Cost effective and efficient ore liberation is at the forefront of the current focus by mining groups on efficiency and economy. Crushing and grinding represents the most energy intensive step in the mining process, and according to at least one source, accounts for around 3% of total world energy consumption. Thus the stakes are high to supply larger, higher capacity crusher and mill solutions to achieve greater economies of scale – but this is limited by available castings and componentry.

In terms of the wider challenges in furthering the comminution process, Kevin Graney, Product Development Manager at Metso discussed the difficulties faced, stating: “A big challenge in comminution is cost. As more ore is processed, larger equipment is needed. When producing such large castings, there are tremendous pressures to provide products as cost efficiently as possible. A couple of years ago we introduced the 60-110E SUPERIOR primary gyratory crusher. The focus of the 60-110E was to efficiently use material while simplifying the manufacturing process in order to lower the purchase price of the crusher. These manufacturing efficiencies have been transferred into the MP2500 project to ensure the crusher is designed for manufacturing and Metso can offer the crusher on a cost competitive basis while maintaining the quality we are known for.”

There are also limitations to how big equipment can be designed, and foundry pouring capacities can be a constraint for machine design. It is necessary to create crushers that can process more material without making the components so large that they cannot be produced. This requires more creative design processes.

**Pushing boundaries**

**Metso** has developed the world’s largest cone crusher, and supplied two of them to the Sentinel copper project in Zambia. The mentioned MP2500 cone crusher is based on the industry leading MP crusher series, and was developed to improve efficiency within the comminution circuit. The MP2500 crusher dynamics offer “an efficient crusher that is capable of processing more material than ever.” Two MP2500 cone crushers have been supplied to First Quantum Minerals subsidiary Kalumbila Minerals, the Sentinel operator, which has a 55 Mt/y processing facility. The new cone crushers will be part of the secondary crushing circuit installed to maintain the mill throughput to offset a harder ore in the deeper areas of the pit. The crushers will treat a portion of the ore feeding the stockpile, crushing the top size to below 40mm.

Metso has also won an order to install a 20,000 t/d crushing and screening system at Chile’s Minera Esperanza, increasing annual production of copper and gold by 15 to 20%. The new plant will bypass much of the existing grinding circuit and includes three MP1000 cone crushers. Production is expected to start in 2015. The equipment to be supplied for the new crushing plant consists of three MP1000 cone crushers, three multi-flotation double deck banana screens in two sizes, seven belt feeders, two pan feeders and nine belt conveyors with a total length of 1 km. Einary Ojala, Senior Project Manager, Metso said: “Metso will provide engineering and construction of this new crushing plant from the beginning of the project. Metso is providing services in all the stages of design, civil engineering works, installation and commissioning of equipment. The work will be done using the highest safety standards in the industry.”

Graney also noted “Metso is continually looking for ways to improve the equipment, but more importantly we are trying to share our knowledge with end users about how to efficiently feed and operate the crushers. With high turnover in the mining industry, tribal knowledge can be lost, so it is important to assist EPCMs and end users with our experience and knowledge to allow crushing plants to be designed as efficiently as possible.”

He adds: "There are also many opportunities to reduce energy usage with existing equipment by making minor changes in how the equipment is operated. Applications in terms of the proper sizing of crushers, operations and maintenance practices are all important pieces of an efficient process."
Metso told IM that the BRIC (Brazil, Russia, India, and China) countries have been the most popular destinations for Metso crushers in recent times as well as a healthy market in Africa and the Middle East.

“We are always looking at ways to improve our existing products whether through cost reductions or product improvements. We are also trying to focus on the services business and how to ensure our products can be adapted to simplify maintenance and maintenance processes,” said Graney.

A process plant mindset

One of the major challenges with comminution is the compartmentalisation of the complete process, and the sub-optimising of process steps. Sandvik told IM that it is in a somewhat unique position in that it supports everything from drilling through crushing.

“We can see the opportunities to implement the mine-to-mill concept, in particular in reducing the total cost and energy consumption. The industry will also have to come to grips with energy demands. Aside from temporary fluctuations, diesel fuel will not get any cheaper, and availability constraints of electric power will affect both permitting and operating costs. Emerging markets such as China and India struggle to keep up with surging demand, and major mining countries such as South Africa and Chile fight to produce enough power. In this environment, mining companies will have to demonstrate increased energy efficiency and reduction of total consumption. The European Union has identified an over-dependence on import of 14 critical raw materials. If they act on this, it is quite likely any new mine operations will have to be extremely energy efficient to be permitted.”

