



MILLING

Not just run of the mill

Ailbhe Goodbody looks at the current trends in milling, including new advances in milling technology

There have been some new advances recently in milling technology for mineral processing. Trends that have been very prominent in driving advances in equipment include the continuing trend to minimise the number of production lines and minimise the number of pieces of equipment. This, along with higher concentrator production rates, is resulting in larger machines.

Larger-diameter mills result in more single-stream processes and higher tonnages being treated. Spike Taylor, managing director of Multotec Rubber, says: "This is coupled with the design and manufacture of larger steel mill liners to reduce downtime during mill relines because there are a lower number of liners to remove and install during a reline. This development has been

matched by the design and manufacture of mill-liner handling machines suitable to safely handle these large liners."

In addition, the need for higher plant availability is leading to better designs for ease of maintenance and reliability in components. Matti Gallimore, manager, process engineering at Metso, suggests: "These two primary trends are requiring closer collaboration between mining companies and vendors to spearhead product development."

There has also been a lot of discussion on the move towards high-pressure grinding rolls (HPGRs) replacing semi-autogenous grinding (SAG) mills over the last few decades. This is mainly related to the energy efficiency of the circuit, and HPGRs have been installed on some recent projects.

Stephen Cantwell, executive general manager of Bradken's Mineral-Processing Division, says: "The focus on size reduction and energy consumption has resulted in HPGRs becoming more accepted as an alternative to large, less energy-efficient SAG mills. Looking forward, it would appear that HPGRs will continue to gain industry acceptance in the right circumstances."

Taylor notes that stirred mills have been known for some time, but with the advent of Glencore Technology's IsaMill, which is a horizontal mill, there has been more of an emphasis on fine grinding to liberate the finest particles of ore.

Thomas Plochberger, head of research and development and process technology at Cemtec, adds: "Comminution alternatives such as HPGRs or vertical roller mills are ►

The Bradken Vortex discharge end design

Mill inspection under way during a circuit survey by Multotec at a plant in Central Africa



“Superior mill-lining design and materials will result in improved throughput and grind efficiency”

► both sensitive in regards to wear rate but are rumoured to be beneficial in terms of energy efficiency.”

Mike Haugen, senior product development engineer at ME Elec-metal, tells *Mining Magazine* that at the recent SAG Conference in Vancouver, Canada, in September there was a lot of interest in discrete and finite-element modelling, “not only in the development of the models themselves, but in how to integrate them into the various grinding circuits, allowing for increased throughput and liner life while reducing power draw”.

Other trends in this area include the reduction of feed rate to comminution by run-of-mine (ROM) pre-sorting techniques such as near-infrared (NIR) or X-ray diffraction (XRD); the pre-weakening of feed by

electric flash treatment; a higher degree of automation so as to decrease specific energy costs; and the design of more flexible flow sheets to better handle ore variation.

MAINTENANCE

With the current downturn in the mining industry, there has been an increased focus on good maintenance practice for mineral-processing equipment such as mills and mill liners at some operations.

Haugen notes: “We’re seeing more innovative ways of maintenance; things similar to manufacturing time-motion studies, where liner change-outs are captured on camera and reviewed, in an effort to maximise the efficiency of the change-out, which will ultimately result in more process availability.

“End users in mineral processing are now demanding more than just base products from their suppliers. They are looking for value-added services to increase the efficiency of not only supplier products, but of the complete grinding circuit.”

However, at some operations, maintenance is not the main focus, as with declining head grades there has been more emphasis on mill throughput and metal recovery than anything else.

Taylor cautions: “Many sites have more of a focus on treating higher tonnages and spending less on the mill liners, which then get run past the recommended change-out point, having a negative effect on the grind and therefore on the liberation and subsequent recovery of the process plant.”

Cantwell says: “Good maintenance practices are only part of the equation. Optimising liner designs to reduce downtime, increase mill availability and improve grind is a very practical and cost-effective way of not only improving mill performance but also engineering out possible safety issues.”

With the current challenges facing the mining industry, improved performance and the lowest possible total cost of ownership (TCO) are what customers are looking for to ensure that productivity is maximised. Good maintenance practices are certainly important, but for mill-lining systems it can be more important that lining designs and materials are of the highest quality.

Mark Lockyer, global product manager, mill lining systems at Weir Minerals, comments: “In recent years we have definitely seen a growing understanding that total cost of ownership, and not up-front or maintenance costs, is the key to achieving the highest productivity. Superior mill-lining design and materials will result in improved throughput and grind efficiency.”

