MINING TRUCKS
COMMINUTION

EQUIPMENT FINANCE
& RENTALS

AUTOMATION

SURFACE DRILLS

CANADIAN TECHNOLOGY

HIGH PROFILE:
XEMC, FLSmidth

ASI's AHS kit fitted on a Komatsu 930E truck
REMOVE YOUR BOTTLENECKS FROM MINE TO MILL

Automation that drives production. Not costs.

**BULK MATERIAL FLOW & BELT MONITORING**
- For volume reconciliation & production control
- Allows feed optimization & belt monitoring
- Contact-free sensing with no maintenance required

**LEVEL CONTROL & BLOCKAGE DETECTION**
- Productivity optimization & rock breaker automation
- Truck dump timing control
- Level Control (keep secondary/tertiary crushers choke fed)

**VOLUME MEASUREMENT & FEEDER DRAW CONTROL**
- 3D volumetric inventory control for domes, bunkers & silos
- Control of drawpoints, feeders & dozer indoor positioning
- Fully replace cost & time intensive manual surveying

More solutions on indurad.com
The comminution sector has been in line for a transformation for some time. Near-identical flowsheets have remained the status quo for decades, with the only variation tending to be how many pieces of conventional equipment are used, as opposed to what new innovations are slotted in up or downstream of primary crushing.

As has been acknowledged throughout these pages for at least a few years, miners are no longer just looking for higher throughputs and bigger machines; they are after optimal solutions that can be constructed quickly, easily and cheaply; will reduce their energy consumption; fit within tighter plant footprints; and – as of late – use as little water as possible.

These same miners are being urged to look across the entire mining process to achieve these water and energy goals, in particular. This could involve using tighter drill spacing in their drill and blast patterns, employing pre-concentration processes ahead of the costliest comminution activities, or grinding material in a certain way as to reduce the energy and water consumption associated with the follow-on flotation process.

Bjorn Diex, Global Product Manager for Weir Minerals, recognises this market move and says the industry's original equipment manufacturers (OEMs) have been responding.

"It is no secret that our industry currently sits in a very exciting but challenging phase," he told IM. "Our clients are under immense pressure to consume less energy, less water and reduce carbon emissions. In fact, this pressure is higher than ever."

As existing high-grade orebodies deplete and average ore grades in newly explored ore deposits fall, higher volumes of ore need to be processed in order to achieve the same recovery rates. This makes the task of reducing energy and water even more difficult.

"That is why efficient technologies are needed to remain profitable," he said.

It is this pressure that has led to the mining industry, technology companies and research institutes putting their collective heads together.

For example, Natural Resources Canada's (NRC) Crush It! Challenge has seen the mining and research communities unite.

The primary objectives of the challenge are to fight climate change by creating innovative technologies that reduce energy consumption and pollution, increase competitiveness by developing world-leading clean technologies, and transform the mining cycle to establish a new "future in mining", NRC says.

The six finalists in this challenge include:
- Gillian Holcroft from the Canada Mining Innovation Council for her Conjugate Anvil Hammer Mill (CAHM);
- Claude Gagnon from COREM for his Optimization of High-Pressure Grinding Rolls (HPGRs);
- Erin Bobicki from the University of Toronto for her Microwave Pre-treatment and Ore Sorting;
- Tracy Holmes from Jenike & Johanson for her Microwave Treatment and Materials Handling;
- Philippe Gagnon from COREM for his IntelliCrush; and
- Cliff Edwards from Envisioning Labs for his Transcritical CO2 Pulverization.

Each finalist is eligible to receive up to C$800,000 ($578,780) to build and test his or her clean technology solution before advancing to the next stage of the challenge.

Holcroft, specifically, has been helped along the way by one of the industry's biggest miners. Glencore's XPS (Expert Process Solutions) technical and operational teams have been involved in the development and testing of her CAHM platform technology. According to Glencore, this innovation – which has the potential to replace conventional crushers and SAG mills – could reduce energy consumption by 50%, transforming non-viable mineral development projects into new mines in Canada.

Goldcorp (now Newmont), along with the Centre of Excellence in Mining Innovation, also got behind the initiative, offering a platform at its #DisruptMining event at PDAC 2019 for all second-round entrants to present their innovations. In March 2021, a C$5 million Grand Prize will be awarded to the innovator demonstrating the best energy breakthrough in crushing and grinding rocks.

The big technology companies and OEMs have
also felt the pressure to come up with more environmentally friendly equipment, responding with ambitious programs of their own to tackle climate change.

