MINING & QUARRY WORLD



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Crushing the Uncrushable

Pebble crushing is one of the toughest crushing applications on a mine site. Pebbles are rounded and very hard rocks that contain valuable ore. As ore is treated in a tumbling mill (SAG or AG), some rocks are hardened by the process and this hard, round-shaped material is known as pebbles. Without a crusher capable of processing them, pebbles often end up as lost product and are discarded or stockpiled.

However, with the right technology, pebbles can be effectively crushed and the otherwise lost ore can be obtained. The Trio[®] TC84XR cone crusher has been specifically engineered to perform in the most challenging applications, including pebble crushing.

Unlocking value, driving production

The TC84XR cone crusher from Weir Minerals, quite literally, unlocks value - it transforms what would be a waste product into

a saleable one. This is becoming increasingly consequential: as mines are getting deeper and ore is normally becoming harder and more difficult to extract, miners are consequently finding more pebbles. It's often said that the first stage of mining is done by nature; rock that has been exposed to the elements has already undergone - and is undergoing - a process of erosion. In contrast, rock that's been locked underground for millennia is harder and more difficult to crush and process

As well as adding significant value through increased production, the Trio[®] TC84XR crusher also helps prevent losses by reducing downtime. If pebbles are not properly processed and are, instead, allowed to build up in the mill, then they start to reduce processing capacity and can result in catastrophic plant and equipment damage. The Trio[®] TC84XR crusher's (and the smaller TC series)

TRIO®

unmatched ability when it comes to handling pebbles is one of the reasons why it's widely regarded as one of the most reliable cone crushers on the market.

Tackling variable feed

You only have to see the Trio[®] TC84XR machine alongside other cone crushers to appreciate just how robust it is. It's 40-50% heavier than similarly sized machines and, as a result. it can process unstable feed and it just keeps on running. When it comes to crushing pebbles, weight really does matter.

The ability of the Trio® TC84XR crusher to handle variable feed and crush pebbles is also partly a result of its large motor; it's been designed with higher power capability than comparable cone crushers. Ultimately, this translates to a higher potential crushing force and therefore increase in production.

Another feature that allows it to handle variable feed, as well as deal safely, is the fully-automated tramp-release and setting recovery system. Tramp material is metallic scrap that accidentally finds its way into the crusher; it has the potential to damage equipment and lead to stoppages. The tramp release hydraulics can also be used to safely clear the

crushing chamber should a sudden disruption in plant power cause a shut-down of the cone crusher.

The tight closed side setting (CSS) of the TRIO® TC84XR crusher is also crucial in enhancing its pebble crushing capabilities. The CSS defines the maximum product size and has a significant effect on crusher capacity and crusher liner wear. Trio® TC series cone crushers can be operated at a small CSS, 10 to 12 mm can be seen as a recommended operational setting for effective pebble crushing. Sometimes and in some applications, we can even go smaller, but this is dependent on the material characteristics and needs to be judged on a case-bycase basis.

The TC84XR crusher also has very high clamp pressure, which holds the adjustment ring in place. Increasing the clamp pressure helps to control the adjustment ring position and deliver a CSS, eliminating bowl creep (i.e. where the bowl begins to move as crushing forces overcome clamping forces).

Global support network

The TRIO® TC84XR cone crusher can also be fitted with ESCO[®] wear parts, designed with superior ESCO[®] alloys, they can be custom designed based on your specific requirements. With over 100 years of casting expertise and in-house engineering and metallurgy, ESCO[®] transforms what was already a robust machine into one that, in the toughest conditions, is unsurpassed.

With on-the-ground staff and service facilities already operating in more than 70 countries, Weir Minerals' unmatched regional support network ensures product experts are always close to their customers.

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It's about knowing. Not guessing. By giving your operation a 6th Sense, you can make data-driven decisions based on real-time insights. Smart technology is built into most of our products. It's about connected machines and tools that tell you how they perform. And it's about autonomous machines and automation solutions that increase both profitability and safety. See how you can activate your 6th Sense at www.epiroc.com/6thsense





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NEWS, PLANT AND EQUIPMENT

The digital tire management of the future: ContiConnect 2.0 – data-driven decisions for fleets

- Comprehensive upgrade of the ContiConnect intelligent tire management solution: new web portal, new multifunctional app
- Coordination of vehicle and tire services generates cost efficiency, lowers CO2 emissions and strengthens sustainability
- Big data and artificial intelligence: broad pool of data and continuous analysis of data from tire sensors fuel drive towards predictive maintenance

Recently, in Hanover Germany, Continental presented a new generation of the ContiConnect tire management system. Version 2.0 puts in place the necessary infrastructure for the all-encompassing, digital tire management of the future. To this end, the technology company has refined its system environment to keep it perfectly in line with the specific requirements of fleet customers around the world. "ContiConnect 2.0 is focused on the digitalization of tires. It paves the way for intelligent tire management combined with a tailored selection of digital, service-based tire solutions," explains Tansu Isik, Head of Business Development and Global Marketing at Continental Tires. Continuous analysis of the extensive data collected from the tires creates a broad data pool.

ContiConnect 2.0 will allow maintenance of tires - on passenger cars, trucks, buses and off-road vehicles - to be carried out exactly when it is needed. In the context of off-road vehicles, ContiConnect is already frequently used by fleet customers in the construction industry, intralogistics or in ports. "Our fleet customers benefit from the modularity, flexibility and compatibility of ContiConnect 2.0. It enables exceptionally secure

digital tire management, increases vehicle uptime and maximises cost transparency," says lsik. Vehicles are out of use less of the time, and trucking companies and fleet managers on construction sites, in intralogistics and in ports will also gain from lower maintenance costs and higher tire mileage. ContiConnect 2.0 therefore represents a great solution in terms of sustainable mobility. The digitally optimised tire management system is a big plus for operators overall, allowing them to focus their attention on their core business.

Continuing the drive towards predictive maintenance

ContiConnect 2.0 is a new version of Continental's proven digital tire management system developed from scratch. "With ContiConnect 2.0, we are building on existing functions such as continuous tire pressure monitoring to also enable our fleet customers to digitally track the remaining mileage, tread depth, and condition of all the tires in their fleets," says Sven Wilhelmsen, Head of Product Management Digital Solutions at Continental Tires. Added to which, the user experience has been significantly improved thanks to the release of a new app, which covers all the work taking place on the vehicle and presents the fleet manager with the information relevant to them in an even more precisely targeted form.

Big data for precise tire forecasts

All of the available data on the tire and vehicle is continuously analyzed in the cloud. Big data therefore makes it possible to issue precise tire condition forecasts. Vehicle and tire services can be coordinated



and aligned with one another to optimum effect, which creates synergies and seamless links to workshops and dealers. The result is increased fleet efficiency, lower overall costs and reassurance for fleet managers that their vehicles will be ready to use more of the time. "With ContiConnect 2.0, we are continuing to expand our offering of smart, digital tire solutions as we move towards predictive maintenance," adds Wilhelmsen. ContiConnect 2.0 has been trialed successfully by a selected group of customers since late 2021, and the new platform will be rolled out worldwide over the course of 2022.

Designed for sustainable mobility

The technology company is using these smart, intelligent tire services to optimise tire management across its fleet customers in various fields of application around the world. ContiConnect 2.0 is a solution for truck, bus and passenger car fleets, as well as off-road

vehicles. The fleet manager is presented with a fast and userfriendly overview of their entire fleet – regardless of where the vehicles happen to be. "The modular design of ContiConnect 2.0, the flexibility of its components and its level of compatibility allow us to integrate additional solutions, as requested by the customer," explains Sven Wilhelmsen. "Plus, we are working on the integration of external systems for recording tread depth."

The premium tire manufacturer enters development partnerships with customers and technology companies with the clear aim of continuously expanding its tire-related offering with servicebased, digital solutions. Its goal is to offer the allencompassing, digital tire management of the future: technology that can utilise the potential of tires – as an important element in sustainable mobility - safely and as comprehensively as possible. "Our aim is to offer the best solution for tire monitoring and management," concludes Tansu Isik. "A solution which can be integrated seamlessly



into the processes and

systems of our fleet

customers.'

MacLean takes another mining vehicle solution around the hard rock globe

Company launches purpose-built road grader for the underground environment

With the first-ever MacLean GR5 underground road grader already shipped to Africa and additional units scheduled for factory production, the newest addition to the MacLean line of Mine-MateTM utility vehicles, which offers up a ruggedised, high performance mobile solution for maintaining haulage ramps in optimal condition, is ready to be introduced to the mining world.

The GR5 mining vehicle is an evolution for MacLean. starting back in 2018 when the company collaborated with the specialty engineering firm Medatech to retrofit a battery electric grader for Borden Gold in northern Ontario (then owned and operated by Goldcorp). Based on the engineering and manufacturing learnings from this one-off custom project, MacLean embarked on a collaborative process to better understand the grader vehicle category, so that it could be successfully adapted from road to underground mining applications. Working closely with road

grader industry professionals from a former Canadian Grader OEM with decades of respected industry expertise, MacLean went back to the drawing board to develop a fit-for-purpose design for the underground environment. While most products in this category tend to be considered too lightweight for the work. the GR5 is purposely sized to match the tractive effort and drawbar pull of fullsized surface graders. The unit features a CAN bus control system that allows joystick control technology to be deployed for both steering and application functions simultaneously to ease operator comfort and control, while also boasting an onboard vehicle telemetry package that can monitor the performance and health of the vehicle. On the powertrain side, the unit can be either battery electric or diesel-powered, and comes equipped standard with a six-wheel infinitely adjustable drive system using dual hydrostatic motors and active traction control.

Size, maneuverability, visibility, simplicity, and ruggedness were key design factors. As a result, the unit is similar in height to the rest of the MacLean Utility Vehicle



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product line, designed to work optimally in 5m x 5m headings. The unit's design also includes a combination of frame articulation and front wheel-steering, which minimises its turning radius underground and its moldboard system uses a simpler design than its surface grader counterparts to ensure durability and reliability.

"When we designed the GR5 Grader we started from the ground-up, where we literally began with a clean slate and developed the rig using the latest in proven technologies and components," notes Dan Stern, Senior Product Manager. "The GR5's cab environment, for example, was developed using an Oculus Rift VR headset to map out placement of controls, verify visibility and sightlines, and ultimately get a good sense of what this rig would feel like to operate before any steel was cut."

"The product development approach on this unit is a great example of what we like to call MacLean 'Application Intelligence', where we take our mobile equipment engineering expertise and combine it with our knowledge of the mining environment

to design units that are fit for the job they need to do underground," adds David Jacques, Vice President of Engineering at MacLean. "We truly believe we've 'made the grade' and developed a winning product that leverages our core knowledge of the underground environment and combines it with application knowledge from grader design experts to address the actual needs of the mining industry - it all comes back to our Application Intelligence."