Sandvik also believes that the mining community would benefit from more of the process plant mindset already at the mine site: “Mining in the future should be a more of a continuous process, including consistency in mine planning and preventive maintenance.”

Sandvik are carrying out projects aimed at improving the lifetime of segments and crushing teeth for the CR series of roll crushers in abrasive applications. Sandvik are investigating a selection of materials and alternative manufacturing methodologies for components to improve lifetimes. Some of these manufacturing methodologies can be displayed in a matrix with resistance against abrasiveness and impact on its axis. The identified solutions are then tested in partnership with actual end users to determine the effectiveness and comparative performance of these solutions against standard materials and manufacturing techniques.

As well as this Sandvik are looking to develop the serviceability of crushers. Fast and easy service is a key driver of both safety and productivity. One of the developments here can be seen with the quick-release system and form-fitted teeth for the recently developed CR810 hybrid crusher. The crushing technology itself facilitates smaller and more mobile units than traditional gyratory crushers would, and also has a greater range in the feed materials it can handle.

The newly developed CR810 hybrid crusher has one fixed roll and one loose roll which releases when “uncrushable” material enters the machine. In combination with very robust crushing elements, Sandvik believes that the hybrid crusher can efficiently handle much harder materials than in the past. The CR180 hybrid crusher has a design capacity of 11,500 t/h.

Sandvik’s focus on safe and easy service is also seen in the latest designs of its crushing stations. By mounting it on rails, the entire crusher can be slid out for service, or complete replacement. An installed crane can be used to assist in the safe exchange of crushing teeth or segments during maintenance tasks.

Sandvik says it aims to reduce energy consumption in the comminution process by moving the primary crusher closer to the mine. In-pit crushing and conveying (covered in detail again by this year’s IPCC event in South Africa – see http://corporate.im-mining.com/imevents/IPCC-2014.asp) is often associated with waste handling. In surface mining, this usually represents the largest tonnage of materials movement. The additional cost of crushing is more than off-set by the savings from conveying rather than hauling by truck. Ore haulage may not quite have the same economies of scale as waste haulage, but primary crushing has to be done regardless and is not an additional cost. In-pit crushing and conveying of ore is simply a cost comparison of conveying versus trucking. It is nothing more complicated than moving the primary crusher as close to the mine face as practical, with an extended conveyor to the processing plant. Sandvik is a big proponent of this process solution to reduce not only the total energy consumption, but also cost and other environmental impacts.

Stirring stuff

FLSmidth is launching its new VXP5000 Vertical Stirred Mill which has completed internal quality control factory acceptance testing. The VXP5000 is FLSmidth’s largest mill and was showcased to clients and employees in late 2013 at its Vancouver, Canada facilities. The VXP500 mill has been designed to have a smaller footprint than other stirred media mills which is especially helpful on brownfield projects, where equipment must fit into an existing structure.

The mill speed is also an important differentiator between the low (3 m/sec) and high (15 m/sec) speed stirred mills according to David Rahal, Product Manager, FLSmidth VXPMill: “It allows the VXPMill to be used in applications where the design constraints of the other mills limit their ability to operate at the optimum stress intensity for a given application. The VXPMill bridges the gap between these two extremes.”

The VXP5000 mill also has a unique, newly designed maintenance procedure designed to increase safety by eliminating workers exposure to suspended load while changing out the discs and spacers. Three VXP5000 mills have already been shipped to the MAK project in Mongolia, the one is scheduled to go to the Bozhskal plant in northern Kazakhstan, with commissioning scheduled for mid-2014.

FLSmidth has also provided Katanga Mining with a new grinding mill to boost plant reliability and enable production throughout predictability. Terence Osborn, Minerals Capital Sales and Marketing Manager at FLSmidth said: “It has been well proven to be high quality and reliable equipment, and we have a growing relationship with this client.”
Katanga Mining will also implement FLSmidth’s proprietary Process Expert™ system (PXP) advanced process control mill optimisation package. This high-level process control solution is a proven method to simultaneously reduce costs and improve product quality. “The mill is running in closed circuit with hydrocyclones, and we’ve developed software that takes the milling plant operation into account holistically,” Osborn said. “Having expert knowledge of mill circuits, we’re in an ideal position to ensure that the whole system runs in a well-balanced and optimal manner, harnessing PXP to achieve a consistent throughput. Achieving consistency is particularly important at this operation, since test work data indicates that the ore from this project will be variable from a hardness perspective and this always makes mill circuit control more challenging. The best way to maximize plant productivity is to maximize stability. By running the plant as consistently as possible, the mine will achieve a better quality downstream product.”