FLSmidth, in November, launched its new MissionZero sustainability program at its Capital Markets Day aimed at significantly reducing emissions across the global cement and mining industries by 2030, while Metso recently had its greenhouse gas (GHG) emission targets approved by the Science Based Targets initiative (SBTi). These targets include reducing Scope 1 and 2 GHG emissions by 25% by 2030 and cutting transport emissions by 20% by 2025.

Outotec's own targets – reducing the absolute Scope 1 and 2 greenhouse gas emissions of its own operations by 25% as well as Scope 3 emissions by 10% by 2025, compared with its 2017 base year – were validated by the SBTi in early 2019.

These initiatives come on top of Weir Group, the parent company of Weir Minerals, launching a sustainability strategy that would enable net zero carbon dioxide emissions in mining through supporting the industry's technology transformation and halving its own CO₂ emissions by 2030.

The likes of Rio Tinto, BHP, Anglo American and others have also made significant commitments to investors to cut their GHG footprints.

Leading from the front

While these mining companies are clearly prioritising their environmental, social and governance initiatives when evaluating their operations, this philosophy is not evident across the entire sector.

When asked whether he had seen energy efficiency move up the list of priorities for mining companies assessing their comminution requirements, Alan Boylston, Director, Process Engineering Development, at Metso, said: “It depends. It’s not necessarily just about the orebody, it is about the owner too.”

Speaking to IM on the side lines of the recent SME MineXchange Expo and Conference, in Phoenix, Arizona, he continued: “If we’re talking about an owner that has access to a lot of capital – the majors or a mining company with government backing – then that focus is a real thing.

“Often, however, increased energy efficiency and capital costs are at odds with each other. If you are a mid-cap or junior miner and you are faced with the prospect of having to pay so many million more to put in this energy efficient equipment, they quite often say, ‘that would be nice, but we don’t have the money right now’.”

Boylston says there are cases where, if mining companies approach the OEM early enough in the design phase, it can design scenarios where the capital cost is comparable or even less for an energy-efficient design than a conventional flowsheet but, again, it depends on the project in question.

“One example we’ve looked at recently is a large mine site where they were going to go with an HPGR to ball mill type design, except that the ball mills were going to be large enough to require gearless motor drives – which can be very expensive,” Boylston said.

“In this particular case, we suggested an HPGR, to a ball mill, to a Vertimill; so a third grinding stage. This allowed us to go with a smaller ball mill with dual pinion drives and then finish up the grinding in a more efficient Vertimill – reducing your energy and media consumption substantially. So, there were opex benefits to the energy efficient design and the capex – as you were getting rid of the GMDs – was comparable with the original design.”

Such examples prove illustrative for mining companies on the lookout for energy efficient comminution options, but Boylston believes the take up of such technology would benefit from wider industry acknowledgement of the potential carbon footprint improvements they offer.

“With, for example, a Vertimill, when you are talking about tertiary grind or re-grind applications, these machines are much more efficient than ball mills in the range of 30-50% when it comes to power, which is directly related to greenhouse gases,” he said.

Vertimills also use a lot less media – in the order of about half the media a ball mill does, according to Boylston. “That is intrinsic, or embedded, CO₂, from having to make that steel media and transport it to site.

“When you start adding all of those things together, if greenhouse gas load or carbon footprint is something that starts to become tradeable, all of these technologies that on the surface add a little bit of capital cost can be paid back with real dollar savings in media and power, and also the credits from any greenhouse gas abatements.”

Should such a situation arise, certain ‘alternative’ technologies are in line for extra credit.

Learning from other industries

More than three decades have passed since the introduction of HPGRs, yet this crushing tool is still to achieve the widespread adoption many assumed would occur upon its release.

Originally implemented in the cement industry in 1985, it later found a home in the circuits of diamond and iron ore operations. It took until 2006 for a HPGR to be installed in a copper processing circuit – the Freeport McMoRan-owned Cerro Verde mine, in Peru – and has taken even longer to filter down to precious metals mining.

As recently as September 2019, Coeur Mining told investors during a site visit, “HPGR technology is relatively new to precious metals mining, although it has been proven in processing other materials”.

In reviewing a newly commissioned comminution circuit at the Rochester mine, in Nevada, USA – a thyssenkrupp Industrial Solutions HPGR – the company said it expected a boost in both silver recoveries and lower operating costs by applying the technology at the mine.