"The state of ramps is always an important factor in a mine's haulage performance, and it becomes even more important in the context of full-fleet electrification that mining companies around the globe are actively pursuing," remarks Maarten van Koppen, Vice President of Product Management at MacLean. "I know this firsthand from my time as a mining engineer at Borden Gold, where I was part of the team responsible for designing and developing that project. To maximise the benefits of down-ramp energy regeneration, mines need well-maintained roadbeds, and we've got the solution."

NEWS, PLANT AND EQUIPMENT

The Multiflo[®] Mudflo[™] hydraulic submersible pump is unsurpassed in pit dewatering applications

In parts of the world that experience heavy rainfall, particularly during the wet season, mud in the mining pit is a persistent hinderance that affects production and poses a safety hazard to both the mine and miners.

Traditionally, operators have moved mud using a truck-and-shovel method, whereby the mud is picked up by an excavator, dumped onto the back of a truck and driven out of the mine pit via the haul roads and then emptied into a disused pit. This is expensive, inefficient and risky. The amount of people and equipment required, as well as the mess created by the mud sluicing around in the back of the trucks, spilling and damaging the haul roads, all contribute to higher operating costs and reduced production.

Alternatively, some operators use standard dewatering pumps to remove the mud and slurry, but, because they haven't been designed for such harsh applications, the pumps are inefficient and wear quickly. Dewatering pumps pump high volumes and high heads, whereas mud or slurry pumping requires slower speeds in order to transport higher slurry concentrations.

Weir Minerals' team of dewatering specialists set out to develop a solution to these persistent challenges. We have designed and manufactured a submersible dredge pump to effectively, efficiently and safely transport the mud, as well as other

large particle and abrasive solutions, from the mine pit. The Multiflo[®] Mudflo™ hydraulic submersible slurry pumps have the flow range capability of between 150m³/ hr – 1,200m³/hr with just one operator. Compared with the truck-and-shovel method, it's estimated to save operators significant operational costs per cubic metre of mud pumped.

Weir Minerals' dewatering team works closely with its customers to develop solutions based on their specific needs and requirements. We don't just sell them a product and, if it doesn't work, blame it on them and wash our hands of it. Instead, we size the iob and recommend what we believe to be the best solution. We then work with them to provide the equipment and expertise needed to operate it to get the best results. Weir Minerals sees this as part of its responsibility not just as an OEM, but as a service provider with an abiding commitment to those we partner with.

Indeed, this is how the development of Multiflo® Mudflo[™] pump started years ago: a customer came to us and said, 'We want to you build a submersible slurry pump with better life expectations.'

One of the major competitive advantages of our Mudflo™ pump is that we have access to the full range of Warman® material compositions, so we're able to accommodate whatever





solution needs to be pumped. If it's an abrasive solution, a harder wearing material will be required; if it's an acidic abrasive solution, then you need to strike a balance between erosion and corrosion. The Multiflo® Mudflo[™] pump features Weir Minerals' Ultrachrome® A05, which contains approximately 27% chromium by weight, resulting in a chromium carbide content of about 25% by volume.

Moreover, the Multiflo® Mudlfo[™] pump features twin hydraulic cutters with ESCO[®] Ground Engagement Technology (GET), providing industry-leading wear life and impact resistance. Each cutter is also fitted with ESCO[®] teeth that utilise the two-piece Ultralok[®] tooth system to prevent premature breakage, avoid tooth loss and protect the integral locking system to ensure continuous operation of the pump.

We also work hard to accommodate the customers' duty expectations; we work

closely with them to assess how much power will be required in order for them to achieve their desired flowrate versus the head. Transporting the concentration of solution through the pipeline is obviously the primary objective, but we also have to make sure it doesn't settle in suspension.

One of the perennial challenges when it comes to pit dewatering is that it's difficult to predict how much rainfall to expect from one season to the next. Operators always need to plan for the worst case scenario because that's the eventuality that, if and when it does occur, can be catastrophic. Therefore, it's necessary to ensure that along with proven and reliable equipment – the pumping system has additional capacity to meet the variable seasonal flow rates. And that's what we have with the Multiflo[®] Mudflo[™] - a submersible slurry pump that will save you money, increase production and perform when you need it most.



Quarries move with technology as better times beckon

A positive tone at the recent Institute of Quarrying Southern Africa (IQSA) conference is giving hope that the region's economy is recovering, according to Tinus Brits, BME's Global Product Manager -AXXIS™

At the event, Omnia group company BME was showcasing its new AXXIS Silver™ digital initiation system, which was specifically developed with quarrying in mind. Over time, electronic detonation technology has become steadily more popular in the quarrying sector, said Brits.

He noted said the presentations at the IQSA event provided an encouraging picture of emerging economic opportunities - especially in road construction. which relies on guarries for aggregate and other building material. As plans were implemented to repair national infrastructure and roll out new projects, contractors were expected to become much busier this year.

"There are definitely improvements in the performance of a range of sectors, and it was exciting to hear that organisations like the South African Roads Agency Limited (SANRAL) had a strong pipeline of projects," he said. "As quarries position themselves for the growing demand, they are also



Tinus Brits, BME's Global Product Manager – AXXIS™

looking at the efficiencies of their operations - which is where BME makes an important contribution."

He sees more quarry managers moving toward newer blasting technology, for a couple of key reasons. As quarries age, areas to be blasted can become more challenging, requiring that blasting techniques and equipment become more accurate. flexible and controlled. There is also a cost factor related to energy consumption, where rising electricity prices are incentivising energyefficiency.

"Quarries want their primary blasted rock to be optimally fragmented, so that their crushers operate as productively and efficiently as possible." he said. "A presentation at the IQSA conference estimated that the added cost of secondary blasting or breaking of large boulders could reach four times the cost of the initial blast."

This is where electronic detonators - and the suite of digital tools that accompany this technology - allow guarries to achieve a higher quality of blasts, with better results. Conference visitors showed considerable interest in AXXIS Silver[™], he said, which is a slimmed-down version of BME's flagship initiation system AXXIS Titanium[™].

According to Bennie van Nieuwenhuizen, BME's AXXIS[™] quality manager, AXXIS Titanium[™] allowed large blasts of up to 20,000 detonators, while AXXIS Silver[™] boasted the same high levels of safety but are aimed at smaller operations.

"Our existing customers operating our AXXIS GII™ system are enthusiastic about moving up to AXXIS Silver[™] – and we also received considerable interest from potential customers who would like

NEWS, PLANT AND EQUIPMENT



to see the new system demonstrated and tested on their sites," said Van Nieuwenhuizen. For those quarries still using non-electric detonation methods, the step to take them to AXXIS Silver[™] was easily manageable.

"There has been a steady annual conversion rate of quarries from non-electric detonators to electronic detonators, of about 12-14%," he said. "Within the next five years, it is likely that most quarries will have moved over to electronics."

AXXIS Silver[™] retains all the stringent safety features that has made AXXIS Titanium[™] so popular, including an application-specific integrated circuit (ASIC) chip in the BME detonators. Among the added benefits of the ASIC is more internal safety gates against stray current and lightning – which enhances safety levels and allows for inherently safe logging and testing.

"The new system speeds up the blasting process. as the logging, testing and programming is done with one unit and requires only one visit to the blast hole,' he says.

The AXXIS Silver™ initiation system integrates with BME's Blast Alliance suite of digital tools, including its BLASTMAP blast planning software, XPLOLOG data logger

and online dashboard, and the Blasting Guide App for Android devices. This allows customised solutions that can be implemented with speed, accuracy and safety, he said.

"There are also specific advantages for guarries that we have built into AXXIS Silver[™], such as the thinner wire which we've developed to suit small-diameter waterlogged blastholes," he said. "This results in a perfectly straight wire down the hole, so you know exactly where the booster is - without compromising on the line strength."

In addition to being fit for purpose and guick to install the reduced thickness also translates into a cost benefit for the customer.



The AXXIS Silver™ initiation system also integrates with BME's Blast Alliance suite of digital tools.



Conveyor belt specialist Leslie David explains how the price of an apparently identical specification conveyor belt can be as much as 50% less than one produced by another manufacturer.



he industrial conveyor belt market in Europe has always been very competitive. However, as the volume of belting being imported into Europe continues to increase dramatically, the



'Big name' European manufacturers such as Dunlop Conveyor Belting have traditionally built their brand images based on higher quality standards. huge variations in the prices being offered by traders and manufacturers are becoming increasingly difficult to understand. It is not uncommon to see differences of 50% or more for belts that are supposedly of exactly the same specification. So, how can such a huge difference be achieved?

PAYING FOR THE NAME?

A common assumption is that the reason for the higher price is that you are 'paying for the name'. Another common misconception is that European manufacturers apply much bigger profit margins or that labour costs in Asia are much lower than those in Europe. However, none of these theories are actually correct. The fact is that 'big brand name' European manufacturers such as the Dunlop Conveyor Belting and Contitech's of this world, have built their brand images based on producing belts of much higher quality standards compared to those at the bottom end of the market. When you consider the extreme levels of competition, no manufacturer would survive for very long if they applied unrealistic margins. In fact, European manufacturers could only dream of having a margin that even comes close to double figures! Buying power is not a reason because virtually all of the biggest conveyor belt manufacturers are part of, or at least closely associated with, major tyre manufacturers and all the essential raw materials are available on the global market. The 'lower labour costs' argument does not hold water either because the very high level of automation means that the labour cost element of producing a conveyor belt is actually insufficient to make a significant difference to the selling price.

NO NAME, NO SHAME

Strong brand images are built up over many years based on producing belts with much higher quality standards and lowest 'whole life cost' compared to those at the middle and bottom end of the market. That reputation for quality has also had to stand the test of time, 100 years in cases such as Dunlop. A big brand name is only as strong as the quality and value for money consistently provided by the products that carry the manufacturer's name. When you think about it, big brand companies should actually be applauded for being prepared to be held accountable for their products. They are brave enough to have their names on them whereas cheap import goods with no name have little or no accountability at all. When unbranded products fail or simply disappoint, there is nowhere to seek recompense. Where there is no name there is no shame.

WHAT GOES IN MUST COME OUT

The key to the huge differences in price almost entirely lies in the quality of the materials being used. It is an inescapable truth that for finished products to be comparable in quality they must at least contain raw materials of a comparable quality. Another inescapable truth is that when poor quality ingredients are used then the end product cannot be anything other than poor quality. What goes in must come out. Raw materials constitute between 70 to 75% of the total cost of producing a conveyor belt and are available on the global market, with price ultimately determining the quality. This logically means that if there is a big difference in price then there must be a comparable difference in the quality of the materials used.

