordination, and determining the optimal sequence of steps.

In a Chilean mine, for example, one time and motion study helped to reduce shutdown time from 100 to just 56 hours. Similar results were achieved in Finland, where mantle replacement times were cut in half, and the duration of a full reline was similarly shortened.

Further optimisation – connectivity and data analytics

The industry is quite rapidly moving from a reactive to a preventive approach to crusher care, backed up by data analysis. Connectivity adds an extra layer of support that enables preventive maintenance and troubleshooting. The data from sensors monitoring the critical functions of equipment is collected and used to generate trend reports that can warn of upcoming issues in time to prevent production stops or safety risks.

Connectivity also enables remote troubleshooting — an excellent complement to on-site crushing services that lets operators access whatever expertise they need without having to physically bring a specialist out to the site.

More and more customers are demanding reliable analytics services and the ability to resolve issues remotely and efficiently, with access to global experts. Metso Performance Centers for example, use advanced digital tools, and connect global experts to bring together data, knowledge and global expertise to improve the reliability, safety, availability and operational performance of crushing and processing equipment. These improvements can lead to substantial improvements to a site's profitability.

Final thoughts and next steps

Many who are familiar with the techniques for selecting crushing equipment believe that it is possible to make a selection merely based on calculations. However, theoretical conclusions must always be counterbalanced by practical experience with operating factors, as well as the maintenance and economic aspects of a site.

From the choice of crusher and wear parts to long-term crusher care, considering all elements can help to make the right decisions, resolve issues and ensure the company gets the very best out of the equipment. DB

About the authors

Dusty Jacobson began his career in the mining and aggregates industries in 2003 after obtaining a BSc in Mechanical Engineering. Over his 20 years with Metso, he has held roles in research, design, sales and product development. His current role is director of process engineering for crushing equipment and plants.

Stuart Baillie has a bachelor's degree in mechanical engineering and has been in the crushing business in Metso for 20 years. Originally from the UK, Stuart relocated to Australia in 2013. He is currently the regional support manager for mining crusher wears for Asia-Pacific and India.