The precious metals miner’s HPGR order comes on top of an unnamed Middle East gold mine selecting Weir Minerals’ Enduron® HPGR for its own asset. Weir claimed the HPGR could provide the operation with a potential energy saving of 22% and a more than 25% increase in throughput.

And, close by in Turkey, Eldorado Gold recently said it will replace the tertiary crushing circuit at its Kisiladag mine with a HPGR circuit as it looks to extend the mine life and improve gold recoveries at the heap leach operation.
Despite these recent orders, HPGRs remain the exception rather than the rule in hard-rock comminution circuits.

There are a few reasons for this.

First, it can be quite difficult to slot HPGRs into existing brownfield circuits. While OEMs are working on initiatives to make the process easier – reducing the size of the HPGR equipment or the amount of civil work involved with installation – it is still a major task that requires careful planning and more money than the machine’s price tag alone.

Second, the introduction of an HPGR may influence the rest of the comminution circuit, meaning changes may be required in order to best optimise the new equipment. Weir’s Dierx said this change management requires an “integrated solutions approach”.

He said: “Implementing a HPGR to uplift capacity in the existing tumbling mills requires knowledge of not only the HPGR, but also cone crushers, mills, pumps, cyclones, etc.

“As every stage in the processing plant is interlinked, every process change has a consequence, which requires a team of dedicated process and equipment experts to partner with our customers and to demonstrate the potential of lowering the total cost of ownership.”

Weir would know all about this. It booked £72 million ($92 million) of Enduron HPGR orders in 2019.

Third, HPGRs have, in the past, been criticised for an inability to handle varied feed. Should the material being fed to the machine change over time, this can result in either a coarser product that requires further downstream processing, or excessive wearing of components.

The benefits of introducing these machines are starting to outweigh these cons. This is especially true given the refinement of existing products on the market and the increased industry demand placed on energy and water efficient technologies.

**HPGR benefits**

HPGRs are widely acknowledged to produce more fine material at a given crush size than conventional comminution equipment, form micro-cracks in the crushed rock particles beneficial for subsequent grinding and leaching, generate less noise and dust compared with conventional cone crushers, consume less power per tonne than conventional crushing plants and offer a dry processing option. In some cases, they can also improve liberation.

Weir Minerals’ Dierx said every operation considering an HPGR installation requires a specially tailored flowsheet supporting its objectives and working within the acceptable boundaries, but, “in the right application, HPGRs represent energy savings of as much as 40% compared to conventional circuits whilst reducing downstream milling requirements”.

He went on to say of Weir’s Enduron HPGR, specifically: “The patented Enduron tyne surface technology with spring-loaded lateral walls provides long component wear life and maximises product quality.

“Further supporting grinding performance, our design philosophy maximises the width of the tyre, whilst keeping the diameter as small as possible. First, this allows the pressure to fully penetrate through the full operating gap, exceeding the material's compressive strength. And, secondly, it reduces the so-called edge effect area, which is a result of reduced pressure on the edges of the rollers.”

The ability for the HPGR rollers to skew – reducing wear and ensuring optimal grinding across the whole feed – combined with a fully controlled oil-lubricated cylindrical bearing system, increases the longevity of the bearings and eradicates the need for additional water cooling, he said.

“Given the global shortage of large engineered bearings, our clients feel secure knowing that the Enduron HPGR has never experienced a premature bearing failure,” Dierx said. “Another major advantage of the Enduron bearing arrangement is that it reduces the overall height of the machine, reducing the structural costs in the overall layout.”

Metso owns the largest fully operating HPGR in the world, the HRC™ 3000, which comes with an ore processing capability of over 5,400 t/h.

It, too, thinks its HRC equipment has a few standout qualities.

By directing the feed material straight to the crushing zone and adjusting the speed and pressure, Metso’s HRCs avoid wasting energy and reduce operating costs, the company says requirement that is only 40-50% that of a classic ball mill, making it one of the most efficient grinding systems on the market.

The company is also finalising the field implementation of a package of what it says are “massive design advancements and innovations” to its HPGR technology ahead of the market launch of its next generation HPGRs.

Most of these improvements are a result of learnings from more than 150 units in mineral applications, more than 50 of which are in hard rock, it said.

Included in these developments are an oil lubrication and cooling system for the main bearings. This system has been successfully used on vertical roller mills for years, with the first HPGR retrofits set for existing installations to allow a further increase of grinding pressure and roll speed while extending the lifetime of the self-aligning roller bearings, it said.