IGNORANCE IS BLISS

Conveyor belts are technically complex components and over the years, they have become even more complicated. Not surprisingly, most of those responsible for buying conveyor belts usually have only a very basic understanding of conveyor belts. The natural consequence of course, is that the alarm bells do not start ringing when there is a big disparity between the prices being offered. Without any other way of judging, the price becomes the primary buying criteria rather than reliability and longevity.

WHAT THE EYE CANNOT SEE

Many traders and manufacturers rely on this lack of knowledge plus the fact that all conveyor belts look pretty much identical in terms of their outward appearance. Even to the most experienced eye, it is impossible to tell how well the rubber will perform or how long the inner carcass will handle the stresses and strains placed upon it before problems start to occur or repairs are necessary or the belt fails completely. Based on the principle of 'what the eye cannot see', there are a number of methods and tricks that belt manufacturers use in order to undercut their competitor's prices.

INDUSTRIAL CONVEYOR BELTING



The labour cost element of producing a conveyor belt is very low.



Raw materials constitute some 75% of the total cost of producing a conveyor belt.



What the eye cannot see – all conveyor belts look the same.

INDUSTRIAL CONVEYOR BELTING



Rubber represents the biggest cost-cutting opportunity.

THE RUBBER

Some 85% of industrial conveyor belts used in Europe are rubber 'multi-ply' with a polyester/nylon (EP) fabric reinforced carcass protected by an outer cover of rubber with a thin layer (skim) of rubber between the layers of fabric. It is the quality of the rubber covers, in particular the ability to resist wear and tear that mostly influences the performance and operational lifetime of a conveyor belt. The rubber used for multi-ply and steelcord conveyor belts usually constitutes at least 70% of the volume mass of a conveyor belt and more than 50% of the cost.



Ozone & ultra violet light causes rubber to literally disintegrate.

Consequently, it is the single biggest opportunity for manufacturers to cut corners in order to minimise costs.

MISSING PROTECTION

Because of its adaptability, most of the rubber is synthetic. Dozens of different chemical components and substances are used to create the numerous different synthetic rubber compounds needed to cope with a multitude of different demands. These chemical components and additives are very costly so a combination of using low-grade chemicals at the absolute minimum levels all helps to contribute towards the 'lowest possible cost' objective. Perhaps the best example of this concerns the additives needed to combat the considerable damage caused by ground level ozone and ultra violet light. Ozone becomes a pollutant at ground level and exposure is unavoidable. It increases the acidity of carbon black surfaces and causes reactions to take place within the molecular structure of the rubber resulting in surface cracking and a marked decrease in its tensile strength.

Rubber degradation is also caused by ultraviolet light from sunlight and artificial (fluorescent) lighting because it produces photochemical reactions that promote the oxidation of the surface of the rubber resulting in a loss in mechanical strength. In both cases, this kind of degradation causes the covers of the belt to wear out faster than they should. Protecting the rubber against ozone and UV is easily achieved simply by adding special anti-oxidant additives during the mixing process of the rubber compound, which provide protection against the effects of ozone and ultra violet. They are therefore an essential ingredient in any belt of reasonable quality.



However, despite their critical importance, anti-ozonants are not used in the vast majority of conveyor belts purely because they are an avoidable cost.

SAFE TO HANDLE?

To make some rubber compounds it is unavoidable that chemicals that may be extremely dangerous in their own right have to be used. Fortunately, there are very strong regulations in place to protect humans and the environment in the form of **REACH** (**R**egistration, **E**valuation and **A**uthorisation of **Ch**emical substances) regulation EC 1907/2006.

REACH regulations stipulate that all European manufacturers are legally obliged to comply with the regulations relating to chemicals, preparations and substances used to create finished products. Although not commonly known by consumers, the use of any "substance of very high concern" (SVHC) listed within the regulations must be registered with ECHA (European Chemical Agency) headquarters in Helsinki. For example, if a product contains a SVHC that is more than 0.1% of the total weight of the finished product then the manufacturer is compelled to both register its use with the European Chemicals Agency and provide their customer with a safety datasheet.

One of the biggest concerns involves short-chain chlorinated paraffin's (SCCP's). These are commonly used, especially in Asia, to artificially speed up the vulcanizing process. REACH regulations clearly stipulate that SCCP's should either not be used at all or at least only used on a very restricted basis because they are persistent organic pollutants. They are bioaccumulative* in human and wildlife and toxic to aquatic organisms at low concentration. These chemicals pose hazards to human health and the environment because they have category 2 carcinogenic classifications and are what is scientifically termed as 'persistent'. The clue to their presence is the strong, pungent aroma whereas good quality rubber usually has very little smell at all.

(**Authors note:** Bioaccumulation occurs when an organism absorbs a substance at a rate faster than that at which the substance is lost or eliminated)

The formation of nitrosamine gasses is another concern and known to occur when certain types of vulcanisation accelerators are used. Nitrosamine gasses gradually release themselves from rubber belts, which could be a

INDUSTRIAL CONVEYOR BELTING



Good quality rubber usually has very little smell at all.

problem when the belts are stored indoors. *Nitrosamines* are chemical compounds classified as probable human carcinogens based on animal studies. Investigative research is still ongoing but publicly available information from the rubber industry (primarily from within Germany and The Netherlands) indicates that nitrosamine formation can be avoided if the accelerators are replaced by others that do not contain nitrosatable substances.

Sadly, most European manufacturers have chosen to ignore these legal requirements, either completely or at least partially because of the impact on production costs. Of even more concern is that manufacturers located outside of EU member states and the UK are not subject to EU regulation concerning the use of hazardous chemicals or the use of Persistent Organic Pollutants (POPs). This provides them with an open door because they are free to use unregulated raw materials that cost much less on the global market compared to their regulated counterparts, even though those same materials may be entirely prohibited or at least have strict usage limitations within the European community.



Non-EU and UK based manufacturers are not, subject to REACH regulation or EU regulations concerning Persistent Organic Pollutants.

INDUSTRIAL CONVEYOR BELTING



Low-grade carbon black is produced by burning scrap car tyres.

Other methods used to minimise rubber costs include the use of recycled rubber of highly questionable origin, the use of reject rubber compounds and cheap 'bulking' fillers such as chalk to replace part of the otherwise more expensive rubber polymers. An even more alarming costcutting practice involves a key component contained in every black rubber conveyor belt – carbon black.

UP IN SMOKE

Carbon black is one of the most important ingredients of synthetic rubber. It represents some 20% of a rubber compound and is used not only as a pigment but, much more importantly, as a reinforcing compound. Carbon black is produced by the reaction of a hydrocarbon fuel such as oil or gas with a limited supply of combustion air at temperatures of 1320 to 1540°C. The unburned carbon is collected as an extremely fine black fluffy particle.

Good quality carbon black is costly to produce. However, the important role that it plays should not be underestimated. For example, it prolongs belt life by helping to conduct heat away from the surface area of the belt, thereby reducing thermal damage, and it also absorbs ultraviolet radiation. Belts offered with much lower prices are almost certain to contain carbon black that is of a much lower quality and which has been produced much more cheaply by burning scrap car tyres. It is also much more damaging to the environment.

OUT OF CONTROL

Only a limited number of genuine conveyor belt companies who actually manufacture belts themselves still exist in Europe. Apart from one notable exception, virtually all European manufacturers import belting from outside of Europe to some degree in order to supplement their own production. Many manufacturers outsource the manufacturing of their rubber to large-scale rubber compound manufacturers (again, mostly outside of Europe) rather than produce it in-house. Although it is cheaper, the downside is that it is virtually impossible to ensure the consistency of the rubber's physical properties and equally impossible to ensure compliance with REACH regulations or those concerning Persistent Organic Pollutants.



The carcass provides the innate strength of any conveyor belt.

THE CARCASS

The carcass provides the innate strength of any conveyor belt. Very significantly, the strength under load needs to be consistent throughout the belt both longitudinally and transversely in order for the belt to steer and handle correctly. I explain this for a very good reason. Although they may be the same basic specification, there are often huge differences in the quality of the fabric plies between one belt and another.



Lower quality (lower cost) fabrics have much less resistance to rip, tear and impact.

In cheaper, lower quality fabrics, although the amount of material used in the longitudinal (polyester) strands of the fabric may be adequate, the amount of transversal weft material (nylon) is kept to an absolute minimum in order to reduce cost. Although the required tensile strength is achieved, rip and tear resistance is reduced and elongation (stretch) is unacceptably low. Elongation that is too low can cause problems with transition distances and a general inability to accommodate the contours of the conveyor and its drums and pulleys and ultimately lead to the premature failure of the belt.

EP OR NOT EP? THAT IS THE QUESTION

Another deception that is now increasingly common involves the use of totally polyester (EE) fabric plies in a carcass that has been sold as being an EP carcass (polyester/nylon mix) construction. Until fairly recently, this dishonest practice was most

Not what they seem – The use of totally polyester (EE) fabric instead of polyester/nylon mix (EP) in order to cut costs can cause some very big problems.

frequently found in belting that had been imported from Asia but it is now being used by a growing number of European-based manufacturers. The whole basis of using a mix of polyester and nylon fabric (EP) is that it has the best balance of mechanical properties including allowing a conveyor belt to run straight and true, to trough, to flex round pulleys and drums, stretch, provide sufficient transversal rigidity, longitudinal strength and much more besides.

The use of totally polyester (EE) fabric compromises a whole range of essential mechanical properties*. The biggest danger is that a polyester weft can cause low transverse elasticity, which reduces both the troughability and impact resistance of the belt as well as causing tracking issues. In addition, less weft in the belt can also reduce rip resistance, fastener strength and the ability to handle smaller pulley sizes. The seriousness of the detrimental physical effects should never be underestimated.

(*Author's note: The use of fabrics made entirely of polyester (EE) has its place in certain belt types and constructions. However, in those cases the declared specification of the belt should clearly be EE and not EP).

As I touched on earlier, the simple reason for this dishonest practice is to keep the selling price down because totally polyester (EE) fabric costs some 30% less than EP fabric. In itself this may not seem like a great deal but the fabric plies are a major cost component in any multiple ply conveyor belt so using cheaper polyester fabric is a big help when trying to achieve the perception of a lower 'like for like' price. As far as the manufacturer using these underhand tactics is concerned, they know that it is highly unlikely that the end-user will have tests carried out that would reveal their trickery and dishonesty.

INDUSTRIAL CONVEYOR BELTING



THE INESCAPABLE TRUTH

As I said at the beginning, the inescapable truth is that for products to be comparable in quality they must at least contain raw materials of a comparable quality. Raw materials constitute some 75% of the cost of producing a conveyor belt so if there is a significant difference in price then the obvious conclusion is that the quality of performance and the longevity of the product will be significantly less. As the old saying goes, "Price is what you pay but the cost is what you spend".



