KMRC’s Z. Pokrajcic, explains “the comminution process remains inherently inefficient. It is understood that 85% of the energy used is dissipated as heat, 12% is attributed to mechanical losses and only 1% of the total energy input is used in size reduction of feed material.

“Another aspect of comminution which contributes significantly to the energy intensity of the process is the consumption of media and mill liners. The quantity of energy necessary for the fabrication of the media and/or liners from extraction, to transport, to manufacture and assembly is considered part of the total energy utilisation of the comminution process. This is also quite an energy intensive process and opportunities to minimise steel consumption in comminution circuits should be realised.

“The third factor which contributes significantly to the energy intensity of comminution circuit is the chosen grind size. As the target product size decreases the energy required to achieve the product size increases significantly. As the particles become smaller their strength and therefore their resistance to breakage increases. For small particles as internal flaws are depleted, the observed strength approaches the high intrinsic strength of the solid.”

Pokrajcic says energy cuts “can be achieved by purposely targeting the comminution energy at specific problematic size fractions such as the critical size material in the primary mill and the very fine fraction in the secondary mill. Through the use of more efficient comminution devices such as HPGR (high pressure grinding rolls) a product size distribution that is narrower in size range can be generated. This size distribution contains less material in the coarse fraction to aid overall mineral liberation and less material in the fine fraction to minimise the effects of slimes.”

JKMRC made eco-efficient modifications to an existing SABC (SAG mill with recycle crushing and a single stage ball mill). First, a pre-crush stage using HPGR was introduced to minimise the generation of critical size material in the primary mill. The aim was to reduce a portion of the feed material below critical size and generate more fines to decrease the load in the primary mill. Not all of the feed material was pre-crushed to allow for sufficient abrasion breakage in the primary mill.

The SAG mill was converted to an AG mill and the ball mill was converted to a pebble mill to decrease liner and media consumption. Existing mill sizes were reduced.

When the performance of this new ABC-HPGR-PM circuit was compared to the original SABC circuit, (based on JKSimMet and mass balancing predictions) it was observed that the new circuit produced both finer and steeper product size distribution, which promoted better flotation performance – some 2% increase in gold recovery.

Direct energy comparisons show that the ABC-HPGR-PM circuit had an operating work index of 15.9 kWh/t compared to 24.3 kWh/t for the base case SABC circuit. This is a significant energy saving greater than 8 kWh/t for the whole circuit. Comparing indirect energy consumption, again the ABC-HPGR-PM out performed the standard SABC circuit with a 79% saving in indirect energy based on media and liner wear alone. The SABC circuit consumed 3,535 kW while the new circuit consumed 753 kW. These figures are based on 6 kWh/kg required to manufacture the grinding consumables.
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FLSmidth Minerals has been looking at different crushing combinations and says that while “traditional crushing circuits such as gyratory/cone, jaw/cone, two-stage or three-stage low-speed sizing, and two-stage impactors are still the norm, in recent years FLS has been working on hybrid circuits that combine various crushing technologies into a single circuit when special circumstances exist.” In today’s market many of the typical applications have already been addressed and quite often the newer applications involve special circumstances such as working with wet, sticky, clay-like feed, or trying to achieve a relatively small final product while controlling fines generation.

FLS has several crushing technologies within its catalogue which enables it to offer good overall solutions. It says that “while some companies have one or two crusher types, FLS has globally-recognised gyratory crushers, low-speed sizers, jaw crushers, cone crushers, hammermills, and feeder-breakers. By having these various crusher types FLS can mix and match crusher types for customised crushing solutions instead of trying to adapt a single type of machine to a specific application that has certain objectives. That ‘one-machine-fits-many-applications’ way of thinking brings about compromise from both the supplier and the purchaser. The FLS approach to any project is, and has always been, to meet the end-user’s objectives with the best combination of crusher types to minimise upfront capital cost [and] delivery time, and provide the specified end product for the application.”