New launches and deliveries
Russian mining equipment company Uralmash has developed a crusher to be used at Yubileinaya mine of ore-dressing and processing enterprise EVRAZ Sukha Balkha. The crusher supplied was a KMD-22000Ti-D which is a fine crusher with a 2,200 mm cone head base diameter, designed for fine crushing of rock product and ore mineral resources.

As previously announced by IM, Uralmash also shipped a primary gyratory crusher of model KKD 1500/180 in November 2013, to ENRC’s Sokolovsky-Sarbaiskiy iron ore mining and processing production association in Rudnyi, Kazakhstan. This was the second of three crushers that Uralmash will produce for the company. The KKD 1500/180 crushers are being used to develop the Kacharskiy deposit and can handle 1,900 m³/hr. These KKD 1500/180 models include high-altitude automated maintenance and grease systems and a PLC-based drive control system.

Andrey Saltanov, General Director of Uralmash said “Uralmash has great experience of working with enterprises in Kazakhstan and we have got an order for these new machines in highly competitive conditions with foreign suppliers. We offered the best price and delivery terms along with exceeding their engineering needs versus foreign products.”

Weir Minerals launched its new Enduron line of comminution equipment, including crushers, screens and feeders during 2013. The Enduron range significantly expands Weir Minerals’ comminution solutions portfolio, adding to its range of mill circuit products. The use of KHD HPGR equipment in conjunction with the new range of Enduron vibrating screens, feeders and crushers offers an effective comminution package. Weir Minerals has an emphasis on enhancing mining productivity and safety, with the new equipment being designed to maximise customers’ operational efficiency.

“Screens and crushers are typically the workhorses of an ore processing operation,” said Ekkhart Matthies, Weir Minerals Global VP of Comminution. “Weir Minerals’ design and application expertise, combined with our product support resources will ensure the new products provide optimum performance as they cope with the demands of today’s mining industry, and we are already developing the next generation of crusher technology for future applications. The introduction of the new Enduron brand provides the quality, scale and breadth of product to help mine operators maximise efficiency and productivity, while maintaining field safety,” said Matthies.

As mentioned by IM in 2013, Telsmith has developed the T300 cone crusher which has been engineered for maximum uptime and productivity while delivering 300 hp performance and a crushing capacity output range from 125 to 400 t/h. With an emphasis on lower operating costs and increased safety, the T300 features a large clearing circuit, which is engineered to safely and quickly allow any uncrushable materials to pass. The T300 has been designed with six cylinders, which is fewer than conventional units, but maintains the largest crushing force availability. The unit also offers a new and improved patent-pending anti-spin feature that prevents head spin to extend manganese life. This is mounted on top of the machine to offer top-service access. The T300 is also designed to operate with pressure lubrication oil, while eliminating the use of a gear box and a separate hydraulic circuit.

The T300 features the largest-in-class, patent-pending hybrid bearings and unlike roller bearing machines, these large hybrid bearings offer both a static and dynamic lift – resulting in far greater lift to efficiently carry the crushing forces. The hybrid bearings also have a washer and ramp design to replace the conventional use of a socket, socket liner, and head ball – all of which require time-consuming removal when servicing the machine, and to minimise downtime and reduce inventory costs, the T300 enables the use of a single bowl for all liners over its range of operation – allowing optimum versatility, flexibility, and efficiency in any aggregate application.

Telsmith also showcased its new hydra-jaw crushers with their worldwide product launch at the 2014 CONEXPO-CON/AGG. The H3450 (863 mm x 1,270 mm) hydra-jaw is capable of processing up to 598 t/h. It also includes a hydraulic toggle for reduced maintenance, with fast and safe hydraulic chamber clearing.

ABB recently commissioned an upgrade to Vale’s existing Clarabelle dual pinion SAG mill. The mill is used to reduce the size of the ore at the company’s nickel and copper mines in the Sudbury area of Ontario. The Sudbury operations are primarily underground nickel sulphide mines with integrated mining, milling, smelting and refining operations. The Clarabelle mill was designed to accept nickel-copper ore from various sources and companies and to produce a nickel-copper concentrate and copper concentrate for further processing. The size of the ore is further reduced in SAG mills, rod mills and ball mills where all milling is done wet.