ABOUT THE AUTHOR

Leslie David

After spending 23 years in logistics management, Leslie David has specialised in conveyor belting for over 16 years. During that time, he has become one of the most published authors on conveyor belt technology in the world.

Re-engineering the Digital Transformation

Processes and people alike must be upgraded to take full advantage of tools and technology.

he tools and techniques of digital transformation greatly simplify and speed up new product development. They are counterproductive and even senseless, however, if put to work supporting the "same-old, same-old" processes of product development, design engineering, manufacturing and service. The same is true for the processes used in every other business unit in the enterprise.

For project managers and enterprise leadership in digital transformation, the need for process modernization should be obvious. Digital transformation's tools and techniques can greatly improve collaboration and innovation in new-product development, as just one example, but not until many existing processes are updated – or, as is often necessary, re-engineered. This is never simple.

Just as products are re-engineered to accommodate new capabilities, processes also must be re-engineered. Reengineering is a proven way to address processes illsuited to the trends and enablers of digital transformation; these can be large stumbling blocks for collaboration, productivity and even enterprise sustainability.

These views were spelled out in a recent virtual conference I participated in on process innovation and digital transformation ("PI-DX") run by Marketkey Ltd., a Londonbased business-information company focused on refining data into intelligence, business insights and innovation. The panel focused on what Marketkey labels "legacy technical debt." The remedies discussed included process "modernization" and process "innovation," but problems in some processes run deep. These can only be addressed by re-engineering the process, ideally while replacing obsolete legacy systems and upgrading the technical skills of the workforce.

Process re-engineering is tied to digital transformation at several levels wherein information is freed from preoperative formats such as spreadsheets, CAD-generated drawings and e-mail attachments; many critical processes are rendered obsolete.

Digital transformation requires up-to-date systems, tools, techniques and solutions; they can be difficult to work with. Amid new realities of data and information, these challenges require skills updates, too.

Processes that until recently were expected to change little have been demolished by technology and tech-savvy new workers, choosier customers, ceaseless innovation and shorter product lifecycles. Consequently, many longestablished practices in the handling of information in processes are headed for the dustbin of digital history. CIMdata Inc.

The complexities of how business units and enterprise processes fit together make re-engineering almost



unavoidable. It also can lead to a reduction in those complexities.

CHANGING THE THINKING

As goes information, so go the processes we use to search, use and manage it. Enterprises, business units and solution providers clearly see that their assumptions about many everyday processes have become questionable.

"The way we have been getting things done" no longer keeps up with the speed of innovation in today's marketplaces. And it is product and process innovation that helps fend off competitors, hang on to demanding customers and shore up profit margins.

Viewed in this light, it is little wonder that processes are being impacted in every product and asset lifecycle. These impacts are most disruptive in determining new product requirements and throughout design, engineering, production, service, and all data handling and information gathering tasks.

Users and managers also struggle with fallout from legacy systems and tools and the processes that support them. A pair of all-too-common examples:

- Reworking newly manufactured products at the ends of assembly lines, delaying shipment and running up costs
- Iffy, on-the-fly workarounds that turn into repetitive doloops producing nothing but frustration

Both are good places to launch process re-engineering and easily win user support.

Re-engineering any process starts with a deep dive to pinpoint where and why things go wrong. Once the problems and their causes are clearly identified, address

DIGITAL TRANSFORMATION

them one by one. So a big part of process re-engineering is developing new capabilities to reconfigure the tasks and sub-tasks that make up the process. Once these new capabilities are chosen, test and verify them. Though tedious, testing and verifying must be done with care.

Processes usually generate predetermined outcomes that support decisions or feed additional processes. Poorly planned changes to a process, or even to just a few of its tasks, could blindside workers elsewhere in the business unit.



Author Tom Gill at work on a process re-engineering project.

DIGITAL TRANSFORMATION

In the enterprise's high-level business processes, the impacts of re-engineering run even deeper. These processes include concept to design, design to manufacturing, orders to cash and others that must not be overlooked.

A typical scenario for CIMdata clients takes shape while the processes are being re-engineered. After the process changes have been verified as viable, CIMdata continues to help the client while the re-engineered processes are pu into use and, equally importantly, integrate the changes with other processes that are closely connected.

At this point, several crucial decisions must be made, and the synergy of outside expertise and knowledgeable staffers comes into force. These decisions focus on ensuring user buy-in as well as how best to gain the support of all those whose work is tied to the process(es) being re-engineered. Other key decisions cover lining up in-house technical resources and securing financial support.

CHANGING THE WORK PROCESS

A big part of the value of process re-engineering lies in helping the workforce grasp the benefits in letting go of obsolete processes. If the workforce is to welcome change and embrace innovation, make sure that decisions about re-engineering are clearly communicated.

An alternative approach to these communications is budgetary – putting business issues first. This means linking anticipated re-engineering costs to projected revenue gains.

To help with building your case for re-engineering a process, here are a few realities that must not be overlooked:

- · Processes are linked in countless ways, even without the bidirectional and end-to-end (E2E) connectivity essential for maximum efficiency
- Process changes occur fast and often, prompting users to modify their processes themselves
- · Process changes at the business-unit level are triggered by innovation such as augmented/virtual reality and advanced analytics
- Process changes also impact users directly artificial intelligence and machine learning, for example
- · At the enterprise level, processes are disrupted by model-based engineering, system-of-systems thinking, predictive analytics and agile software development

As the skills of the workforce are upgraded and transformed, new and better ways will be found to connect people, data, technologies and tools. As these are implemented, process re-engineering will grow in value - and inevitability.

Perhaps the best approach to process re-engineering is to undertake it together with workforce transition and skills upgrades. None of these crucial initiatives can achieve its full potential without the others. Transitioning workforce skills while re-engineering their processes can go a long way assure the ultimate success of digital transformation and, in turn, help secure the sustainability and long-term competitiveness of the enterprise.

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Elementos confirms Spanish tin potential

An optimisation study into the Oropesa tin project, in Spain, has confirmed that the 1.25-million-tonne-ayear project could produce 3 350 t/y of contained tin.

Based on a tin price of \$32 500/t, the optimisation study estimated that the project would have a posttax net present value (NPV) of A\$198-million and a pretax internal rate of return of 46%, based on a mine life of at least 13 years, owner Elementos said.

The study estimated that the project would require a capital investment of \$86-million, which included a 20% contingency, with the project expected to generate annual gross revenues of \$108-million a year, with operating costs estimated at \$50-million a year, and all-in sustaining costs at \$18 607/t of metal.

The optimisation study provides a significant increase from Elementos' previous 2020 updated economic study, which considered a 750 000 t/y operation, resulting in a pretax NPV of \$92-million. Elementos noted that

the increase in project scale includes increases to mining, ore sorting, processing and supporting infrastructure and is designed to comply with the Spanish mining and environmental regulations, including back-fill and rehabilitation of the openpit.

"The optimisation study confirms that Oropesa will deliver a low capitalintensive project, with a competitive operational cost base, producing significant quantities of tin concentrate for at least 13 years," said Elementos MD Joe David.

"The operational and financial metrics summarised in this optimisation study are extremely positive. It demonstrates Oropesa's



NEWS, PLANT AND EQUIPMENT



potential to become a significant European tin operation, supplying material quantities of tin concentrate into the global supply chains during a period of unanticipated growth in demand to service the world's insatiable appetite for critical electrical components.

"This optimisation study is now the basis for the company's definitive feasibility study and will be the basis of all the required regulatory submissions. The fact that the financial outcomes presented are incredibly strong when

based on a design which we believe is conservative and complies with all required regulations, has the company more motivated than ever.

"Following recent mineralisation intercepts outside the current mineral resource limits, the company anticipates that the presented optimisation study will prove to be the first phase of a larger mining operation, with the company planning further Oropesa exploration programmes at the appropriate time," said David.



Security and privacy concerns prevent effective use of IoT data, Inmarsat research reveals

Industrial IoT in the Time of Covid-19 – reveals majority of mining businesses do not share IoT data effectively across their business ecosystem but plan to in future

esearch by Inmarsat, the world leader in global, mobile satellite communications, reveals relatively few businesses derive maximum benefit from the IoT data that they gather. Most of today's businesses only share IoT data within their own organisations, with security and privacy concerns preventing them from disseminating it to organisations in their wider supply chains. Infrequent data collection and lacking an IoT data strategy leaves many businesses surveyed struggling to extract full value from their IoT data. A more strategic, ambitious and open approach to gathering and sharing non-sensitive data could unlock substantial benefits for business struggling to make the most of IoT projects.

Collecting and sharing the right data at the right time enables companies and their partners to take better, more proactive decisions across the value chain to optimise operations as soon as a problem occurs, or even anticipate and mitigate it before it happens. Such data driven insight can help businesses reduce waste, increase productivity, improve customer service and run more sustainable operations.

The research was based on the interviews of 450 global respondents across the agriculture, electrical utilities, mining, oil and gas, and transport and logistics sectors. According to the research, of those who worked in mining,

as many as 84% of respondents admit their organisation does not use the data collected from IoT projects as effectively as it could. This is despite high levels of IoT adoption overall. The most prevalent barriers are security and data privacy concerns, cited as a barrier by almost half (49%) of all respondents, followed closely by a lag between data collection and availability (48%) and the lack of an IoT data strategy (34%).

Accelerating IoT adoption over the course of the Covid-19 pandemic has highlighted the fact that many businesses' data sharing strategies are not yet as advanced as they need to be. Currently, only 23% of mining organisations make non-sensitive IoT data available to anyone in their organisation, and to their partners, to access and to use. Conversely, a third (33%) limit the use of IoT data to certain departments involved in their IoT projects. However, this is set to change, with a larger proportion of mining organisations (40%) shifting towards sharing data with their wider supply chain and far fewer (17%) planning on limiting IoT data to specific departments. This change is occurring as more businesses come to understand that the responsible and secure sharing of IoT data is a necessary step towards unlocking the maximum value of that data.

The research reveals that having a formal IoT data strategy is a vital step towards drawing the optimum

benefits from the technology, ensuring data is produced, shared, and analysed between the right parties at the right time. Organisations with a formal IoT strategy are far more likely to gather data points in their IoT projects in real time (44% of respondents compared to only 22% amongst organisations without an IoT strategy).

There are also notable differences in how strategic mining businesses are in the usage of their IoT data based on the region they operate in and the size of their organisations. While only 27% of businesses in the Asia Pacific region struggle to use IoT data effectively due to the lack of an IoT data strategy, this increases to 42% of organisations in Latin America and 43% in Europe (excluding Russia). Likewise, while 14% of the largest organisations (over 5,000 employees) struggle with a lack of an IoT data strategy, 43% of smaller businesses (between 500 and 1,000 employees) cite this as a barrier to effective IoT data use.