Examples of FLS’ latest crushing circuits include:

- A primary impactor followed by a low speed sizer
- A primary low-speed sizer followed by a secondary cone crusher
- A primary gyratory crusher followed by secondary and tertiary sizers
- A primary jaw crusher followed by secondary and tertiary low speed sizers.

Depending on the customer’s goals, these circuits were designed around objectives such as minimising fines and dust while getting the most reduction ratio, or being able to reliably crush feed with wet and sticky properties. Hybrid crushing circuits work very well when special conditions need to be addressed and they give more flexibility with the product for downstream processes. An example of this involves a low-speed sizer ahead of the SAG mill at a gold mine. The orientation of the teeth in the sizer was configured to deliver the best size and shape of feed to the SAG mill, thus optimising the SAG mill performance.

FLS says today “the crushing circuit should be viewed with an open mind to new possibilities. No longer is the crushing circuit limited to a single crushing method (compression, impact, or sizing). Combination circuits may provide the best alternative, especially if special conditions exist.”

In addition to hybrid crushing circuits, FLS has proven solutions for crushing high-work index ores and can provide plant designs with varied levels of mobility.

The addition of FLSmidth Excel, with its Rapto line of cone crushers, has provided FLS with a product offering to complement its combination of complete mineral processing solutions. As it has done with the cement industry, FLS is now doing for the mining industry - offering complete mineral processing plants through its innovative ‘One Source’ program.

These Raptor crushers join other industry-leading products from FLS, including Traylor primary gyratory crushers, ABON sizers, Fuller grinding mills and pumps, hydrocyclones, flotation cells, thickeners and filter presses, to deliver a great combination of technologies.

Excel Crushers shipped its first cone crusher, the Raptor XL400, in February 2005. Before the end of 2005, FLS had purchased a 50% interest in the venture with the goal of developing of full line of Raptor cone crushers dedicated to serving the minerals industry. Whilst the XL300 was already in development, the FLS investment drove the fast-track engineering of the Raptor XL1100, a 3-m diameter, 895 kW cone crusher. By the summer of 2006, FLSmidth had received orders for a total of nine XL1100 cone crushers before the first casting had even been poured. Now FLSmidth Excel has added the XL600 and XL900 cone crushers. Raptor cone crushers come packed with features aimed at maximising performance, reducing maintenance requirements and Pennsylvania Crusher says its Mountaineer Sizer is designed for primary or secondary sizing of coals, industrial minerals, and ores with minimum fines generation. Its rolls are linked via gearing in the drive system to ensure product size and it is of single drive motor and reducer design. It employs standard drive components and has an integral base for foot-mounted drive components. The company also says it is an extremely rugged, high-capacity machine. The Mountaineer crushing chamber is lined with heavy-duty liners. The sizing rolls are offered in a variety of tooth patterns to suit the application. Side reflectors prevent oversize material by-pass and clean mud off the rolls.

smooth integration into an automated plant environment. FLSmidth’s Automation Technology is available on multiple platforms, and the cone crusher automation package was developed specifically to meet the unique requirements and expectations of the mineral processing engineer, Excel says.

New crushers

There is a new jaw crusher now available in the Sandvik CJ200 series – the CJ208. This is a crusher for customers who do not want to compromise between lightweight and heavy-duty equipment, mobile and stationary applications, and process flexibility and easy operation. The new Sandvik CJ208 is the smallest member of the family, but this does not reflect in anyway on its performance.

Sandvik’s CJ200 series offers a combination of lightweight equipment and heavy-duty crushing applications, offering superior cost efficiency. The optimised crushing chamber provides a high reduction ratio and capacity.

The frame of Sandvik’s CJ200 series of jaw crushers is all-welded. The clear advantage of a welded frame is that it is equally strong in all directions and ensures excellent durability against shock loads. In turn, this minimises the
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risk of mainframe failure, as seen with a bolted design. Furthermore, the design of the deep symmetrical crushing chamber maximises feed size, capacity and reduction.

The CJ200’s heavy-duty capacity makes it an excellent choice for stationary applications. But its compact, low-weight and easy-to-install design also makes it ideal for use in mobile applications. Its bolted feet enable the Sandvik crusher to be used as a stationary unit with zero degree inclination or on a mobile unit with 5° inclination.