First awarded in 2010, the project is the largest of several turnkey projects completed for Vale in Canada. This complex project involved an upgrade to a SAG mill of 10 m diameter and 11.2 rpm that had reached end-of-life with a newer, more robust system. ABB replaced all of the electrical equipment including 5500KW motors, converter, transformer, motor control centres, switchgear and mechanical auxiliary equipment such as the cooling system – pump skid, chillers and fin-fan heat exchangers. As well as modifying existing foundation and air clutch coupling to adapt it to the new motors. A number of SAG mill applications were implemented to facilitate the operation and maintenance of the SAG mill.
Sizer developments

MMD has installed a pair of semi-mobile systems at a coal operation in Africa. These installations are fed by Euclid EH4000 dump trucks into a 450 m³ hopper over a MMD D9 Apron Plate Feeder, which discharges into an MMD 1300 Primary Sizer with a short sacrificial belt to an MMD 625 Secondary Sizer. The secondary sizer is positioned in the pit just after the primary to produce a 150 mm product for the overland belt (the end user being of the opinion that larger lumps damage the belt) and the plant acceptance size. Currently the throughput is constricted by the secondary to a maximum of 3,400 t/h. MMD has also been asked to investigate installing another secondary unit in parallel, to enable running at 6000 t/hr, as the Apron Plate Feeder and Primary Sizer can easily cope with this.

This project included a 500 t capacity Crawler Transporter which is the newest piece of equipment available from MMD, used initially to transport the semi-mobile structures from the construction area, outside the mine, down to the mine face. Each piece was successfully transported a distance of over 5 km and negotiating grades of up to 8% in fewer than 20 hours. The Crawler Transporter will be used to relocate the Semi-Mobile Sizer Stations as the mine develops, to maintain a short truck haul distance of approximately 500 m. MMD stated: “These are believed to be the first two truly relocatable machines of this size in Africa, with all previous machines by other suppliers using equipment that was so large, and relocation so complicated, that all attempts to move them were abandoned and the plants became fixed.”

MMD also provided a Fully Mobile Sizer at the Pingshou open pit coal mine in China. This unit is a “third generation” MMD high-capacity (>5,000 t/h) fully mobile sizing unit, and the first fully mobile MMD unit to go into operation in China, where the group has already been highly successful with semi-mobile systems. This machine will process 9,000 t/h of overburden consisting primarily of sandstones. The horizons at Pingshou contain several muddy layers and are expected to get sticky in the short wet season, when the daily precipitation can exceed 150 mm. The material, produced from 15 m high benches of up to 1,700 m in length, will be loaded by 60 m³ capacity rope shovel into the MMD Mobile Sizer. The Sizer reduces the ROM material (maximum dimensions 2.5 m x 2.5 m x 2 m) to a product suitable for belt conveying (400 mm maximum). The MMD Mobile Sizer feeds an independent mobile 70 m bridge conveyor, which in turn feeds the MMD Hopper car mounted on a moveable face conveyor. The face conveyor, subsequent haulage system, stacking and spreading systems are not part of MMD’s scope of supply, having been the subject to a separate tender process.

HPGR and SMMs

High pressure grinding rolls (HPGRs) and stirred media mills (SMMs) have been successfully introduced into the minerals industry as an answer to the need to reduce energy consumption. HPGRs have mainly been used for tertiary fine crushing of competent and hard ores in order to produce ball mill feed, and are potential substitutes of SAG mills or conventional tertiary cone crushers in traditional comminution circuits.

ThyssenKrupp states: “Experience from other industries suggests that HPGRs could even do even more to reduce power demand due to their high energy efficiency and their ability to be used as dry grinding systems. HPGR systems already have been successfully applied in the cement industry for grinding limestone, clinker and slag to a final product fineness of between 30 and 90 µm (P80) without the need to use any downstream ball milling. The energy consumption of an HPGR finish grinding plant has been found to be significant lower than in ball mill plants. This leads to the question of whether the same methodology can be adopted in minerals applications. Such a step would require the use of dry rather than wet grinding systems.”

The company adds: “Dry grinding systems are so far only an exception in mineral processing, since most post grinding processes are wet. However, there are successful – mainly ball mill based – dry grinding examples in gold, nickel or iron ore. A lot of the questions which arise for HPGR finish grinding systems were already proven in the field as well as in pilot test work in the lab. Considering the conservatism of the minerals industry, a request for extended field testing – at least on a pilot scale – will be quite likely. The basic engineering work for such a pilot trial plant and even a full scale commercial installation is already available.”