Nicholas Prevost, Director of Mining at Inmarsat Enterprise said: "While we've seen the mining industry make great strides on IoT, it is evident that mining companies are lagging behind other businesses in their use of IoT data. It's no surprise to see mining ranked the second least likely to have a formal strategy on this, given that organisations are not using data as effectively as they could. This needs to change.

"Implementing a clear IoT data strategy will help ensure that mining companies' data is effectively communicated internally and across the supply chain. In such a critical industry, data and information is integral to the success of any mining operation, but to make the most of this wealth of data, a coherent strategy and approach is essential. Putting the right people and processes in place to make this a reality will be crucial."

Commenting on the findings, Mike Carter, President of Inmarsat Enterprise said: "While our latest research shows that the majority of today's organisations are now gathering IoT data, there is still plenty more that businesses need to do to derive the maximum benefit from it. The ultimate measure of an IoT project's success is how it improves the way a company and its partner eco-system operates. This is largely resultant on the type of data extracted and how it is shared and turned into practical and actionable business insights in a timely

"It's clear from our findings that many businesses still need to employ an IoT data strategy as part of their overall IoT strategy, to ensure their data gets to where it needs to go within the organisation, let alone to other parts of the supply chain. Four out of five businesses currently share the data created from their IoT projects only within their organisation, due to concerns around security or privacy, limiting their ability to extract real business value from this data. However, it is

manner.



encouraging businesses intend to change this situation, as organisations become increasingly open to sharing non-sensitive IoT data with their partners, increasing productive supply chains.

"Without a coherent IoT data strategy in place, businesses will struggle to develop the culture of open and responsible data sharing and collaboration required to ensure their IoT projects are successful. Inmarsat's Enterprise business is focused on providing IoT connectivity to businesscritical applications and to remote locations, providing vital access to valuable data points across global supply chains. Our industry-leading ELERA narrowband network enables organisations that grow, mine, extract, move, save, and inform to access, use and share IoT data anywhere, helping them to improve efficiencies, safety and sustainability."

ABOUT INMARSAT

Inmarsat is the world leader in global, mobile satellite communications. It owns and operates the world's most diverse global portfolio of mobile telecommunications satellite networks, and holds a multi-layered, global spectrum portfolio, covering L-band, Ka-band and S-band, enabling unparalleled breadth and diversity in the solutions it provides. Inmarsat's long-established global distribution network includes not only the world's leading channel partners but also its own strong direct retail capabilities, enabling end to end customer service assurance.

The company has an unrivalled track record of operating the world's most reliable global mobile satellite telecommunications networks, sustaining business and mission critical safety & operational applications for more than 40 years. It is also a major driving force behind technological innovation in mobile satellite communications, sustaining its leadership through a substantial investment and a powerful network of technology and manufacturing partners.

Inmarsat operates across a diversified portfolio of sectors with the financial resources to fund its business strategy and holds leading positions in the Maritime, Government, Aviation and Enterprise satcoms markets, operating consistently as a trusted, responsive and high-quality partner to its customers across the globe.

Energy consumption remains a challenge

eneficiation of minerals, also called mineral processing, implies processing of mineral resources to enhance its potential value to the benefit of the humankind. The mineral resources as mined, or the 'run-of-mine ores' or 'raw ores,' are not uniform in their composition of constituents, may be too coarse and/or unstable in size and consistancy, and furthermore, in many cases, too poor in grade to be utilised for sustaining our modern life. In other words, if mines venture to extract the valuable metal components included in such ores, they must spend inhibitive cost and/or energy to recover only a small amount of refined metals from them. To circumvent such issues, mines need to process the run-of-mine ores prior to final smelting and refining stages, which require too much energy consumption by rendering less energy intensive procedures, based on physical rather than chemical principles.

Comminution is mechanically a very wasteful process in present practice in view of the campaign now developing to eliminate energy -intensive processes in industry. Because of the widely distributed zones of low resistance, rock is not homogeneous to breakage, and there is no basic theory of comminution that can be accepted.

Mining operations are complex environments. Even for something as "simple" as surface mining or open pit mining, there are a whole host of variables to consider. Small changes in blasting operations, haul truck speed, stockpiling, and equipment can have significant impact on throughput and operating cost. Furthermore, all these components are inter-related, making second-order effects difficult to identify, let alone correct.

On top of this, many companies treat different parts of their mining operations as independent units. It's not uncommon for a large mine to have independent planners looking after blasting, primary crusher throughput, secondary and ball mill grinding as well as the concentration plant

There is significant potential to reduce energy costs in mining through an integrated approach to energyefficiency investment. Applying energy-efficiency strategies to comminution, the largest area of energy usage, usually offers the best scope for saving. Comminution (crushing and grinding) is responsible for at least 40% of total energy use in mining and mineral processing. Improving flow sheet design will: ensure the most energy-efficient crushing and grinding technologies.

Energy use in mineral comminution is a key area where emphasis on innovation needs to be focused and collaborative development of new technologies to reduce energy requirements in ore still remain a challenge.

Most of the energy in mineral processing (power and steel) is used in crushing and grinding rock. This process is simple at an elevated level, and able to be modelled based on simple physics. However, understanding, and optimising

comminution processes have presented researchers and practitioners with significant challenges.

In mineral processing or metallurgy, the first stage of comminution is crushing. Depending on the type of rock (geo-metallurgy) to be crushed, there are two different techniques at the disposition for crushing rocks. Crushing is performed on the large particles, and the grinding is performed on the particles smaller than about 50 mm. and is the first step of mineral processing after drilling and blasting operations in the mine.

MQW Managing Editor Trevor Barratt looks at the various types of equipment used in comminution and some important factors being deployed to reduce energy costs.

PARTICLE SIZE

The reduction ratios for each successive crushing and grinding process influence the distribution of particle sizes and the energy use in the process. Energy use is relatively low when particle sizes are consistent. Finer particles resist breaking and are displaced, causing energy to dissipate. Larger particles reduce grinding efficiency. Screens and filtering devices help achieve a more consistent particle size.

PROGRESSIVE LIBERATION

The target product size influences the size and energy use of a comminution circuit. As the product becomes finer, the internal flaws in each particle decrease.

An alternative approach for the selection of a target product-size for multi-mineral ores is the progressive liberation method. This involves liberating one mineral at a time by applying the following concepts:

- Multiple valuable minerals are grouped, increasing their effective concentration, and enabling liberation to be achieved at coarser target product sizes.
- Fully liberated particles (100% valuable mineral) are recoverable in a flotation process.
- Particles containing at least 15% valuable mineral by sectional area are recoverable in a flotation process using the appropriate conditions and reagents.

If minerals are sufficiently liberated or recoverable they can be separated from the ore before further comminution. This strategy can also remove gangue from the ore which leads to less grinding energy and more efficient separation in downstream processes.

ADVANCED AND FLEXIBLE COMMINUTION CIRCUITS

Using a single comminution circuit with very large SAG mills has enabled companies to expand into large, low-grade ore bodies. A disadvantage of this approach is comminution becomes less efficient as ore body concentrations decline with only one circuit operating.

Many companies address this problem by using two parallel milling circuits. This allows high- and low-grade ores to be processed simultaneously but on separate circuits, enabling each grade to be ground closer to optimal recovery size.

MINERAL COMMINUTION

The discrete element method (DEM) is increasingly useful as a tool that can help provide fundamental insights into comminution processes and the behaviour of specific comminution machines.

DEM can contribute to:

- · design and rapid manufacture of comminution equipment
- increased operational efficiency of all comminution unit processes
- greater understanding of particle flow and breakage processes within comminution equipment through DEM modelling.

The last two decades have been marked by a sharp increase in global environmental awareness. As a result, many industries are concerned about efficiency and sustainability. In broad terms, efficiency is measure of input savings that can be realised with technological development without necessarily compromising output. Opportunities for improved efficiency in comminution cut across a range of scientific and engineering aspects. In recent years, research and developments from different professional bodies have expanded the wealth of knowledge in the field of comminution.

Mathematical models and computer simulations can now be used to provide an insight of what takes place inside comminution machines. Engineering developments have enabled improvements of conventional comminution equipment. Process developments have provided more accurate methods of measuring and characterising control parameters such as particle size distribution to reduce unnecessary grinding. It is anticipated that a multidisciplinary approach of scientists and engineers with different expertise provides the best hope for a lasting solution to the challenges in comminution.

CRUSHING

The most common machines for the comminution of coarse feed material (primary crushers) are the jaw crusher (1m > P 80 > 100 mm), cone crusher (P 80 > 20 mm) and hammer crusher.

Obtaining the best product size after the crushing process plays a crucial role in the subsequent beneficiation process to get the valuable mineral from the gangue. To achieve the required product size, the jaw crusher, impact crusher (horizontal and vertical), and cone crusher are mainly used in the primary, secondary, tertiary crushing stages.

CRUSHING PRINCIPLE

Compression, impact, and attrition are the main mechanical forces in the comminution processing, and other possible grinding modes, including torsion, twisting, stretching, and so on.

Rock crushers are available in different types, and capacities ranging from 1TPH to 500TPH, the mechanism of crushing process is either by applying impact force, pressure, shearing or a combination of them. In the crushing and grinding equipment, various grinding modes can occur simultaneously, but it is usually dominated by a grinding method. The material for size reduction may be a mineral, rock or ore containing useful and gangue minerals. The purpose of crushing rocks and ore materials is to liberate valuable minerals particles from gangue. If



the liberation has not been completed, then the product of crushing is the product of symbiosis.

CRUSHER SELECTION

There are many manufactures worldwide offering crushers/ sizers purpose built for each mines requirements and it would be wrong for MQW to endorse any one particular company.

Finding the best circuit to crush and grind minerals to beneficiation sizes is a complex problem that can lead to interminable discussion. Conclusions reached can be questioned. This will continue as long as the technology of comminution continues to expand and is a mixture of many technical and economic factors in what is not a precise science.

Laboratory and pilot plant procedures now exist that can help process engineers make sound decisions on which circuits are the best for crushing and grinding the specific ore being studied

It is considered that the crushability of the rock depends on the type of crusher, the setting of the crushing process, the rock strength, and the hardness of the mineral. How to meet the needs of total production at a lower cost and maximise profits needs the help of a professional engineer.

Depending on the characteristics of the material (such as hardness in various size ranges) and application requirements (such as output and maintenance), different types of crushers and crushers can be selected. Crushers usually classify the degree of crushing of raw materials with a primary crusher that does not have too much fineness. The fineness of the intermediate crusher is higher, and the crusher crushes it into fine powder. The crusher can be divided into primary crusher, secondary crusher, or fine crusher according to the proportion of material size reduction.