A number of design improvements related to wear, which includes the capability to specifically adjust roll protection on a case by case basis for widely differing ore types had already been implemented in earlier designs. These improvements extended wear life significantly to 8,000 – 20,000 hours when processing challenging ores in hard rock applications, thyssenkrupp said. Additionally available innovations have the potential to increase wear life by up to 50%, in general.

A disruptive innovation being tabled by the company is the application of so-called flanges on conventional thyssenkrupp HPGRs. While flanges are starting to replace conventional cheek plates,
which seal the grinding gap towards the roll edges, the industry perception, to date, has been that their use would require full skew suppression - a process built into earlier designs by others allowing the use of flanges. Yet, mechanical skew suppression made this technology space "consuming, heavy and consequently disproportional expensive", the company said.

After testing a conventional thyssenkrupp HPGR with flanges for close to 6,000 hours in a copper mine, in Peru, they have been shown to improve the unit capacity by about 20% at a finer product, while consuming about 15% less energy than a conventional HPGR with cheek plates, according to thyssenkrupp. Also, current projections suggest wear life can be increased by at least 20-30% due to a more uniform pressure distribution along the roll width.

"First implementation of a skew limiter to protect the thyssenkrupp HPGR even under emergency conditions against excessive skew peaks is scheduled for July this year," the company said. "This skew limiter fully eliminates the need of mechanical skew suppression; an unnecessary cost driver."

The new skew limiter ensuring safe protection of flanges is an innovative milestone in making thyssenkrupp HPGR technology more competitive in terms of capital expenditure – offering 20% more capacity for the same unit price – and in terms of capital expenditure – offering 20% of thysenkrupp technology more competitive.

FLSmidth's Joe Dziedzina also sees the uptake of HPGR technology in mining rising.

The Global Product Manager for HPGR told IM on the side lines of the SME MineXchange Expo and Conference, that FLSmidth installed its first "large HPGR" for mining last year, at a gold heap leach project in Turkey.

While he said there had been lots of interest globally for HPGR-based flowsheets, he thinks another grinding technology could offer the energy and water efficiency Tier One miners are currently demanding.

FLSmith's OK™ Mill has typically been seen at cement and slag operations around the world, grinding material that ranges from soft limestone to hard, granulated blast furnace slag. The OK Mill technology carries this out with 5-10% less power consumption than other vertical roller mills (VRM) and with the lowest maintenance costs of similar machines in its class, according to FLSmidth.

With the MissionZero sustainability program behind it, FLSmidth is now working on leveraging this VRM experience to make a mining-ready OK Mill that comes with all the benefits seen in cement and slag processing, according to Dziedzina.

MissionZero has been devised by the Denmark-based company to significantly reduce emissions across the global cement and mining industries by 2030, with a specific focus on water and power management. Dziedzina thinks a mining-ready OK Mill may help the company achieve this goal, explaining that the technology has the potential to provide a dry comminution circuit that could be the "centrepiece of FLSmidth's program".

The OK Mill is set up to allow material to be fed from the side of the machine and fall onto the centre of a powered table where it is ground by hydraulically-assisted free-spinning tyres. The material then progresses from the edges of the table upward with the help of a strong, constant air stream into an integral classifier where it is deemed to be a 'product' or 'reject'. Material that makes the cut is discharged out the top of the machine with over-sized material falling back onto the table for re-processing.

The mill can be operated in three standard configurations – airswep, overflow and semi-airswep. The former tends to be the typical setup where the plant layout is optimised. The overflow option sees material fed from the top and discharged and screened at the bottom. This could act as a pre-grinding option that is less sensitive to moisture, perhaps as a pebble crusher, FLSmidth believes. The last option, once again, sees material fed from the top, yet offers more classifier options, according to the company. There is a smaller required fan and less “jet” abrasion occurring in such a setup, FLSmidth says.

Dziedzina sees an adapted version of the OK Mill offering the “complete grinding” option in a standard SAG and ball mill comminution circuit, saying it could eliminate the ultrafines that cause issues further downstream.

The major differences between the milling products that FLSmidth currently offers and the OK Mill are the larger allowable feed size (versus HPGR), a reduction in metal contamination, the highest available power efficiency, and the ability to handle a wide range of ores and high moisture content, it says.

On top of this – and in keeping with the theme under discussion – it eliminates the need for grinding media and is a “dry application” suitable for water sensitive areas.

Mining companies worried about the scale of the OK Mill would be wise to look at the FLSmidth OK 81-6 Mill installation at a Bangladesh cement grinding plant. Having started up in August 2018, it is now grinding slag and cement.