However, Plochberger doesn’t have the feeling that more effort is spent on maintenance due to the downturn so as to reduce costs. He says: “Due to the downturn, many mine operators have been forced to reduce HR costs.

“As a consequence, the fluctuation of people is increased. As the maintenance of mills is a very experience-driven business, ground was getting lost in this field in many operations.” ►

Composite mill-lining systems

Traditionally, SAG and autogenous grinding (AG) lining systems have been composed of metal castings, and ball mills generally lined with rubber compounds. However, inherent problems exist with some all-metal or all-rubber systems.

Composite lining systems are an innovative development for grinding-mill applications. For example, Weir Minerals’ Vulco composite liners are made with a combination of rubber and metal, with either cast or laminated steel inserts. The resilience and shock-absorbing properties of rubber improve the wear properties of metals, delivering a lower total cost of ownership (TCO).

The benefits of composite lining systems are considerable, such as safer installation and removal handling, due to lighter

weights, and linings that can wear thinner without the risk of cracking. They can also achieve up to a 50% reduction in lining-system replacement time compared with cast liners, due to lighter and fewer components being installed. Design modifications are significantly easier and faster to implement than cast liners, and since there is the ability to create larger lining components, it reduces the total number of installed components required.

Weir Minerals says that continued development in composite mill-liner technology by engineers and material scientists at the company has resulted in such composite systems, which are being installed into large SAG milling applications with excellent results.

Products and projects

Mining Magazine spoke to some mill and mill-liner manufacturers about the newest technologies and developments

Cemtec has provided mills to some of the biggest players in the mining industry

BRADKEN

Bradken states that it continues to evaluate mill-liner designs that optimise the performance of its customers' mills. Cantwell says: "No two mills are operated the same, and therefore designs need to be customised to suit each operation. Mill-liner designs continue to evolve the more we learn about the interaction between liners, grinding media and ore inside a mill."

The company's emphasis right now is on working with customers to optimise designs for best throughput at lowest whole-of-life costs. Cantwell explains: "In these efforts we are developing some very sophisticated and useful simulation tools. Also, while not ready to talk with the market yet, we are doing some very exciting work in materials design."

Bradken presented a paper at the recent SAG Conference in Vancouver that highlighted the benefits that can be delivered if customers are prepared to partner with their mill-liner supplier to develop a lining system that can significantly improve mill performance.

CEMTEC

Wet- and dry-grinding technologies specialist Cemtec is investing a substantial percentage of its turnover each year in R&D. Some of the recent focuses include:

- The development of stirred-media grinding mills, which represent a completion of the company's current product portfolio towards fine grinding; and
- The development of online particle-measurement techniques, which are especially of interest for saving operating expenditure (OPEX) in times of downturn.

Plochberger states: "Cemtec tries to work with external partners and universities so as to validate current trends and to objectively judge if they are beneficial to our clients."

"Without stressing the names of our customers, the world's biggest players in gold, iron ore, cement, phosphate and coal grinding feel very comfortable investing in Cemtec's products."



ME ELECMETAL

Anticipating the developing trends in milling, ME Elecmetal recently launched the ME FIT System. This is an optimised mill-liner and grinding-media system that aims to improve mill performance by bringing together numerous disciplines:

- Modelling to determine ultimate liner design;
- Alloy development, taking into consideration the hardness and chemistry of the grinding media produced; and
- Providing quality liners that wear consistently.

Haugen says: "By offering liners and grinding media, ME is in a unique position to have close access to the specifics needed for each product line to provide effective solutions for grinding circuits."

In addition, ME Elecmetal offers apps that are available through its website. Haugen notes: "A good example is the ME Elecmetal Grinding App. This is a grinding-media guide to help mineral processors use the grinding media more effectively in their mills. Operators can determine mill power-draw characteristics, steel charge estimation, as well as other valuable information."

ME Elecmetal is continually working on new alloy development and services to benefit mineral processors. Haugen says: "Currently, our metallurgists are working on an alloy that can increase mill liner life up to 30%."

The company is also improving its S3 [Search Study Simulation] service for grinding-mill relining. S3 identifies and measures all the activities involved in a mill relining. It can ►

"No two mills are operated the same, and therefore designs need to be customised to suit each operation"

Typical ball-mill liner designs from ME Elecmetal allow for different scenarios where activities can be improved, reducing mill downtime. ME Elecmetal plans to launch a new edition for iPads soon.