The Sandvik CJ208 and the other members of the 200 series are available with a range of optional equipment, such as automatic bearing lubrication, feed hopper, intermediate protection plate and a complete drive package, including motor, bracket, pulley, belt and flywheel/belt protection. The CJ200 series has low energy and operating costs thanks to its optimised flywheels. For example, the CJ208 model requires only a 55 kW motor to crush the hardest material with the smallest feed openings.

Sandvik has also recently launched an innovative, patented and tested mantle - the Sandvik Flexifeed FF mantle. This crushing mantle has a patented design featuring a variable intake in the upper section. Although the feed opening is narrower in some sections of the intake, capability is maintained. The mantle and pockets rotate during crushing, thus facilitating the passage of top-size material through the chamber.

The extension of the mantle means that more crushing takes place in the upper section of the chamber, while large stones can still be crushed where there is no extension. This translates into maximum utilisation of the chamber and more even wear throughout the entire chamber.

The proven benefits resulting from tests performed at customers’ facilities are clear:

- Liner life is 20-50% longer, depending on the application, as a result of optimised utilisation
- Reduction ratio is increased by approximately 5%
- Production levels are maintained throughout the mantle’s life
- Top-size capability is maintained.

At present, the Flexifeed mantle is only available for the Sandvik CH440 cone crusher in combination with EC, C and MC concaves.

Better jaw crushers

Telsmith says that recent advances in jaw crusher design it has developed “are yielding greater productivity through reductions in maintenance and unplanned downtime. The application of computer technology and hydraulics technology is allowing the modern Telsmith jaw crusher to operate reliably in 24 hour operations, while processing greater quantities of ore than ever before.”

Telsmith engineers have adapted advanced hydraulic systems and Programmable Logic Controllers into the crusher to yield new benefits not previously available on jaw crushers. Combined, the company says, “these benefits yield greater reliability, increased operating hours and the confidence to operate at 100% production speed at all times, delivering greater efficiency and productivity.

Hydraulic chamber clearing: Any time a crusher stops while full of ore it must be cleared before it can restart. This has historically meant anywhere from four to eight hours of unplanned downtime as well as service people putting themselves at risk of injury. Telsmith chamber clearing uses hydraulic cylinders and push button controls to clear the crusher, typically in 15 minutes. Hydraulic cylinders retract the pitman slightly - allowing ore to fall deeper into the crushing chamber. Powerful hydraulics then push the pitman forward, crushing the ore. As the pitman retracts again, crushed ore falls onto the belt below. Repeating the process several times clears the chamber while yielding properly sized material for the next stage in the process. Start-up can typically begin within 15 minutes.

Hydraulic overload relief: Tramp iron or any uncrushable material, including clay, can overload a crusher and cause premature failure of internal parts. Overload relief allows the setting to open when an overload condition occurs. In the automatic mode, the PLC will re-set the crusher and provide feedback to the operator, and/or automated control system, allowing them to take appropriate action for the process downstream.

Hydraulic adjustment: Adjusting a jaw crusher setting has typically involved adjusting wedges or installing shims as well as adjusting tension rod springs. This process requires maintenance crew preparation and anywhere from 20 to 60 minutes of crusher downtime. The hydraulic adjustment system provides the operator remote push button control and virtually eliminates downtime for setting adjustment. The PLC provides feedback on the
FLSmidth provides performance with globally-recognized gyratory crushers, low-speed sizers, jaw crushers, cone crushers, hammermills, feeder-breakers, and a variety of mills including SAG, AG, Rod, Ball, Pebble, Vertical Roller, and Hydraulic Roll Presses.

Our experience and combination of product offerings means we offer the best overall solutions to minimize upfront capital costs, minimize delivery time, and assure the most optimum equipment is provided for your specific requirements.

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crusher setting and liner wear tracking for maintenance planning.