This specific installation comes with 2.7 m x 1.1 m diameter rolls, an 8.1 m diameter table size, six rollers, 11 MW of power (two 5,500 kW motors) and a specific maximum operating press force of 1,040 kN/m². This mill, the world’s largest vertical roll mill, according to Dziedzina (and Guinness World Records), has a top feed size of 100 mm (maximum 160 mm) and a product size of 96% at 45µm.

The caveat to this example is it is for processing cement and slag; not hard rock.

Dziedzina was keen to point out the adaptations the company is working on to make the OK Mill mining-ready.

"One study performed with traditional hard-faced wear surfaces would have required the plant to change the rollers every six days, which is not acceptable," he said, reflecting on the company’s expectations of how quickly the current components could wear out if they were charged with processing some of the mining industry’s harder rock.
Automated feeder control

On the interface between mine and mill are the primary crusher installations, which are typically the first bottleneck of large mining operations. The production of large crushers can be enhanced significantly by optimising the feed rate control. Historically, this is achieved by manually controlling the feed to the crushers, either via controlling the dump traffic lights or the apron feeder speed.

**indurad** radar sensors in its **iCrusher** offering enable real-time measurement of the crusher or apron feeder levels, thereby allowing automatic feeder control. Fabian Riedel, VP Sales & Projects at indurad, confirms: “Current and previous **indurad** projects have proven to increase production by up to 20% sustainably over long periods. The **indurad** sensor systems can be installed above crusher chambers to avoid over- and under-filling.” Such installations have successfully been implemented in Chile, Australia and the US.

Most processes between primary crusher and mill are also constrained by volume flow (silos, draw points, transfer chutes, etc) and it is therefore paramount to measure actual bulk volumes within the process plant. Due to fluctuations in bulk density and material moisture, the measurements achieved by belt scales (mass) are only indicative of the volume and necessitate an over-design of bulk material handling equipment to avoid spillage and blockages. The **indurad** iBelt volumetric belt scale enables real-time volume flow measurement under harsh conditions and does not require frequent calibration as it is a contactless measurement method. It is therefore a dependable component in any large plant’s automation system. This has been shown in dozens of installations in bulk material handling operations worldwide.

Riedel states: “**indurad** thus offers a unique package of autonomous functions for increasing competitiveness according to specific customer needs. Automation solutions from **indurad** are often in the spotlight as the general and safety regulations become stricter for mining companies around the world.” **indurad** solutions, he says, not only improve productivity and operating costs, but overcome several challenges: harsh environmental and process-related conditions, heavy vibration, thick dust, varying measurement requirements like 1D, 2D, 3D, and high and low refresh rates.

He said FLSmidth has developed new wear surface technology that improves the robustness of these parts and pushes the life of the rollers out to around 10-12 months (as a goal) in true hard-rock mining applications, bringing down the operating this grinding technology.

Dziedzina expected the maximum feed size of a ‘mining-ready’ **OK Mill** to be around the 160 mm mark, opening the number of applications even further. He also saw the machine working in tandem with **FLSmidth**’s **EcoTails™** filtered tailings management solution. By removing the difficult to dewater ultrafines prior to flotation, tailings filtration will become more efficient and less expensive making it attractive to mine owners, **FLSmidth** says.

“**Miners are increasingly on the lookout for ways to optimise their flowsheets,**” the company said. “**Dry grinding and classification are one way to optimise not only the grinding circuit, but also the flotation and tailings process at the same time.**” Dziedzina expects to provide more insight on **OK Mill timelines around MINExpo later this year, but even at this stage, he could clearly see the technology having a massive industry impact.”

“The development of HPGR in mining has been the biggest technology shift in comminution during my time within the industry,” he said. “This VRM technology could be as big – if not bigger – than that. That is attainable, it is just a matter of time and money.

“The future of mining is (hopefully) dry classification and separation technology with the highest energy efficiency and lowest impact on our environment.”

**The daily grind**

Energy efficiency is one of the core attributes of **Metso’s Vertimill technology**, hence the reason why it, the HRC and the company’s SMD (stirred media detritor) are set to play a major role in achieving its target of lowering GHG emissions by 10% in the most “energy-intensive customer processes” by 2025.

According to the company, the Vertimill provides the lowest total cost of ownership compared with other grinding mills in many applications thanks to its high energy efficiency, reduced media consumption, low installation cost as well as minimal liner wear and maintenance.