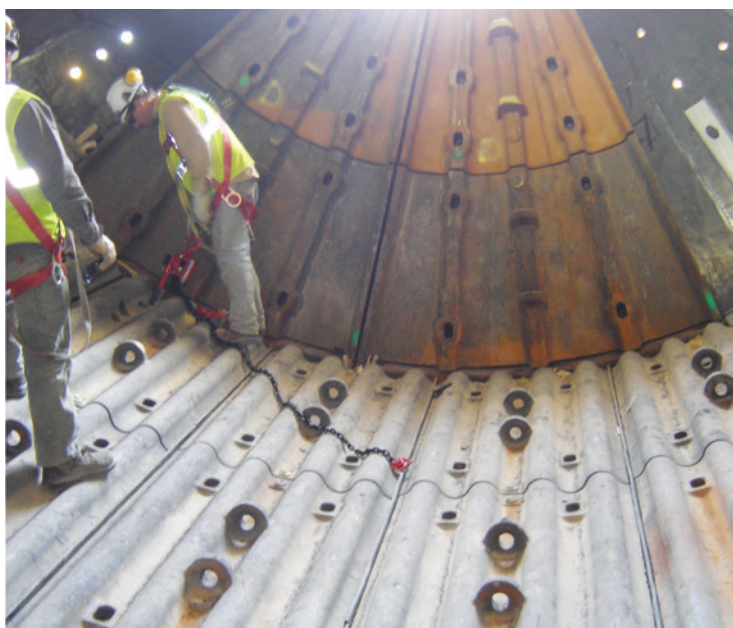
ME Elecmetal's mill liners are in use in hard-rock mining operations worldwide, including copper, gold, iron ore and molybdenum processors. The company supplies operations belonging to major mining companies such as Kinross, Rio Tinto, Freeport McMoRan, Codelco, Antofagasta Minerals, Anglo American, Cliff Natural Resources and BHP Billiton.

Haugen comments: "Our mill-liner products are present in more than 35 countries, many of them featuring extreme climate and operating conditions; from the cold weather of Alaska, US, to the hot and dry environments of the Atacama Desert in Chile and the Gobi Desert in Mongolia; to the torrid and humid climates of Ghana and Indonesia."

METSO

Metso's recent primary product developments have all resulted from addressing customer needs, whether it is with larger crushers, HRC HPGRs, SAG mills, ball mills or Vertimills.

Metso recently launched the HRC, its new line of HPGRs. Gallimore says: "The HRC HPGR provides increased circuit efficiency and capacity over traditional HPGRs through the use of the patented arch-frame and a flanged roll design. The flanges on the roll help to draw material into the crushing zone, max-



imising the amount of ore crushed."

In a closed-circuit pilot-scale operation, the flanges were shown on average to reduce the energy demand of the circuit by 13.6% and increase the machine capacity by 19%.

In May 2014, the HRC3000 began operation at a site in Arizona, US, and to date has operated for over 9,000 crushing hours. Gallimore comments: "The HRC3000 is the world's largest HPGR with 3m-diameter by 2m-wide rolls and an 11.4MW total installed power. This machine is double the capacity of the previously largest HPGR in operation, which has 2.4m-diameter by 1.65m-wide rolls. Depending on the application, the capacity of this machine can exceed 5,400t/h."

Metso recently announced the development of what it says is the next generation in gear/pinion mill drives, the Metso QdX4 mill drive system. Gallimore explains: "This drive system effectively provides up to twice the power transmission of a conventional dual-pinion drive."

"Going from a dual pinion to a quad-pinion arrangement is the natural progression to a robust, cost-effective mechanical solution as an alternative to the gearless mill drive (GMD)."

For the Metso QdX4 mill-drive system, exhaustive research was conducted and a prototype developed to provide power transmission up to 32MW.

The QdX4 system was developed in close collaboration with both

CMD and Ferry Captain as a drive solution for large mills for the mining industry. In comparison with a gearless mill drive, some key aspects of using a gear/pinion approach are:

- The foundation design requirements are similar to dual-pinion-drive mills;
- Significant time savings in installation and commissioning;
- Reduced equipment mass means a reduction in required shipping and lifting/crane capacities;
- Reduction in capital and operating costs and maintenance spare parts;
- Less complexity, simplified training and specialised services; and
- Standard motor design.