Turbocharged crushers
Sam Sawant, President of Innotech Solutions notes “Symons™ cone crushers [Metso Minerals] have been the workhorses in the mining industry for the last 80 years. They are amazing crushers with proven reliability and durability in the toughest crushing applications.” Now, he explains, Innotech Solutions, with its world class crusher expertise, has been able to “turbocharge these crushers to substantially increase their performance.”

Innotech has also developed several add-ons for these crushers that improve their operational safety and ease of automation. “Thus,” he says, “for a fraction of the cost of a new expensive replacement crusher, a very good crusher now becomes the best crusher.

“Turbocharging is accomplished with a simple add on kit that allows the crusher to absorb higher power and use this additional power to crush more ore and/or lower the P80 of the discharge. Based on our field experience, the crusher production increases as much as 20%. The ROI on this investment is typically less than six months.”

The Rotating Feed Distributor for the tertiary crushers is one of the most significant add-ons. This device homogenises the feed by distributing it 360º around the cavity, eliminating segregation. “This,” Sawant says, “causes even crushing around the cavity, eliminates crusher abuse, increases liner life up to 20%, reduces power draw and allows operator to run the crusher at tighter settings to make finer feed for the mills. ROI is less than three months in most cases.”

The Tramp Release System will help owners meet OSHA/MSHA safety requirements and significantly increase the run time of the crushers thereby increasing daily production. The system can be added in the field without removing any major components.

ME Elecmetal has added an automated epoxy backing pump to its product line to assist in the replacement of wear components in crushing equipment. Mounted to a frame allowing the use of large volume epoxy containers, it is capable of pumping up to 11.4 litres/minute. The pump uses disposable applicator tips that mix the two part epoxy, eliminating the need for repetitive hand mixing of smaller containers. The applicator/mixing tips also minimise exposure to fumes that may develop from the mixing process.

The unit includes a self contained heater to facilitate quicker pumping and curing of the epoxy, and is accessible by fork truck from all sides. It has certified lifting rings to allow for overhead crane movement and is available with the option of being mounted on a trailer for relocating to different crusher sites. According to John Sellars, ME Elecmetal’s Vice President of North American Sales, “Not only will the pump..."
increase equipment availability, when used in combination with our non-hazardous backing epoxy and larger volume containers, it offers a safer, more environmentally responsible option for crushing operations.”

**Vertimills save money/energy**

Metso has mature, green technology to meet demands to cut energy costs and public pressure to be environmentally conscious. The company says that “operating with higher energy efficiency, the Vertimill’s, total cost of ownership is almost always significantly less than a traditional horizontal ball mill solution, lowering processing costs and improving profitability while reducing carbon emissions. Since 1978, more than 300 Vertimills have been sold globally, with 76 of those in the last three years alone, giving it the largest installed base of any stirred milling technology.”

Available in standard sizes from 15 to 2,240 kW, the Vertimill has a relatively large practical operating range, handling feed sizes from 6 mm and grinding to sub 20 microns products. Mechanically, it is a very simple machine with advantages that include reduced energy and media consumption, long wear life, reduced maintenance and high availability, lower installation cost in less floor space and greater operational safety.

According to Jonathan Allen, Metso Manager Stirred Mills, the Vertimill has been proven to provide energy savings ranging from 30% to greater than 50% compared with traditional ball mills. “By using the best available technology,” he says, “companies are going to be able to save millions of metric tons of carbon. At a time when everyone is focused on limiting their footprint, this is not an insignificant factor in choosing a mill.”

The Vertimill’s improved grinding energy efficiency is due largely to the effect of its vertical arrangement, which maximises attrition grinding and eliminates wasteful impact breakage. More efficient grinding is also obtained by using finer media. The Vertimill can be charged with a smaller media top size, creating an overall smaller size distribution. “A small change in media size can have a big impact on the total grinding surface area,” explains Allen. “In general, a Vertimill size distribution has greater than three times the surface areas of an equivalent ball mill grinding charge.” For an initial conservative comparison, the Vertimill is evaluated as 30% more efficient than a ball mill for coarser applications (P80 > 200 µm) and 35% for fine grinding applications (P80 < 200 µm); but field surveys show that greater energy improvements can be achieved, according to Metso.