Outotec and Maschinenfabrik Köpperm have agreed that they will cooperate in the manufacture and supply of Outotec branded
comminution products as part of Outotec’s process solutions. Köppern has experience in HPGR technology as well as briquetting and compaction solutions. Köppern’s HPGR looks to complement Outotec’s comminution technologies and services and strengthen Outotec’s market position. Outotec’s comminution product range includes autogenous (AG) mills, semi-autogenous (SAG) mills, high intensity grinding (HIG) mills, rod mills, ball mills and pebble mills.

“Partnership with Köppern will broaden our scope of delivery. We can offer our customers a wide range of sustainable comminution solutions and tailor the most energy efficient solution for each customer”, says Jari Rosendal, President of Outotec’s Non-ferrous Solutions business area.

“As an independent and family-owned manufacturer and solution-supplier, we are proud to partner with Outotec on an exclusive basis to enhance our world-wide market potential for HPGR applications” says Christopher Schafer, Managing Director of Köppern.

As covered in a recent edition of *International Mining*, FLSmidth’s engineers have improved their HPGR frame design. They not only looked into the roll change out time requirements, but also the actual frame design and steel requirements. The traditional FLSmidth cement HRP L-gable has proven very effective for roll change outs, and is a unique system that allows rolls to be lifted out of the machine without having to extract a top frame or incorporate an extended work platform. The L-gable incorporates a vertical side pressure beam and a portion of the top frame. It also uses a pinning system, which greatly reduces roll replacement time compared to the conventional hard bolting frames.

However, with plant sizes growing due to declining grades, more optimal flow sheets with reduced footprints are being implemented. The areas around the HPGRs are more compact, while chute-work and conveyors are less retractable than in the past. With this in mind, FLSmidth engineering created the FLSmidth Express Frame, which is designed and built for the quick replacement of mineral application roll surfaces.

Mobile crushing

Powerscreen has launched two new tracked mobile crushing plants within the past 12 months. The Premiertrak 300 is a new mobile jaw crusher with a 1,000 mm wide x 600 mm deep jaw chamber, which can produce up to 280 t/hr of crushed material. The Premiertrak 300 crusher has been developed with the option of a vibrating grizzly feeder (VGF) or a large fully independent hydraulically driven pre-screen, which improves fines removal and reduces chamber wear costs for the customer.

To coincide with the independent pre-screen feature, an optional hydraulically folding extended side conveyor with a stockpile height of 3.1 m has been added to the machine to improve stockpile capacity.

The Powerscreen jaw chamber has hydraulically adjustable Closed Side Setting (CSS), which can be adjusted in a matter of minutes by a single operator without requiring tools. The hydraulic release chamber option (Premiertrak R300 crusher) incorporates the proven hydraulic release mechanism to allow the chamber to ‘dump’ and pass un-crushable material which is ideal for recycling applications. A hydraulically adjustable deflector plate is an option for recycling applications. The machine is highly versatile as it also incorporates a new lock-out function to allow the operator to work in hard rock quarry applications with the same chamber.

The new hopper design incorporates a complete hydraulic fold and lock system which removes the need for manual wedges and can be raised/ lowered from ground level removing the need to work at height and providing rapid setup times. The Premiertrak 300 jaw crusher features a hydraulically lowering product conveyor with 3.5 m discharge height for easy removal of trapped metal in recycling applications and features full tunnelling to reducing snagging of rebar.

The Premiertrak 300 can be powered by a Tier 3 CAT C9 Acer 205 kW or a Tier 4 Final compliant...
Scania DC9 80A 202kW engine which is designed to run at the most economical speeds to reduce fuel consumption and noise pollution.

Damian Power, Powerscreen Global Product Director, said: “With its exciting new features and feedback from the testing period, we’re confident that the Premiertrak 300 will set new standards worldwide. The machine was recently showcased at a preview demonstration for distributors and customers and there was a lot of enthusiasm among the attendees.”

Powerscreen has also developed the Trakpactor 320, which is the latest evolution within the Trakpactor series of mobile horizontal shaft impactor machines. The Trakpactor 320 comes in both standard and closed circuit configurations.

The Powerscreen Trakpactor 320SR is a mid-sized horizontal impact crusher redesigned with some key enhancements to offer operators and contractors’ excellent reduction and high consistency of product shape for performance in quarry and recycling applications. The crushing chamber features a 1,130mm x 800mm feed opening, hydraulically assisted CSS adjustment, four bar rotor and twin apron design, and hydraulic overload protection as standard. New to this model is an optional fully independent hydraulic pre-screen which improves fines removal and reduces chamber wear costs.