Metso says that through innovative circuit design and mill technologies, it has been able to save customers plant floorspace, energy consumption and media cost. The company believes that brownfield retrofits to supplement capacity and improve recoveries will be a recurring trend in this difficult commodity market.

A recent example of this is the installation of a VTM-3000-WB at a gold-mine operation in British Columbia, Canada. The VTM-3000-WB is in a tertiary grind after a semi-autogenous-ball milling-crushing (SABC) circuit to supplement capacity and grind finer.

Gallimore states that this installation was exceptional for several reasons: "The Vertimill installation took a total of three weeks. The process

The Metso HRC3000 HPGR is 3m in diameter with 2m-wide rolls and an 11.4MW total installed power



commissioning immediately followed, with design capacity being achieved in only two days.

"An unexpected benefit was that the Vertimill operated as a buffer tank to the downstream flotation process, reducing the time to reach stability from two hours to 30 minutes. The grinding energy-efficiency expectations were exceeded.

"Lastly, copper and gold recoveries increased by more than 3% each, partially due to the narrow particle size distribution that the Vertimill circuit can produce."

Metso says that due to low manpower at many operations, its customers depend on equipment reliability and serviceability; the company provides advanced controls and condition monitoring to reduce costs and improve profitability. Metso has a Life Cycle Services team that can help customers improve maintenance on their equipment, which is especially important at sites in remote locations.

MULTOTEC

Multotec has rolled out Hawkeye, its in-house programme used successfully for monitoring screen pan-

els, to cover the mill liners that the company supplies and installs.

This package has a display of the mill liners and their descriptions, with the progressive wear rate monitoring of the lifter bars and plate liners being shown graphically.

Taylor explains: "It is a web-based system, enabling the mill operator and managers to accurately identify the life expectancy of their liners."

The Hawkeye data is used in conjunction with the latest software update of MillTraj to determine the performance of the mill as the liners wear, ensuring that the mill liners are replaced in time to continue providing the optimum grind.

The liners are measured when the mill shuts down, since the liners will have a different wear amount at each measurement as the MillTraj trajectory is different.

Taylor tells *MM*: "Ongoing research and development is a cornerstone of Multotec's success, and current development will see the launch of an ancillary tool that will assist customers to measure their liners accurately and in a cost-effective manner." ▸



Metso recently installed a VTM-3000-WB at a gold operation in British Columbia, Canada

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“Technological improvements play an important role, not just in materials development but also in advancing mill-design tools”

Multotec liners installed in a mill are lasting seven to nine months, resulting in cost savings for the customer



► Multotec has successfully supplied rubber and rubber composite mill liners throughout Africa for 15 years, with recent supplies to new installations at Agbaou in the Ivory Coast and Kinsevere in the Democratic Republic of the Congo.

TRELLEBORG

Trelleborg has recently developed a superior-grade rubber compound called 1605AM to replace the composite steel linings (polymets) in some primary and all secondary milling applications. The initial trial, which was carried out in a ball mill at one of the biggest gold mines in Australia in 2014, had positive results and led to the complete replacement of the shell liners at the site.

The company says that the benefits of converting from composite steel linings to premium-grade rubber linings, such as the 1605AM compound, for grinding mills include:

- Lower cost;
- Less power draw;
- Reduced weight;
- Easy and faster installation;
- Reduced load on mill bearings;
- Noise reduction;
- Easier wear monitoring;
- No cracking or falling inserts; and
- Safe operation.

In addition, Trelleborg has recently developed and supplied a SAG mill trunnion liner with an arrow head fixing design which is very easy to install and remove, as there are no fixings (nuts and bolts) involved.

Zane Thomas, technical manager at Trelleborg, explains: “The liner

is supplied with an indicator layer in a different colour so that it is easy to monitor the replacement without actually carrying out wear measurements. These liners have outperformed the conventional bolt-in rubber liners and can be supplied in our premium-grade rubber.”

In addition, Thomas says that the Trelleborg ceramic-lined lip liner for SAG mills has worked beyond expectations at a customer site, and has saved the client installation and replacement costs.

WEIR MINERALS

Weir Minerals is constantly working to introduce new materials and design processes to the industry. Recent materials developments have included continued improvements in its Vulco composite liner designs, where the resilience and shock-absorbing properties of advanced rubber materials are improving the wear properties of metal.