The Vertimill’s carbon footprint much smaller than other technologies, offering both direct and indirect (use of less grinding media that takes energy to produce) energy savings. Allen believes that the environmental impact of a concentrator is significantly decreased by using Vertimills. “In the future,” he says, “it is extremely likely that more sites will adopt this technology for more of their grinding needs to increase their profitability and decrease their environmental impact.”

**High pressure grinding**

HPGRs are increasingly becoming a part of hard rock processing due to their energy efficiency, ability to induce micro-cracks and preferential liberation, coupled with high throughput and high reduction ratio.

With more than 250 Polycom® installations in different industrial sectors, Polysius says it “is the worldwide market leader for this technology. This comminution system offers numerous benefits that Polysius list as:

- Low operating costs, in comparison to other systems – both power consumption and costs for wear parts are significantly lower
- High throughput rates: an HPGR can replace several crushers
- Metallurgical advantages in the downstream process stages
- Shorter delivery and commissioning times
than can be achieved with other systems. Polycom units are designed for throughput rates in excess of 3,000 t/h. The mill feed material can be dry or moist and with particle sizes ranging from below 1 mm to more than 75 mm. If required, the material can be dried in screens or air separators in a closed circuit grinding system.

Köppern says its HPGRs are operation- and maintenance-friendly. “Easy separation of drive and rolls together with the Köppern hinged frame allow for quick roll removal and replacement.” The wear parts of the gravity feeder can be replaced easily from the outside. The roller surfaces are provided with a wear-resistant Hexaduur® liner produced by powder metallurgical technology.

JKMRC has a project to determine whether a series of HPGR units could be used to perform most of the grinding duty in a process plant, increasing the amount of breakage performed in these machines. Such a circuit could substantially reduce the energy and grinding media used and therefore reduce the carbon footprint of new processing plants.

“To date, HPGRs have been installed as single unit, either in open circuit or closed circuit with...
A single HPGR unit is typically limited to around 3 kWh/t, compared with SAG mills which may have energy inputs exceeding 10 kWh/t, and therefore despite being less efficient can generate a finer product.”

The samples were crushed to minus-32 mm top-size and processed in a three-pass HPGR circuit. Test work was carried out on two large pilot-scale Köppern HPGRs at AMMTEC in Perth. In each case, up to three passes of the HPGR were used. The energy consumption and product size was measured for each stage in the flow sheets to determine the energy efficiency of circuit.

Initial data showed “the three-HPGR circuit produces a broad product size distribution, but also that the magnitude of size reduction reduces with subsequent passes. Two passes were found to be effective; however the third pass continues to generate fines without substantially reducing the top size. The result is a flatter or broader product size distribution.”

Optimised circuits

“Process audits are an excellent way to benchmark current performance, review current operating and production targets,” says Richard Jenner Outotec’s Account Manager for Service and After Sales – Minerals Processing Technologies – Australia. “They are also extremely useful in identifying projects to meet or exceed budget targets and business goals. A process audit will answer the tough questions that threaten your sustainability:

■ How do I get that extra 3% yield?
■ How can I reduce water consumption?
■ How can I reduce my power usage without reducing productivity?
■ What gains can be achieved without capex?
■ Where can I spend my limited capex for maximum returns?

“The scope of a process audit will depend on your needs, and can range from basic to detailed, with either a narrow single process stage focus or broader site wide perspective. Depending entirely on the scope, a process audit may include:

■ Site-wide mass, energy and water balance
■ Overall and unit efficiency of existing plant (grinding, thickeners and flotation)
■ Mechanical condition of existing plant (grinding, thickeners and flotation)
■ Identification of bottlenecks and root cause analysis of performance issues
■ Corrective actions and improvement opportunities identification
■ Budgets, scoping, engineering, contracts, implementation, and gains!

“A skilled process audit team will approach your operation from a number of perspectives to determine your needs, including: metallurgical, process, mechanical, operation, maintenance, and personnel training.