Damian Power, Powerscreen Global Product Director, said, “Building upon the success of the Powerscreen Trakpactor 320 impact crusher for the quarry and recycling industry, the new Trakpactor 320SR crusher is set to establish itself as a class leader amongst its peers and demonstrates what is possible when we work with customers in defining features and specifications.”

Power told IM: “With all the increasing costs associated with energy, plant efficiency is more important now than it has ever been before. Ore deposits are becoming more difficult to access and more difficult to process and transport, this obviously increases the energy intensity of the process. It is a well-known fact that comminution consumes around 3% of the electricity produced around the world. Other prevalent issues include safety, ore quality, sustainability and environmental impact.”

Powerscreen has looked to remedy this energy challenge with recent product developments. Powerscreen has had process efficiency at the heart of the specification for each machine. Typically using the lower fuel consumption Tier 4 Final Scania engines, which operate at reduced optimum running speeds with a direct drive coupling to the crushing chamber to achieve the highest efficiency possible.

**Mill linings and balls**

Cherylyn Stewart, External Projects Consultant, Russell Mineral Equipment (RME) told IM: “RME’s abiding focus is the development of methods to minimise maintenance downtime associated with any comminution device, including conventional tumbling mills (AG, SAG, ball, rod), HPGR and Vertical Stirred Mills.” RME is the leader in mill liner changeout equipment and has developed the RUSSELL 6V Liner Placement Mill Relining Machine, to compliment the RUSSELL 3V Vertical Stirred Mill Liner Handler. The RUSSELL 6V has been designed to service the new family of large Vertical Stirred Mills such as Metso’s VTM-3000-WB VERTIMILL.

The company also offers RUSSELL Elevating Platforms which surround AG, SAG and ball mills, allowing mill relining crews to access much larger areas of grinding mill shell during knocking in and liner bolt fastening and retorquing without the need to remove safety locks and inch the mill. This innovation was developed through a constructive relationship between the Oyu Tolgoi mine, Kaltech USA Relining management and RME engineers. RUSSELL Elevating Platforms are now in service at Oyu Tolgoi and have proved a success.

RME has additionally developed the RME Mill Reline Director, which is a software package aimed at defining the maximum grinding mill relining performance. The foundation of Mill Reline Director is a database, compiled...
from data derived from video recording reduction of actual relines captured by RME’s specialised reline cameras. The video capture allows analysis of that actual reline which guides future equipment and process changes. This data adds to the database, constantly increasing the accuracy of Mill Reline Director for its other important use: aiding in the design of new mineral concentrator grinding plants. In this application, Mill Reline Director can inform plant design and equipment selection, all assessed against rate of return for each investment decision.

The next 12 months will see the global rollout of RME Mill Reline Director which, in turn, will liberate the full performance potential of each and every RME Mill Relining System delivered to date.

RME’s latest pneumatic recoilless hammer is the THUNDERBOLT 250. The hammer weights less than 20 kg, and is designed to be easily handled by two operators. It delivers recoilless 250 joule blows at one blow per second and has been manufactured to replaces manual sledgehammering. It is a useful tool in grinding mill relining as well as heavy vehicle maintenance.

ME Elecmetal’s joint-venture ball plant recently received its OHSAS 18001 certification, a UK Standard for occupational health and safety management systems, which means that the ME Long Teng Grinding Media (Changshu) Co Ltd plant, has accomplished a high level of safety controls in the manufacturing of grinding balls. The certification was accredited by IQNET, an international network of certifiers that, since its foundation in 1990, has remained the largest and most comprehensive network of quality certification bodies in the world. In the joint-venture ball plant, located in Changshu, China, ME Elecmetal manufactures its premium quality ME Super SAG and ME Ultra Grind forged steel grinding balls.

**Brakes and maintenance**

Twiflex, which is part of the Heavy Duty Overrunning Clutch and Brake division of Altra Industrial Motion, supplies braking systems for both geared and gearless grinding mills. Twiflex told IM that their main focus over the last 12 months has been the development of a large mono spring (floating) spring applied, hydraulic release disc brake for the dual pinion direct drive geared mills. The result has been the introduction of the VMS-FL which is based on Twiflex’s popular VMS range commonly used on mine hoists. The VMS-FL has a braking force rating of 460 kN which assumes a coefficient of friction of 0.4 and 2 mm pad air gap, and the design incorporates Twiflex’s unique safety ‘park-off’ feature meaning the brake can be adjusted so when depressurised there is zero stored energy for maximum safety.