According to the capacity of the crusher, the gyratory or jaw crusher is usually used as the primary crusher. The primary crushing can be carried out underground, or it can be carried out on the surface close to the subsequent crushing and crushing stage.

For placer gold, tin, mineral sand, and the like soft placer deposits, do not need such crushing treatment. But for those large lump of rock ore, percussion rock crusher or similar crusher are required to use to crush them down to size before subsequent mineral processing step.

Primary crushing operations are usually carried out by mechanical operating equipment such as jaw crushers, gyratory crushers.

The secondary crusher can be gyratory or conical. The third crusher is almost entirely a cone crusher. The selection and layout of the secondary and tertiary crushers and screens varies according to the situation.

HIGH PRESSURE GRINDING ROLLS (HPGR)

It was suggested that the most energy efficient method of comminuting particles is to compress them between

two plates (Schoenert, 1979). Compressing a particle bed between two counter rotating rolls was achieved by the invention of the high-pressure grinding rolls (HPGR). Comminution in the HPGR is as a result of high inter particle stresses generated when a bed of solids is compressed as it moves down a gap between two pressured rolls (Wills, 2006). Such inter particle stresses result in a greater proportion of fines in comparison to conventional crushing. The HPGR has achieved considerable interest over the last two decades due to its potential for significant benefits in comminution circuits. Process benefits such as increases in liberation, reduction in untreatable fines, reduction in grinding energy and increase in grade and recovery have been reported (Aydogan et al., 2006, Clarke and Wills, 1989, Fuerstenau and Kapur, 1995, Norgate and Weller, 1994). It has also been claimed that the Bond Work Index of the HPGR product is significantly lower than the product of conventional crushers due to creation of micro cracks (Clarke and Wills, 1989).

The extent of the weakening caused by HPGR is dependent on the specific energy input (grinding pressure) and is greater for coarser sized particles but becomes insignificant for particles less than 1.5 mm (Tavares, 2005). Successful application of the HPGR has been reported at the Argyle Diamond Mine (ADM) in Australia where they have been used for tertiary crushing of material with p80 of 75 mm since the early nineties and more recently for re- crush of material with size range 6-15 mm. The total cost of operating a HPGR was about 14% less than that of operating a cone crusher. The Relative Comminution Efficiency (RCE) of the HPGR was between 51-75% higher than for the Cone crusher depending on the size fraction (Gerrard *et al.*, 2004).

The main advantages of HPGRs are summarised as follows (Kellerwessel, 1993):

- Less specific energy consumption and consequently less wear in downstream ball milling
- Increased capacity of existing plants with comparatively small investment
- · Better liberation of valuable constituents
- · More intense attack by leach liquor
- Comparatively low space requirement depending on the selected flow sheet

The HPGR seems to be the most energy efficient comminution device currently available to the mineral processing plant designer. The focus therefore should be on the development of both the machine and flow sheet to maximise the proportion of total comminution performed by the HPGR. Properly designed HPGR-based circuits offer potential of significant savings in comminution energy requirements, increased liberation and overall operating costs when compared to ball or SAG-mill based circuits.

GRINDING TECHNOLOGIES

Until the 1970s, almost all grinding in mineral processing was carried out using rod and ball mills. Arguably, no novel grinding technologies that significantly differ from the tumbling technology have dominated mineral processing

MINERAL COMMINUTION

to date. However, subsequent technological developments have resulted in "improved versions" of the traditional ball/rod mill. The SAG mills have come to dominate comminution in mineral processing. The efficiency of SAG mills, in terms of energy consumption, has been disputed by some authors. It is claimed that "critical size particles" can build up in the SAG mill charge, limiting mill throughput and increasing unit power consumption (Johnson et al., 1993). However, it has generally been agreed that removing the critical size particles from the mill, crushing them, and returning them to the circuit, can significantly improve the power efficiency of the circuit and result in substantial increases in circuit throughput and efficiency (Apelt and Thornhill, 2009, Napier-Munn et al., 1996). There have also been reports of reduced capital cost as a result of ability to eliminate at least one grinding step, less resistance to lining wear and grinding media capital requirement although these are not very significant when compared to the cost of energy (Johnson et al., 1993).

A plethora of other equipment such as IsaMill, stirred mill and tower mills have also come into use for ultra-fine grinding (Wang and Forssberg, 2007), although these have had little application in base metal mineral processing as, often, ultra-fine grinding is either not necessary or not cost effective. Shi *et al*

Due to limited alternatives for grinding technology with respect to mechanical stressing of particles, significant research efforts have been directed towards optimizing performance of existing mills and grinding circuits. Several studies have focused on enhancing performance indicators such as throughput, energy consumption and product quality. Other studies have investigated the effect of variations in mill load, speed, inlet water flow and feed size distribution on performance of mills (Morrell, 2003, Powell et al., 2009, Powell et al., 2001). Improved particle classification systems during processing can save energy, avoid over grinding, improve product quality, and increase unit capacity. Laboratory test work has also indicated that the way circuits are operated with respect to classifier performance and recycle load in closed ball mill circuits could save up to 15% of the required grinding energy (Morrell, 2008). The increase in efficiency was said to result not from the viewpoint that more of the energy in the balls is transferred into breaking feed ore, but that the same amount of energy is used to break more of the coarser ore particles and less of the finer ones, thereby changing the product size distribution. In effect, the increase in recycle load reduces over grinding. Other work has involved developing numerical models and computer simulations that enable analysis of charge motion for improved mill design and operation and to develop a socalled "virtual comminution machine" (Venugopal and Rajamani, 2001, Morrison and Cleary, 2008). Although all these developments have provided a wealth of knowledge about comminution processes and some significant process benefits, they have not provided the breakthrough in grinding efficiency that is required.

In 2009 a study was conducted to compare the performance of a laboratory scale Vertical Impact Stirred mill with a ball mill. It was reported that there had been an indication that on average, 30% energy savings can be expected by using the stirred mill to replace the ball mill for coarse grinding. However, this difference was expected to decrease to some degree when using a larger ball mill and this claim has not

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been substantiated. In addition, there are reports of other "high efficiency" mills such as the VKE (manufactured by Microgrinding Systems Inc) and The Hicom Mill, that are associated with vibration or eccentric impact and centrifugal actions but likewise these have had little impact in mineral processing due to limitations in capacity and other associated engineering and design problems (Shi *et al.*, 2009).

IS MICROWAVE TECHNOLOGY THE ANSWER?

Conventional grinding as already stated is highly inefficient. Industry estimates of peg conventional grinding efficiency at 3-5%, most of the energy is directed towards unprofitable waste. Without screening material before grinding circuits, valuable energy is spent crushing and grinding all input material, no matter its worth. The microwave process allows valuable minerals to be separated from waste material prior to grinding, directing energy where it matters most. It also creates microfractures in the ore, reducing the energy needed for future grinding.

HOW DOES THIS MICROWAVE PROCESS WORK?

This microwave system applies a short blast of highpowered microwaves at the beginning of the comminution circuit. Since ores are made up of various minerals which heat at different rates in response to microwaves, the differential heating leads to cracking along mineral grain boundaries. This selectively liberates the valuable minerals from the waste.

The waste is then removed from the comminution circuit so that only the valuable mineral ore remains in the circuit for processing.

By effectively removing the waste material and creating microfractures in the valuable ore, it is claimed energy savings of up to 70%.can be obtained.

CONCLUSION

With pressures to improve energy efficiency in mining, reducing energy usage in comminution has become the focus of innovation involving several companies. Several advances have been made however the uptake of innovations and technologies is slow. A Technology Readiness Level guide has been developed for other industries that may be a useful tool for the mining industry. Examination of selected successful energy efficient technologies provides some insights and lessons that may provide direction for advancing new technologies.



thyssenkrupp's HPGR Pro series features rotating side plates for 20% increase in throughput while reducing the energy consumption by 15%, controlled mechanical skew limitation for greater safety, oil lubrication for increased availability, laser based stud detection system for higher operational transparency and reliability, data analytics for continual optimization, compact design for optimised footprint. All HPGR pro features can be retrofitted to existing HPGRs.

REAL INNOVATIONS

"The introduction of rotating side plates on thyssenkrupp HPGRs has turned out to be a real innovation. The use of rotating side plates offers 20 % higher equipment capacity at nearly the same capex. Energy consumption and wear cost are reduced by 15 %. The newly development skew limiter ensures maximum grinding efficiency and provides full mechanical protection against excessive skewing," said Frank Schroers, Product Manager/HPGR. "Rotating side plates can be used on new HPGRs but can also easily retrofitted on existing thyssenkrupp HPGRs," Schroers added.

DIGITAL FEATURES ON THE HPGR PRO SERIES

thyssenkrupp has implemented digital features on their HPGR Pro series to exceed these lifetimes and contribute to better usage of resources.

- The laser-based stud detection system allows the operator to monitor the wear surface during operation and schedule wear surface maintenance only if needed. This makes the operation 'smarter; and reduces costs as well as the risk of unscheduled downtimes.
- The AMPS (advanced machine protection system) uses digitalization to accomplish the concept of predictive maintenance and optimised operation of the machine. The fast and accurate sensor technology in the proprietary AMPS enables process and machine data to be collected much more precisely. The system also detects critical operating conditions early enough for the required adjustments to be made – all with the goal of optimizing processing technology and achieving troublefree HPGR operation with lower production costs.

HPGR'S CO., EMISSION REDUCTION BENEFITS

Up to now, a reduced carbon footprint was mainly perceived due to the fact that HPGRs are more energy-efficient than SABC circuits – and lower energy consumption naturally means fewer CO_2 emissions. "However, another advantage of the HPGR Pro is that it enables a significant reduction



thyssenkrupp Mining Technologies considers itself a frontrunner in introducing new comminution technologies into the mining sector, with a host of innovations gaining acceptance and traction across the industry. As the market leader for HPGRs in the mining industry for over 40 years, thyssenkrupp has over 150 installations worldwide with the majority in hard-rock applications. In in the last six months, alone, clients have ordered 15 new large HPGRs.

"It was quite a journey to get acceptance for the HPGR as a more sustainable alternative to conventional solutions in terms of process efficiency, product quality, energy consumption and wear part consumption," explained Jürgen Remmers, Head of Product Line Grinding. The key to a successful HPGR industry introduction was to bring the wear surface of the roll tires to industrial maturity. In hard-rock applications, lifetimes above 12,000-15,000 hours are generally achieved.