“Particle size distribution and electricity consumption are the two main concerns for any grinding circuit. A process audit in the grinding circuit will:

■ Determine optimum particle size distribution for maximum recovery
■ Outline a process for efficient mill control
■ Determine any potential for reduced power consumption.

Automation is another area which can quickly yield results if the correct process and technology are in place. But the basics of spares, service, maintenance and training are also important Jenner explains:

■ Am I carrying enough critical spares to stay on line?
■ Do I know the lead times for critical spares that I don’t carry?
■ Is my preventative maintenance program suitable?
■ Do my operators have the skills to run my plant optimally?
■ Do we know how to effectively troubleshoot process upsets?

“Answering no to any of these questions represents a risk to the
sustainability of your operation. Not only will a process audit answer these questions, but will outline the corrective actions necessary to achieve sustainability,” Jenner concludes.

AMIRA notes that declining metal prices brought a renewed focus by member companies on improved production efficiency. Its Project P1003, Energy Efficient Grinding and Liberation, will enhance practical application of the industry’s expanding knowledge of the complex relationship between mill type, grinding media and final grind size on cost-efficient recovery.

It has two interdependent components:
1. Application of stirred milling to mainstream grinding for rougher recovery
2. Application of stirred milling to regrinding for cleaner circuits.

(Terry.Braden@amira.com.au)

Successful lateral thinking
FLSmidth’s MAAG Gear AG entered the market with its own integrated side drive in 2003. The design is based on state-of-the-art technology and enhanced the already tried and tested design which is available on the market. It was developed to save cost and space for mills with integrated side drive, such as ball, market and drive mills (FTG/SAG mills).

The first LGD, put into operation five years ago is still running smoothly in line with the customer request. Since then over 20 LGDs have been delivered and are in operation. In this year 13 more will be installed and commissioned.

The success of the LGD is based on its design. It is positioned 40° under the mill which demands a compact type of construction and leads to lower building and foundation costs as a lot of space is saved. The new position of the side drive is combined with many additional advantages:

- Low risk of vibration in the gear unit foundation
- Easy installation as well as easy access for service and maintenance
- Easy replacement of rotating parts
- Integrated oil system
- Direct lube oil return from the girth gear to the integrated lube oil tank prevents contamination of oil
- Minimum oil flow in the girth gear guard
- Simple foundation for gear unit, motor and auxiliary drive
- A tooth safety factor of at least 2,3 (AGMA)
- Calculated bearing service life of 80,000 hrs.

One of the major benefits of the MAAG Gear LGD system is the torque split between the two pinions. It ensures that the total torque to the mill is always equally distributed from both pinions. Any deviations in torque between the two pinions is automatically equalised by axial adjustment of the intermediate shaft triggered by the deviations in the axial forces. A crowned toothing between the pinion and the pinion shaft enables the pinions to self align. This ensures full tooth contact even at a smaller run out of the girth gear and compensates pitch errors.

The LGD unit is a three stage spur gear with load distribution. It drives the various mill types directly via the pinions of the two output shafts and reduces the speed of the mill drive motor to the pre-determined speed of the mill. The casing is cast and comprises three different parts which are horizontally divided into the lower, middle and upper parts.

In contrast to other lateral drive equipment suppliers, no separate oil tank is needed. The LGD has an integrated lube oil system in the lower casing to lubricate all the teeth and bearings. The pinions of the upper and lower output shaft as well as the girth gear of the ball mill are lubricated via the output shaft. With the LGD gearbox positioned partly below the mill, it is possible to return the lubrication oil directly from the girth gear guard to the gearbox.

World’s largest GMDs
Earlier this year ABB won an order from Minera Chinalco Perú to deliver and install three complete gearless mill drive (GMD) systems for Polysius Polycom HPGR breaking copper ore. The company claims “60% of the high-pressure grinding rolls installed in the minerals industry are from Polysius”
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the Toromocho porphyry copper project. Toromocho is in central Peru, approximately 140 km east of Lima in the historic Morococha mining district. ABB says its GMDs for Toromocho “will be the largest such systems worldwide, to be installed at the highest altitude where gearless mill drive systems ever have been installed. The region has a steep topography with elevations over the deposit ranging from 4,700 m to over 4,900 m above sea level.”