Based on a review of the Vertimills currently in operation and a comparison of their efficiency and media consumption relative to a ball mill, Metso estimates some 1.48 million MWh of energy was saved and 652,000 t of CO₂ emissions were abated in 2018 using the machines.

Boylston thinks developing a large-scale comminution circuit that leverages both the HRC and Vertimill could really display to industry just how much energy can be saved by using such equipment.

“We’re really looking for partners to take the next logical step, which for me on a large plant is two stage crushing into our HRC, then directly into a Vertimill to save the most power and media possible,” he said.

There are other manufacturers of fine grinding technology that would argue their equipment should be factored into new energy efficient designs too.

**Glencore Technology** has its **IsaMill™** fine grinding technology, which was recently upgraded with the addition of conical spacers. In tests in an IsaMill processing pyrite concentrate for gold recovery, these new spacers displayed specific energy requirement reductions of 12.7-21.5% depending on the P80 needs. The greater the fine grinding duty, the greater the savings recorded, the company said.

Meanwhile, **FLSmidth** has its **VXP mills**, which were recently selected by Vista Gold as the preferred fine grinding mill in a flowsheet for its Mt Todd gold project in the Northern Territory of Australia.

**Outotec’s HiGmill®** is also gaining popularity as miners look for more energy efficient final grind options.

The **Outotec HiGmill** has several key advantages over other fine and ultra-fine grinding technologies, according to Bjorn Nielsen, Director – Product Management, Grinding at Outotec.

“The vertical arrangement means that gravity helps to compress the media bed, ensuring high contact loads between media and symmetrical energy transfer throughout the charge. As a result, the HiGmill has a very broad operating range – energy efficiency is very similar for a range of media charge levels and operating speeds.”

This operating flexibility lets the machine deal with variations in feed particle size while maintaining efficient operation, according to
Nielsen. “There is no point having the most efficient equipment in the world if it cannot be continuously operated at its most efficient,” he said.

The HIGmill also contributes to efficient circuit design by carrying out internal classification during operation. “Fine particles preferentially flow upwards through the charge, while coarser particles are driven to the high intensity grinding zones nearer to the circumference of the mill body,” Nielsen explained. “This means only a scalping classifier, or even no classifier, is required while minimising overgrinding, all while reducing the required pumping capacity for the circuit.”

Outotec has designed the GrindForce™ rotor, meanwhile, to minimise shear forces at the surface of the rotor, while encouraging high and evenly distributed shear forces in the charge. This maximises grinding efficiency while minimising wear on the rotors, Nielsen said.

The HIGmill is also available with the world’s highest installed power in fine grinding technology, according to the company. “For large projects, with resulting high grinding power requirements, this means that fewer units are required, reducing plant complexity and footprint,” Nielsen added.

Water balance

The HIGmill is set to play a role in one of the more talked about projects currently under development.

Jointly owned by Fortescue Metals Group subsidiary FMG Magnetite Pty Ltd and Formosa Steel IB, the Iron Bridge project, in Western Australia, is notable for a few reasons.

First, it holds Australia’s largest JORC compliant magnetite resource. Second, it is a multi-billion-dollar investment project being built at a time when there is a dearth of new mine developments. Third, and most important for this discussion, it will use a dry crushing and grinding circuit.

Fortescue says the innovative process design, including the use of this dry crushing and grinding circuit, will deliver an industry-leading energy efficient operation with globally competitive capital intensity and operating costs.

A pilot project to verify the Iron Bridge design involved processing 1 Mt of ore through a full-scale HPGR and air classifier over a 12-month period to produce a 67% Fe, low impurity concentrate product, according to Fortescue.

The pilot plant verified the wet magnetite processing flowsheet in close collaboration with key equipment manufacturers, with the demo plant proving the metallurgical and cost benefits of early waste rejection by using full-scale dry processing equipment commonly seen in other industries, the miner said.

Extensive data was collected to support the design of the full-scale 22 Mt/y (wet) ore processing facility, with Fortescue adding that the expected cost and energy savings “are significant in relation to other existing magnetite operations”.

The flowsheet shows primary crushing, followed by secondary crushing into HPGRs (for tertiary crushing) before dry screening, dry separation and air classification/HPGR primary grinding take place. It is only after these activities that process water collected from this last step is reintroduced to take the material through the last grinding and separation stages.

Weir is set to provide Iron Bridge with a range of equipment including Enduron HPGRs and GEHO® pumps, which, it says, will reduce energy consumption and wet tailings waste by more than 30% compared with traditional mining technologies.