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thyssenkrupp installed twelve HPGRs at Cerro Verde.

in equivalent CO₂ emissions as a result of the elimination of the embodied energy linked to grinding media and steel liner consumption in SAG mills," Schroers explained. The specific energy in SAG mills can vary between 4 kWh/t and 12 kWh/t in gold or copper plants, which means around 50% fluctuations in throughput, according to Remmers. The specific energy for tertiary crushing with HPGRs, however, is only around 2.6 kWh/t and does not typically vary by more than around 0.3 kWh/t in similar applications. "Beside the classical HPGR/ball mill flowsheets, HPGR finish grinding circuits without the use of ball mills – in dry grinding as well as wet grinding – are expected," he said. "Furthermore, the combination of HPGRs and vertical mills could be seen in the main material stream in addition to being used without ball mills."



Vertical-helix stirred media mill.

MINERAL COMMINUTION



HPGR Pro Stud-Detection-System.



HPGR_Pro rotating side plates.

VERTICAL MILLS

thyssenkrupp Mining Technologies recently received its first order for four of its velix® vertical-helix stirred media mills for a large iron ore project in Uzbekistan. velix® is an efficient solution for the fine grinding stage in the main material stream of large concentrators, according to Stephan Vilbusch, Product Manager for velix[®], explaining that the mills consume up to 50% less energy than a conventional solution with a ball mill. velix[®] is the result of a long cooperation agreement with Germany-based Eirich, combining Eirich's many years of expertise in vertical milling with the Tower Mill and thyssenkrupp's expertise on large and innovative comminution equipment, Vilbusch mentioned. "Eirich products range up to their ETM 2000 HP, while our product range covers velix 3500, 4500 and 6000," he said. According to Vilbusch the four ordered velix 3500++I include 4200 HP VSD drives which allows to operate the machines sustainably at optimum operating points in terms of production, energy

consumption and steel consumption. "Being proud to have successfully introduced the velix[®] into the market, we see also the benefit of our SAG and Ball mill shell-supported design for savings in Capex and Opex proven in over 300 references in the mining industry," said Remmers.

SHELL-SUPPORTED SAG AND BALL MILLS

Christian Haegele, product manager/ SAG & Ball mills, pointed out that thyssenkrupp Mining Technologies focuses on shell-supported mills based on the significant process advantages that this type of mill provides, such as higher levels of ball charge and greater

flexibility regarding inlet and outlet openings, which better meets process demands. "These higher ball charge levels (up to 38%) allow for more efficient use of mill volumes. Outlet openings are customizable and can be designed in many different ways, including open-end discharge (OED) arrangements," Haegele added.

According to Haegele, a large percentage of the mining industry still prefers the conventional mill design obviously due to the greater familiarity in this industry. As a result, many projects fail to seize the 15% to 20% savings in infrastructure costs stemming from the reduction in building footprint. Not only is there a design difference between shell- and trunnion-supported mills but also a difference in the footprint, which provides advantages for greenfield installations and more so for brownfield upgrades. In an exemplary application, an old trunnion-supported mill was replaced by a shell-supported mill as the client wanted to increase the capacity of the plant. It was possible to use the same space and supply the client with a mill of 20% more volume, that results in a 20% higher throughput.



International Fair EXPO KATOWICE (MTGPEiH) Katowice Mining Expo

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EUROPEAN START-UP DATE

Katowice, Poland 6-9 September 2022

The International EXPO KATOWICE (MTGPEiH) Fair is a meeting place for business and science. The energy and electricity industry has an excellent space to present innovative devices and technologies. An international fair is a great opportunity to establish cooperation between service providers, concerns, including the largest energy concerns, specialists, design offices, and end recipients. The event is also accompanied by B2B meetings and conferences with leading representatives of the power sector, competitions for young engineers and scientific seminars. We listen and adapt to create "the perfect atmosphere for meetings to talk about the direction of development of this strategic industry".



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Managing several stages of waste

The important issues on disposal of solid wastes from many mines is to choose the right varieties for the comprehensive utilization of mining waste and to control contamination from waste rocks and tailings. Environment friendly disposal of solid wastes from mines is the key pathway. It's no secret that mining can produce a lot of waste. This is evident by catching a glimpse of any mining operation and the scale at which they operate. In fact, in most cases, you'll likely only notice the actual mine waste because the majority of the actual operation is occurring underground. Mine wastes can be problematic due to the fact they contain hazardous material that can be released into the environment if not properly handled. Some of these hazardous materials include heavy metals, metalloids, radioactive waste, acidic water, and process chemicals.

ome of the extremely major problems and key challenges facing the contemporary world are shortage of resources and our ever-growing population and environmental pollution. With the development of the mining industry, mining exploitation activities have produced more and more solid wastes and induced increasingly grievous destruction on the environment. Waste rock, tailings and other solid waste are the largest industrial solid waste generated in the process of exploitation of mineral resources. A comprehensive utilization of solid waste from mines to compensate resources shortage and environmental protection will have enormous economic and social benefits.

Open pit mining has several stages of waste. First, to access the actual seams or veins of ore, the top layers of rock or overburden must be removed. Once the overburden has been removed, the seams can be extracted. When extracting the seams, there is additional waste rock that must be separated from the ore.

Waste rock or overburden refers to the often-large mass of initial soil and rock that is removed to get to the valuable mineral deposits. Typically, for every ton of ore that is mined, 5 tons of overburden is displaced. Overburden is not subjected to any chemical processes but must be removed to access the ore underneath. Overburden is



managed by using it to resurface previously mined areas to revegetate and restore them to their original appearance prior to being mined.

GANGUE

Gangue is the worthless rock or material that is closely mixed with the valuable material to be processed. The separation of minerals from gangue is called mineral processing. More Occasionally, inefficient processing methods can produce gangue that still holds an ample amount of valuable minerals. As values of minerals increase, it can even be profitable to reprocess gangue to extract additional minerals that may have been missed during the first processing.

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Tailings are finely ground rocks and other mineral waste as a result of mineral processing. Due to the way minerals are processed, tailings can contain concentrations of processing chemicals. This can make mine tailings an environmental concern, so proper transportation and disposal are crucial. Consequently, the next step is to pump mine tailings away with slurry pumps into tailings ponds. Tailings ponds are sedimentation holding ponds enclosed by dams and liners to capture and store the waste.

LIQUID MINE WASTE, MINE WATER

Mine water is produced in a few different ways at mine sites and can vary in levels of contamination. Water exposed to mining processes is also often acidic and can contaminate local water sources in a process called acid mine drainage (AMD) or acid rock drainage (ARD). Acid mine drainage is a heavy contributor to pollution of surface water across the globe. AMD is primarily caused when water flows over the sulphide-heavy material, forming an acidic solution. Water at mine sites is usually heavily monitored and

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management strategies are used to not only reduce the amount of mine water produced but also to treat the water before it is released back into the environment.

WATER TREATMENT SLUDGE

Sludge is produced at some mine sites and is similar to mine wastewater but has the additions of solids and processing chemicals. These additions turn the water into a more viscous sludge which can then be pumped away from the site. Since the majority of sludge has little economic value, it's essentially handled as waste. In extreme cases where the sludge is rich in harmful or radioactive material, it may be classified as hazardous waste and require special handling and disposal methods.

Mining is big business, but also one of the world's biggest polluters. A 2019 report estimated that operations produce



MINE TAILINGS, WASTE, AND OVERBURDEN



Shamokin, PA is location of one of 80 mine fires burning across Pennsylvania.

over 100 billion tonnes of solid waste per year. The ratio of useful materials to waste minerals is staggering; waste mass can be several times that of base metals and can be millions of times that of rare elements such as gold.

This waste is of particular concern due to its often-toxic content, with poisonous materials such as mercury a frequent by-product of mining operations. Recent accidents, such as the collapse of a tailings dam at Vale's Brazilian operations near the town of Brumadinho, have also shone a spotlight on existing waste storage and treatment facilities, with growing concern that simply collecting vast reserves of solid and liquid waste is both unprofitable and highly dangerous. As demand for minerals, particularly rare earths, and other uncommon commodities, grows, this problem is set to only increase.

A promising counter to this growing problem is that of waste recovery. Rather than cutting down on waste itself, companies are investing in new industrial processes to extract and re-use some of the useful materials that are often dumped among tonnes of less useful mining waste. With platinum group metals (PGMs), base metals, and even rare commodities such as gold among these unintended by-products of mining, there are a number of initiatives across the mining industry to improve the reclamation of resources and push the sector towards a truly circular economy.

IMPORTANT LESSONS TO BE LEARNED

Drive through North-eastern Pennsylvania and you may see black hills of coal and orange water flowing near or through towns. What you're witnessing is the legacy of historic anthracite coal mining, which fuelled the USA's industrial revolution and two world wars, had extremely dangerous labour practices, and lead to the destruction of its landscape. Diverse hardwood forests filled with wildlife were replaced with black mountains of coal waste with acidic soil that can only support birch trees, briar bushes, and scrub vegetation. Thriving cold-water fisheries were replaced with abandoned mine drainage (AMD), orange water devoid of oxygen and all aquatic life.

While mining issues are gaining national attention since the 2015 Gold King mine spill in Colorado, Pennsylvania sometimes seems like the forgotten state despite having more mining issues than any other state in the nation.

Anthracite mining once fuelled the region's economy, but after coal companies began to go bankrupt, once-thriving towns were left with nothing but devastated land & water and the scattered spines of abandoned coal breakers & mine shafts. Land reclamation projects and AMD treatment systems help to alleviate some of these problems, but these solutions are often expensive. While mining issues are gaining national attention since the 2015 Gold King mine spill in Colorado, Pennsylvania sometimes seems like the forgotten state despite having more mining issues than any other state in the nation. Perhaps it's the fact that our mining heritage is in the past, while many other states continue to have active mineral and hard rock mining, allowing their issues to be more present.

The black hills of coal are more commonly known as culm piles. These piles are created by dumping coal waste, such as rock and shale, after separating it from the valuable anthracite coal. While these piles are large, they represent approximately 50% of what was taken out of the ground, revealing the massive size of mining voids lying beneath Pennsylvania's valleys.

Land reclamation generally involves bringing the land back to a natural contour, adding a layer of topsoil to encourage vegetation, and seeding the land in order to begin the reclamation process.

Land reclamation projects are mostly funded through state and federal grants, with EPA Brownfield Grants and PA Department of Environmental Protection Growing Greener grants allowing non-profits to help recover devastated landscapes. Land reclamation generally involves bringing the land back to a natural contour, adding a layer of topsoil to encourage vegetation, and seeding the land in order to begin the reclamation process. While this process is straight-forward, mining pits can be incredibly steep, making the reclamation process take longer and be more costly.

AMD, or abandoned mine drainage, is another legacy of past mining. AMD flows from mine openings and drilled boreholes to relieve pressure from the underground mine pools. AMD forms when water reacts with pyrite, or 'fool's gold', deep in the underground abandoned mine workings. As pyrite is exposed to water and oxygen, the sulphides within the rock react and break down to form sulfuric acid and iron oxide. Other metals and minerals within the rock can also become exposed and pollute the water, with many discharges in PA and other states containing heavy metals such as iron and aluminium, and some discharges containing trace amounts of harmful metals such as lead and arsenic.