ABB’s scope of supply consists of three complete GMD systems including transformers, ring motors and containerised E-houses. One system will be installed on a 12.2 m SAG mill with a power of 28 MW. The SAG mill will be equipped with the new ABB 18-pulse cycloconverter. The other two GMD systems will be installed on 8.5 m ball mills rated with a power of 22 MW.

FLSmidth Minerals will supply the SAG mill and two ball mills. It says the “SAG mill will be the largest in the world at 40’x26’ (12.2 m by 7.9 m). Accompanying the SAG mill will be the world’s largest ball mills at 28’x44’ (8.5 m by 13.4 m).” The grinding line is being designed to handle in excess of 120,000 t/d.” The equipment is scheduled to be shipped in the fourth quarter of 2010, co-ordinating with the owner’s construction schedule to meet the targeted initial plant start-up.

FLS says that “in order to reduce mineral processing costs and increase throughput, ore producers have moved towards increasingly larger mill sizes. FLSmidth grinding mills are designed using the latest technology available in the industry. Strain gauging has been used to verify the predicted stress levels to ensure success of the heavy duty rotating equipment. With over 3,000 grinding mills supplied, FLSmidth holds a leading position in large grinding mill technology.”

The company provides expert analysis of data using Bond Work Index as well as other ore characteristics available to correctly size and apply grinding mills in the most efficient manner. It offers a wide variety of comminution equipment, including SAG, AG, rod, ball, pebble and vertical roller mills, as well as the hydraulic roll press.

Besides the optimal tuning of process parameters it is imperative that energy consumption be as low as possible. Even in good times, unnecessary energy consumption diminishes profit. The main parameters influencing energy consumption for mill drive applications are machine size, torque transmission, variable speed, cooling and electrical design, ABB explains.

For motors, economy of scale is an important factor. Where small motors, e.g. for handheld devices, have an electrical efficiency as low as 10%, large motors in the MW range offer about 95%. Thus, it makes sense to install fewer big machines instead of many smaller ones. This reduces the fixed capital, but increases the operational risk with lower redundancy. The efficiency gain can be in the range of 10% and more, depending on the specific conditions.

The way torque is applied to the mill is also important. It is best to apply it directly as with a GMD. Here magnetic interaction turns the mill directly without mechanical interaction. Each mechanical contact, each reduction stage, introduces losses and introduces maintenance requirements. As GMDs are tailor made pieces of equipment these machines are economically feasible above about 10 MW of power. Below this power a geared solution is more feasible, where a minimum of reduction stages is ideal. Consequently a high pole, slow speed solution, possibly with permanent magnet rotor, is the best solution under these circumstances. The power gain for a direct drive compared to geared solution is in the 5% range depending on the project configuration.

The fixed speed solution is the most efficient for the drive. Unfortunately the parameters may vary, i.e. with changes in ore quality or at partial load. If so, an adjustable speed solution will improve the overall efficiency, even if a frequency converter is needed. These converters consist of electrical switching elements, which introduce little additional loss. Generally, cycloconverters are slightly better than Voltage Source or Line Commutated Inverters. Anyhow, the whole drive system has to be evaluated because the output of cycloconverters tends to have more harmonic content. The estimated increase in overall efficiency for a variable speed solution is 1 to 3%.

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The cooling circuit; minor electrical design features like optimisation of the current density in the windings and application of Roebel bars for GMDs influence the efficiency less than 1% each, at a relatively high investment. Finally it is important to note there is little margin to optimise modern transformer losses; they contribute less than 1%.

When considering energy optimisation, reduced consumption is one important part, but the mine should also be analysed for ‘free’ energy. For example a down-hill conveyer could generate some megawatts.

Finally it is the decision of the owner to balance investment with operational cost for the specific site opportunities.