The VMS-FL is used in conjunction with a torque limiter fitted between the motor and gearbox. During maintenance when the motor is shut down and the torque limiter is disengaged, the brake is activated to hold the mill drive stationary and prevent the mill from moving due to the unbalanced load. The requirement of the brakes is to hold the mill charge at an angle of up to 45°.

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In normal operation, after the mill controller receives the stop command from the customer's DCS it starts to ramp down the speed. When reaching zero speed the drive system slowly starts in the reverse direction to roll back the mill until zero speed is reached and the motor creates a positive torque to just hold the mill with the charge unbalanced. By slightly reducing the torque the direction of rotation is changed and the mill is gently rolled back until the charge is balanced.

During a power failure the motors are disabled so the mill slows to a rocking mode due to the unbalanced charge. This is a critical condition whereby lubrication to the mill pad bearings is limited by the number of accumulators in the system. To prevent equipment damage the brake is used to provide a controlled stop (between 10 and 30 seconds).

Twiflex and US distributors Hilliard have recently completed the installation on both geared and gearless mills at the Mount Milligan mine in British Columbia, Canada. The scope of supply for the 40 ft gearless SAG mill included two brake stations each with 3 off VMSDP brakes and a hydraulic power unit to provide controlled braking functions. For the two 24 ft dual pinion direct drive geared mills, Twiflex provided VKSD-FL (floating) brakes on each mill to provide 454 kNm on the high speed shaft. The brakes act on a 1.178 m diameter disc fitted to a torque limiter.

Steve Powell, Product Manager at Twiflex said: "The increase in the size of grinding mills has become a major challenge to the suppliers of drive chain components but particularly to brake manufacturers. A good example is Twiflex’s braking system on the 11.6 m gearless grinding mill at the Boliden Aitik copper mine in Northern Sweden which is required to produce a massive 38 MNm torque. The 8 off VMDSQ dual piston spring applied hydraulic released brakes each weighing 1,850 kg act on a 13 m diameter flange and can stop the mill with a full process charge of 1,375 kg in less than two seconds."

Whilst the number of brakes and their size have increased to cope with the bigger mills the limiting factor is still the friction material. Twiflex have installed a dedicated test facility at their Bedford facility to investigate materials both for static and dynamic duty with this development in mind.

Powell concluded by saying “Twiflex focus is on developing and introducing new products to the mining industry and the company have recently launched new spring applied, hydraulically released brakes (VBS, VCSD and VKSD large pad) for this market. We are currently working on low temperature versions of these brakes in addition to on-going product development and improvements. Our intention is to develop a larger VMSDP for gearless mills.”

A number of mines globally protect their grinding mills with Lubrication Engineers’ (LE) Pyroshield® open gear lubricant, described as “a long-lasting synthetic solution for high-load, heavy-shock applications.” Its high film strength allows Pyroshield to redistribute loads over the surface area of large open gears. The powerful formulation includes EP additives and Almasol, LE’s exclusive solid wear-reducing additive. The company states: “Converting mills to Pyroshield is a simple process for mines, with no production interruption. Pyroshield is also clear during use, so inspection of gears is easy.” Pyroshield lubricants can be used in automatic lubrication systems, which apply the lubricant to the bull or ring gear teeth at set intervals in metered amounts. Pyroshield lubricants will not clog the lube system and there are no solids to block or abrade measuring valves. It also will not accumulate on nozzles, clog or otherwise interfere with the spraying process.

**Comminution with pulse power**

Swiss company SELFRA AG is known for its technology, centred on high voltage pulse power, that is aimed at “revolutionising the comminution process within the mining industry.” SELFRA has already sold a number of batch units to institutes around the world, including the globally-renowned Julius Kruttschnitt Mineral Research Centre (JKMRC) in Australia, and is now in the process of developing an industrialised continuous system for mining applications.

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Selfrag's high voltage fragmentation is a comminution technique that uses electrical discharges to weaken and/or fragment rocks. Specialised high voltage generators are used to create very powerful underwater high voltage discharges, resulting in the formation of shockwaves that cause widespread fracturing inside the affected particle. Fracture patterns generated by high voltage breakage resemble those resulting from normal blasting, indicating that high voltage fragmentation can be thought of as a smaller-scale analogue of normal blasting using explosives.