Lockyer comments: “We have developed the highest-quality wear materials, both rubber and steel, that are incorporated into the most technologically advanced designs to ensure that our customers have the best possible mill availability to maximise their return on mill-lining investment.”

One such recent development has been the introduction of Weir Minerals’ metal cap system. Dr Michael Lum, team leader at the Weir Global Materials Technology Centre, says: “Our recently developed metal cap systems are an important development that has allowed full steel systems to be replaced in many aggressive SAG and AG applications.

“The metal cap, which is pressure-moulded to the rubber, provides surface impact resistance with considerable weight savings, enabling our customers to achieve significant improvements in grind, service life and mill availability.”

Weir states that technological improvements play an important role, not just in materials development but also in advancing mill-design tools. One such exciting development has been Weir Minerals’ advanced discrete-element method (DEM) analysis capabilities.

DEM modelling, where proposed operating conditions and design are combined into a desktop simulation, provides an excellent understanding of inter-particle relationships. This detailed analysis guarantees the pre-

cise lifter-bar face angle to ensure that the available power is converted to particle-size reduction in an efficient manner.

The development of the next generation of elastomeric and alloy materials for mill systems and mineral-processing applications is the focus of Weir Minerals’ global materials research-and-development strategy. This strategy is supported with significant investment in research facilities, technical teams and laboratories located in Australia, Malaysia, the US and Latin America.

The company says that recent trials in a new elastomeric compound for mill systems have shown significant wear-life improvement and reduced TCO. In addition, a newly developed series of alloys are expected to further reduce TCO for Weir’s customers in the area of crushing and grinding applications.

John Clark, product manager, mill-lining systems and moulded products, North America at Weir Minerals, tells MM: “We are very excited about our new elastomeric compound that is performing exceptionally well in trials, showing significant wear-life improvements. Given the success of these on-site trials, we’ll be looking to offer this new rubber compound to our global customer base in 2016.”

In addition to these developments, Weir Minerals is working with several world-leading universities, including the University of Strathclyde in Scotland, on a number of engineering and technology projects. Considered an important part of Weir Minerals’ R&D strategy, these partnerships aim to ultimately offer greater expertise in the area of engineering and materials projects for mill-system applications.

Stuart Town, mill-system manager, Asia Pacific at Weir Minerals, says: “At Weir Minerals we take a holistic approach to the design and manufacture of mill-lining systems. Our engineers custom-design every Vulco mill-lining system for exceptional life and reliability for each customer’s unique requirements.”

One operation to reap the benefits of this customised approach is Oceana Gold at Reefion in New Zealand. Weir Minerals’ team designed and installed one of the most technically advanced mill-lining systems in the world, significantly increasing the efficiency of the mill’s charge agitation. This consolidated approach



resulted in the most efficient grind possible for the mill, the company says.

The Reeferton mill now consistently maintains throughput of 260 wet tonnes per hour, an increase of 97% over initial throughput rates. In addition, the liner service life increased by 164%, resulting in longer periods

between relines, fewer replacements parts, less downtime, and a lower operating cost per tonne for Oceana Gold.

In addition to the development and introduction of new materials, technology also plays a heavy role in mill-system design. Design and research techniques used by Weir

Minerals' in-house design team include scaled laboratory models, CFX fluid dynamics and DEM charge analysis. Combined with Unigraphics CAD and the latest advancements in trajectory analysis and DEM systems, the company states that these tools ensure optimum system design and material selection to provide customers with the best possible solution at the lowest TCO.

Lockyer says: "Weir Minerals operates in more than 70 countries, and with more than 60 years' experience in mill systems has designed and installed hundreds of mill systems around the world.

"Our strength lies in our in-house facilities that enable total control and customisation of the entire process from design to manufacture, so that our customers' requirements for the best-quality mill systems are met.

"We work in close partnership with our customers and some of our recently completed projects include those with Simplot Phosphates, Barrick Goldstrike and Freeport Henderson in North America, and Oceana Gold, Challenger gold mine and Triton copper mine in the Asia Pacific region." ♥

Trelleborg's ceramic-lined lip liner for an SAG mill

"Our strength lies in our in-house facilities that enable total control and customisation of the entire process"

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BALL / ROD / SAG / AG MILLS

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ONLINE PARTICLE SIZE ANALYSERS



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