Outotec’s scope, meanwhile, includes the design and delivery of 10 HIGmills, as well as installation and commissioning and site services to support Iron Bridge with site operation and maintenance.

Both OEMs agree their respective Iron Bridge orders are representative of a growing trend in the industry.

Dierx said: “The partnership between FMG and Weir has not gone unnoticed in the industry and we are receiving a substantial amount of enquiries about this exciting combination of HPGRs and dry air classification in mining applications.”

In Australia and Latin America, specifically, new deposits are frequently...
found in arid locations with minimal infrastructure or access to process water. This requires moving away from conventional grinding circuits as water is becoming scarce, Dierx says.

“Combining with the HPGR, a complete fine micron-size grinding system can be deployed without consuming a single drop of water,” he said. Such systems can help miners obtain environmental approvals quicker, according to Dierx.

While there is certainly more interest in dry processing to reduce or eliminate water consumption, Outotec’s Nielsen said most of the best-practice beneficiation technologies still require water, so the practical range of commodities that can be processed in this way is limited.

“However, there has been interesting research in dry processing in base metals recently and, I think, eventually we will see some semi- or even fully-dry plants installed in geographical locations where water is scarce, or there are significant social licence requirements around water use,” he said.

One piece of research came from Metso’s Boylston, Newmont’s VP Global Innovation, Process & Metallurgy, Simon Hille, and the gold miner’s Director Metallurgy and Global Projects, Peter Lind, at the most recent SAG Conference, in Vancouver, Canada.

In the paper, ‘Reducing Energy and Water Consumption Through Alternative Comminution Circuits’, the three presented back in September, a dry processing route for a 100,000 t/d copper plant was explored. This design involved HPGR and a “quasi open-circuit” ball mill air classification route, according to Boylston.

“The idea there was we were trying to maximise savings on energy and water,” he said.

“If you’re talking about a copper ore, you are eventually going to have to get it wet to float it, but if you are going to make a separation on your dry materials with the air classification, which we showed with this paper, then you can take the coarse fraction through a coarse flotation step and then have a final grind in a Vertimill on the rest of the material. That way, the coarse flotation is going to dewater much better than your fully ground material, which saves a little bit of water there even if there is likely to be a penalty on metal recovery as you are not grinding all the way.”

While the design was very much “forward looking”, leveraging all of the levers that would allow such a circuit to be designed (regardless of economics), Boylston said it showed you can really reduce both energy and water consumption if these aspects are prioritised.

A new coarse
The need to reduce the size of ore from boulders to a size range where it can practically be floated using conventional technology – about 200 microns or less for many sulphide ores – is the main reason the crushing and grinding process is so energy intensive.

At the same time, most of the water used in mining is required to carry and convey these fine ore particles through the process and to keep the fine tails stabilised in a permanent impoundment.

If ore could be practically floated at a much coarser size, the consumption of energy and water could both be greatly reduced, according to Eriez. Enter coarse particle flotation (CPF), an innovative new process technology based on Eriez’s HydroFloat® technology.

This technology enables semi-liberated ore to be floated at much coarser sizes, typically up to 600 microns for many copper sulphide ores, according to the company.

Eric Wasmund, Global Managing Director, Eriez Flotation, explained: “CPF is an enabling technology for optimising traditional mineral processing flowsheets because conventional stirred tank cells are the primary unit operation used in more than 90% of mineral processing flotation operations worldwide and they are inherently inefficient for floating coarse particles.

“Over the last 10 years there has been increased interest and product development in the area of CPF for sulphide minerals using liquid fluidised beds to host the flotation process, as practised in the Eriez HydroFloat.”

A number of these applications have been commercialised, according to Eriez, most notably the HydroFloat as a tail scavenger at Newcrest’s Cadia copper/gold concentrator in New South Wales, Australia. In such an application of CPF, the cost to build a standalone coarse particle flotation plant on the back end of the concentrator is justified by increasing the overall recovery of payable metals, Eriez says.

Rio Tinto also sees potential for this technology, reporting back in 2017 that 70% of coarse copper and 90% of coarse molybdenum in its plant tails at the Kenneckott copper operation in the US could be recovered using CPF technology.

Eriez said: “This is the most obvious and natural first generation of HydroFloat installations, where a modest investment of capital for a standalone CPF plant can allow the capture of 70-90% of payable metals contained in coarse mine tails.”
The primaries

thyssenkrupp Industrial Solutions has been on a winning streak in Australia of late with its primary gyratory crushers.