The company believes that the Selfrag method has two major advantages over conventional comminution. Firstly, the interaction between minerals and the induced electrical and mechanical stress fields inside a rock matrix is highly selective. This makes Selfrag's high voltage fragmentation exceptional at liberating minerals – ores treated using between 1 and 10 kWh/t are generally liberated both coarser and more selectively. This has been shown to improve concentrate quality for nickel and copper ores. Alternatively, this improved liberation may be used to increase the grind size of an ore, which could represent a considerable energy saving.

Selfrag's Lab system, sold to geology and mining institutes, has proven successful in liberating zircons and other minerals for dating of rocks.

The second advantage is the ability to weaken rocks using small energy inputs; energy inputs of 1 to 4 kWh/t, have typically given weakening values of up to 56% and Bond work reductions in the range of approximately 5% to 20%. JKSimMet simulations have demonstrated that these strength reductions can result in significant overall energy savings. In the case of a SABC circuit with two ball mills (see above), power draw of the SAG mill was kept constant to produce a finer product from the weakened feed; this change in the circuit power balance was sufficient to allow shutdown of one of two ball mills, resulting in significant power savings as well as considerable reductions in other costs such as grinding media and liners (see diagram).

"At Selfrag we currently have a pilot plant capable of processing up to three tonnes per hour," explains CEO, Frédéric von der Weid. "We have been using this plant for internal development, as well as processing of bulk samples for mining and exploration companies. In the last six months, third party projects have included platinum, copper/gold and silver applications. We have also already completed engineering work on a modular 10 t/h pilot unit; this modular design represents a scalable concept allowing for throughputs of 100 t/h or more to be reached." Selfrag also offers services in high voltage characterisation of ores to the mining industry. In addition to mining applications, Selfrag is also actively developing exploration solutions for the diamond market, machines for the recycling of a wide variety of feedstocks, and units suitable for ultra-high purity fragmentation applications such as silicon rod crushing. Selfrag's batch lab unit is already installed in over 20 institutes around the globe, including in Australia, Japan, China, North America, and Brazil.

Mill girth gears

Engineering group David Brown is a leading player in the design and manufacture of the large girth gears that drive large AG, SAG, ball and rod mills. IM spoke to Henk du Preez, Engineering Manager of David Brown South Africa, on the available technologies. Fabricated steel gears are becoming increasingly popular and represent a newer alternative to cast gear blanks, delivering the benefits of steel gears without some of the risks of casting steel. Fabrication allows the designer to use a more cost effective structural steel where the high hardness requirement is not necessary, with the structural strength of the structure being checked using Finite Element Analysis (FEA) modelling techniques.

Girth gear design is stiffness limited and deflection should be controlled to ensure good load distribution over the tooth in contact. The high hardness requirement for the rim is necessary for tooth loads only. Stresses away from the tooth root and flanks are very low, making it possible to utilise normal structural steel for the gear structure. Proven forging practice and reduction ratios in excess of 6:1 are already extensively used for pinion shafts and gear wheels by David Brown, minimising the risk of defects. Reduction ratios in excess of 6:1 reduce segregation, eliminate centre line defects, refine grain structure and increase material toughness and integrity. Commercially proven alloys are used, giving minimum hardness values from 180 to 340 BHN, and much higher impact strengths, typically 35J, but can be as high as 90J. Du Preez comments: "Whereas some fabricated gears have been manufactured using cold formed ring segments for speed and low cost, David Brown utilises a unique hot forming process specifically developed for girth gears. This delivers greater material consistency and reduces residual stresses.

Although fabricated gears are on the rise, cast steel is the traditional material used for girth gears and hardness ranges from 180 to 320 BHN. Although, there are risks associated with large steel castings, upgrading by means of welding prior to final machining eliminates the effect on the final product. Du Preez comments: "Proven David Brown procedures are used to ensure optimal quality and control any necessary upgrading. With mill power and size ever increasing, foundries have to produce larger castings with higher hardness. A higher hardness often means richer alloys, which can be more difficult to manufacture, however technologies such as liquid drenched castings, as used by David Brown enable higher hardnesses at optimum quality. Castings weighing over 20 t at a hardness of 320 BHN are now being produced for girth gears by specialist foundries."

Du Preez added that Spheroidal Graphite Iron (SGI) gears offer further material benefits when compared to cast steel girth gears. The material solidification properties allow easier casting, whilst a sound material choice enables shorter manufacturing processes and the delivery of a robust girth gear. A well designed and manufactured SGI girth gear will prove to be a reliable component in the mill drive system. SGI has a lower stiffness, meaning that the deflection under a given load is more than that for steel which improves load sharing across the face as well as between teeth. IM