For the first time in 40 years of gearless mill drive (GMD) history, ABB recently completed a stator rewinding on site. This was undertaken
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on a SAG mill stator at Minera Escondida, the world’s largest copper mine. In a joint effort, engineers from ABB in close co-operation with its suppliers and Minera Escondida started the design process. Within six months, this team produced a complex and detailed engineering design. The new stator winding material was manufactured at Alstom factories and the equipment from Switzerland and Spain was finally shipped to Antofagasta, Chile, on a Boeing 747 cargo aircraft specially chartered for this occasion.

For training purposes, a stator dummy was manufactured in Santiago de Chile. Expert site staff from 13 countries were trained to become familiar with all possible special conditions. On July 1, some 300 people started work, on three shifts. Under this experienced team, the rewinding job for the SAG mill was accomplished according to schedule.

Frozen charge shaker
In December 2008, Siemens started up the world’s first ore mill with the frozen charge shaker function at the Rio Paracatu gold mine. With the help of this solution, which is integrated in the SimineCIS Mill GD GMD, charge that has become ‘frozen’ to the mill’s inside shell can be removed quickly and efficiently. This reduces maintenance times and costs considerably.

Rio Paracatu’s Morro do Ouro mine is an open-pit operation owned by Kinross Gold. It is near the historical gold mining city of Paracatu, around 220 km to the southeast of the capital, Brasilia. Rio Paracatu is the largest active single gold mine in the world in terms of ROM (run-of-mine) processing, Siemens reports, and uses modern technology to increase its production.

As part of an expansion project, Siemens supplied the GMD system with 20,000 kW of rated power. With a diameter of approximately 12 m and a length of around 7 m, the new SAG mill was one of the largest mills in the world.

When maintenance has to be carried out, grinding mills have to be shut down for several hours or even days. In this time, the remaining mill charge can easily solidify, firmly attaching itself to the shell of the mill – the ‘frozen’ charge. When the mill is restarted, there is a danger that the frozen charge will not detach itself from the mill shell immediately, but will initially be lifted up by the mill and then dropped from a great height. The resulting damage to the mill can be severe. To detect firmly attached charge in good time and switch off the mill, Siemens developed a frozen charge protection function for GMDs of the type SimineCIS Mill GD. In normal operation the charge starts sliding after the mill reaches an angle of between 40° and 70° and the load torque decreases.

This decrease in torque is monitored and used by the frozen charge protection to stop the mill before falling frozen charge damages it. This prevents damage but does not automatically eliminate the frozen charge. Frequently, the material does not break up and remains stuck to the mill’s shell. Only labour-intensive mechanical efforts with jackhammers or pressurised water jets can remove the firmly attached charge. This is time consuming work, which causes loss of production.

With the help of the ‘frozen charge shaker’ function integrated in the SimineCIS Mill GD system, deposits can be loosened by causing the mill to move systematically. To do this, the operating personnel initiate the mill drive’s frozen charge shaker mode from the local control desk. Defined forward and reverse movements of the mill lift the charge to a less critical angle and move the mill in a harmless range with varying speed and acceleration. The angle and movement are designed to break the frozen charge and remove it from the mill body. The motor is the same as that used for grinding. The frozen charge shaker avoids production from being interrupted for frozen charge removal and prevents mill damaged and simultaneously reduces maintenance times considerably. Given that production is worth thousands of dollars per hour, maintenance cycles costing several million dollars can be avoided.

At the Equinox operations in Zambia, Siemens equipped two ore mills on the Lumwana copper mine with gearless SimineCIS Mill GD drive systems. The frozen charge shaker function will also be used there. And across the Atlantic, at Los Bronces, part of Anglo American’s Chilean operations, Siemens supplied a 22 MW GMD for a 12.2 m SAG mill and two 16.4 MW GMDs for two 7.9 m ball mills. Los Bronces will be one of the biggest copper and molybdenum mines in the world. The GMDs are designed to provide mill drives with the lowest possible power consumption and are equipped with the frozen charge shaker function.

References

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