Late last year, it announced it would install the first above ground jaw gyratory crusher in the country at the Roy Hill iron ore mine, in the Pilbara of Western Australia. This followed on the heels of signing a contract to deliver the world’s first “double-mouth” jaw-gyratory crusher to China Molybdenum’s majority-owned Northparkes underground copper-gold mine, in New South Wales, and agreeing to fit a large primary gyratory crusher at OZ Minerals’ Carrapateena copper-gold mine, in South Australia.

While the company’s large primary gyratory crushers were designed for underground block caves, the Roy Hill installation, which will enable the iron ore miner to crush “large oversize material” that conventional machines could not accommodate, shows they may have a home above ground too.

I touched base with Luke Bennett, National Sales Manager – Strategic Accounts, thyssenkrupp Industrial Solutions (Australia), to find out more.

**IM:** Why is the Roy Hill installation the first above-ground installation in Australia?

**LB:** The jaw gyratory crusher was designed with underground block caving in mind. With block caving, the amount of large rocks is significantly higher than above-ground drill and blast mining.

The only reason why this is the first above-ground installation is miners have typically stuck with the same plant and machine design as previous, which has been a standard gyratory crusher for many years. For a long time, miners have accepted the fact they will need to use a rock breaker for some rocks that won’t fit into the crusher.

However, now throughput is king. As the downtime experienced with rock breaking can lead to throughput drops, clients are looking to improve uptime and the jaw gyratory crusher does this.

**IM:** Could you provide some information on the Gyromatic control system within these crushers?

**LB:** The Gyromatic is our proprietary control device for our crushers, ensuring they run to the highest performance and safety. It is installed in several operations worldwide.

**IM:** With the increasing number of block cave mines set to come onto the market in future years, do you expect these jaw gyratory crushers to be in higher demand?

**LB:** Yes, we do; but we haven’t stopped there. We have gone to the next level and developed another machine – the Eccentric Roll crusher (featuring a particularly flat and robust design, thyssenkrupp says) – which we believe will lead the next generation of underground block caves due to its extremely low height and high throughput.

**IM:** How have these primary gyratory crushers evolved since the first installation at Northparkes? Do you expect to make further adaptations in the future?

**LB:** The overall machine has basically stayed the same. We have made improvements to parts, which also cover our standard machine designs. We have also included a top service design, so we have configurations that will suit all sites.

The second generation of applications for CPF involves tighter integration of the HydroFloat into the concentrator flowsheet, according to Eriez.

“This tight integration means that the entire plant becomes dependent on the performance and operability of the HydroFloat, but many additional benefits are unlocked,” Eriez explained. “In this application, called Coarse Gangule Rejection (CGR), the HydroFloat is situated in the milling circuit and is used to develop a low-grade concentrate and reject a fraction of the mill output at a size between 200 and 700 microns.”

Later this year, in a paper at the Conference of Metallurgists in Toronto, Canada, it will be shown that a significant and measurable amount of grinding energy can be eliminated, as well as the size of the grinding mill, through such an installation, Eriez said.

“Additionally, the amount of water can be measurably reduced and the daily contribution of fine tails to the impoundment can be decreased. This is because coarse tailing sand is easy to dewater and does not require impoundment in the same fashion as fine tails.”

It can, for example, be used to raise the walls of a dam rather than contribute to the volume inside the dam.

Both the tail scavenging application and the CPR configuration will be quantitatively evaluated using ore from Capstone Mining’s Cozamin plant in Zacatecas, Mexico, Eriez said, adding that the objective at this site was to show the benefits of both CPF options in the context of the same ore type, geology and site.

**Integrating ideas**

While processes downstream of crushing and grinding are helping the energy and water balance, miners should also look at optimising the upstream processes ahead of comminution.

Sophisticated simulation programs that study the mine-to-mill process and the introduction of “digital twins” will help the cause, as will drill and blast software that assists planners with optimal drilling patterns. Further digitalisation and automation of processes will further aid this.

The introduction of more sophisticated ore sorting solutions ahead of the most energy-intensive processes could also improve the water and energy balance.

In order to address these impending issues, companies will need to take an integrated solutions approach to this problem, studying all parts of an operation and tailoring their solutions to the orebody, company and location at hand.

Just as different parts of the mining community are coming together to work on crushing and grinding innovations, plant managers and drill and blast engineers will need to collaborate more to create the energy and water efficient mine sites all stakeholders now demand.