To put this into perspective, many mines were 500-1000 feet deep, with some mine shafts reaching approximately 2000 feet in depth. Like digging a hole in the sand at the beach, at a certain point water will keep filling the hole no matter how much you try to keep it out. It's the same with mine water. Once mining companies hit the water table, they would always have to pump water out of the mines, continually increasing the cost to produce anthracite coal. After all of the coal companies went bankrupt, along with



Iron oxide swirls in a polluted stream. The iron removes most oxygen from the water and makes it impossible for most plants, fish, and insects to live in the water. AMD throughout NEPA is essentially rust and can be processed into a safe art pigment.

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historic events such as the Knox Mine Disaster in 1959 and the Historic Agnes Flood of 1972, deep mining ended in most parts of the Coal Region.

By the Agnes Flood of 1972 in which the Susguehanna River rose 40 feet and devastated the Wyoming Valley, most mining companies had claimed bankruptcy and as the pumps removing water were shut off, mine water began to spill out of any available opening leaving streets, basements, and streams filled with polluted mine water. Furthermore, because mining companies were not required to treat abandoned mine drainage or reclaim mining land, once a company went bankrupt, the burden fell on taxpayers and government organizations to clean up the mess. Present-day active companies are required to reclaim land and treat any AMD discharges caused by their mining.

In Pennsylvania, AMD occurs in the Anthracite Region in the Northeast and the Bituminous Region in Western PA. In the Northern Anthracite fields, most AMD discharges have heavy concentrations of iron with relatively neutral pH's around 6.5, the same pH as normal rainfall. In the Middle & Southern Fields and the Bituminous Region, discharges tend to be more acidic (4 pH) with heavy concentrations of aluminium. Treatment systems help remove AMD and restore water quality. There are 2 types of treatment, active and passive. Active treatment refers to the use of added components such as chemicals (limestone) and machinery (oxygenation machines and automatic chemical dozers) to treat AMD.

Overall, treatment systems are expensive to install and even after successful installation, long-term upkeep can become difficult to fund and maintain.

In general, active systems are more costly and require electricity and regular maintenance to remain efficient.

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Passive treatment refers to the use of natural settling in large ponds for oxygenation as well as natural growth of wetland plants to treat AMD. Passive methods include settling ponds and using gravity to move water through a treatment system. These systems are usually more cost effective and don't have many long-term maintenance or operation costs. Overall, treatment systems are expensive to install and even after successful installation, long-term upkeep can become difficult to fund and maintain.

While this pollution problem will take a lot of effort to remediate, dedicated watershed associations, local conservation districts, and environmental non-profits are working to fix this problem by installing treatment systems, restoring streams, and educating the public about this issue through community events such as illegal dump clean-ups on mine lands and environmental education projects with community organizations and local school districts.

Pennsylvania's legacy of abandoned mine lands and AMD have implications nationally as well as globally. While clean energy is an important goal to achieve in order to help move towards a new era of environmental stewardship, coal mining communities need to be supported in the form of mine land and AMD clean-ups as well as economic stimulation in order to successfully move towards a better future.

Pennsylvania's mine land issues are a vast, far-reaching, and expensive problem. The effect can be seen nationwide, with other coal states such as Wyoming, Kentucky, West Virginia, and Illinois facing the same issues. Hardrock mining states also face similar issues, as seen with the Gold King Mine disaster in Colorado. Globally, countries like China, India, and Australia are just beginning to produce mass amounts of coal. Pennsylvania's legacy of abandoned mine lands and AMD have implications nationally as well as globally. While clean energy is an important goal to achieve in order to help move towards a new era of environmental stewardship, coal mining communities need to be supported in the form of mine land and AMD clean-ups as well as economic stimulation in order to successfully move towards a better future. Pennsylvania's struggles can serve as an example for other communities throughout the United States and developing industrial countries.

MINEWORX MOVES TO PILOT PLANT

Canada-based Mineworx has been involved in the mining industry for some time, having entered into the sector in 1975 with the acquisition of the Cehegín iron ore project in Spain, which produced four million tonnes of ore in its first fourteen years of operation. Since then, the company has moved into the development of more advanced technologies, aiming to increase the environmental viability of both its operations in particular and mining in general. The business reached a major milestone recently, when it announced an agreement with Tennessee's Davis Recycling Inc. to construct a pilot plant; the operation will see platinum group metals (PGMs) recycled from used catalytic converters.

The project will see the miner enter into a PGM recovery business that it values at around \$30bn annually, and the move is a critical step in demonstrating the efficacy of the technology, which builds on the work of another partner, EnviroLeach. This third company has developed a waterbased process to extract PGMs from catalytic converters,

with up to 90% of the precious metals being recovered. The process removes the need for harmful substances, such as cyanide, to be used in the extraction process, which have been an industry standard but pose significant risks to human health and environmental safety.

This collaborative approach could help share information that could be beneficial across the mining industry, a sector which could see an increased demand for innovative waste treatment in the future. EnviroLeach notes that global electronic waste is predicted to increase to 78 million tonnes by 2026 as electronic devices become more widespread, and demand for gadgets increases.

COMSTOCK TARGETS MERCURY REMOVAL

Another mining company targeting a particular mineral is Comstock Mining, a Nevada-based miner that aims to improve the recovery and removal of mercury from mine tailings. The poisonous metal has long been a source of public health concerns in both artisanal mining and largescale operations. A 2018 report found that over 1,000 tonnes of mercury was produced in the artisanal gold mining sector, due to the metal's use in separating gold from non-precious ores. Notably, the waste that flooded the town of Brumadinho in the infamous Vale tailings dam collapse was found to contain dangerous quantities of mercury, arsenic, and manganese.

Considering these dangers, and the widespread nature of mercury in the mining industry, Comstock's work could prove beneficial for miners across the sector. The miner owns the Comstock Lode, a gold and silver deposit that was first mined in the mid-19th century and saw almost \$4m in investment from the company in 2018. The company plans to use this deposit to test a pilot mercury clean-up operation, backed by technology firms Mercury Cleanup and Oro Industries.

The joint venture will see the construction of a two ton per hour pilot plant to treat the 15 million pounds of poisonous mercury that have been produced over the course of the Comstock Lode's mining life, and a successful operation could demonstrate a way forward for a mining industry that still struggles with mercury production.

VTT'S COLLABORATIVE PROJECT

Many of these mine waste projects are collaborative in nature, and this is especially true for VTT's MetGrow+ project, a collaboration with 19 companies, research organisations, and universities from nine European companies. The project was a four-year, \$8.7m initiative to find ways to improve recovery of a number of waste minerals, such as cobalt, nickel and zinc, and improve Europe's self-sufficiency with regard to metal production.

The project focused more on supply chain optimisation than technological innovation, and VTT reports that miners could see waste mineral recovery increased by up to 20% by following the initiative's recommendations.

A key challenge for the project was developing a robust framework that could be applied to the mining industries of several European countries, each with a different balance of mineral exports and imports. The researchers overcame this by developing the "MetGrow Calculator", an online tool that works out the optimal waste recovery process for a mine or region based on characteristic input by the

user. VTT claims this system can consider factors such as local access to mineral reserves and will recommend an appropriate waste management system.

In addition to supply chain optimisation, the researchers completed work into the best uses for residual material from which metals have already been recovered. VTT noted that many recovered materials can be repurposed for use in building by being reworked into concrete, highlighting the project's broad scope and attempts to improve efficiency across the breadth of the mining and construction industries. Scandium International seeks industry support.

A project at an earlier stage of development, and one seeking, rather than benefitting from, industry support, is Scandium International's ion exchange project. The initiative will use ion exchange technology, a process usually used in the purification of drinking water, where ions are moved between two electrolytes to separate a compound into its component parts.

Scandium International expects to extract cobalt, nickel, and copper from mining waste. The miner also noted that the technology could be used to extract other minerals, such as rare earth elements, but that this would depend on the financial viability of the process itself.

This need to demonstrate technological and economic viability is a key challenge for Scandium International, and it has put out a call for copper miners and processors to sign up for involvement in the project. The miner seeks a partner with a functional copper plant, which can be used to demonstrate the efficacy of the technology on a demonstration scale, before being scaled up to larger productions, or expanded to include other resources.

Scandium International is particularly reliant on this external support considering its own limited mining resources. The company has just completed a feasibility study on its Nyngan scandium mine in New South Wales, Australia, and is a firm with big ideas and significant belief in new technologies, but perhaps lacks the material facilities to put many of these ideas into practice.

MINT INNOVATION'S "BIO-REFINERIES"

Moving from theory to practice is a similar challenge faced by Mint Innovation, a New Zealand technology start-up that uses microorganisms to recover metal from waste streams. The technology is unlike anything else in the mining sector, with the company envisioning a "bio-refinery" to recover gold from waste in a two-stage process. First, a traditional leaching process removes base metals such as iron and copper from electronic waste, before a patented acidic compound is applied to the waste, strong enough to dissolve gold that is then absorbed by microbes in the compound.

While gold is Mint's first objective, the technology has uses across the mining industry, with the microbes able to absorb palladium, platinum, and rhodium with minimal chemical alterations. The start-up is also bullish about the scalability of its solution, relying on a business model where local recyclers help collect electronic waste and aid in distributing the recycled materials, potentially enabling the company to build its bio-refineries in any city with significant electronic waste with minimal up-front costs.

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While the technology needs further development, namely in finding a way to recycle the chemicals used in the goldabsorbing compound, and the start-up is still in search of a financial backer to help realise its lofty ambitions, Mint's work is an example of innovative and technologically driven solutions to a sector that is still struggling to clean up its waste management.

As the mining industry uses large volumes of water under greater environmental scrutiny, operators are finding innovative ways to strain, treat, and reuse water that accumulates in pits, sumps, and wash bays more efficiently.

In the industry, heavy equipment wash downs are a major source of water use. Wash processes are used to clean mud, clay, and other corrosives off mining machinery, trucks, and other heavy-duty equipment. The wastewater is typically collected in a service bay or sump and must be sufficiently strained and treated before reuse.

When rainwater washes over equipment and open pit mine sites, it can also generate water mixed with dirt and sediment that is typically collected in a large sump or pit nearby. In underground mines, groundwater infiltration and condensation can cause a similar effect to that of rain. No matter how the water is generated, any dirt and debris must be removed before it can be used, further treated, recycled, or discarded. Due to the volume of water used,

the mining industry is increasingly seeking new ways to reuse water through more efficient filtration, treatment, and recycling efforts.

Toward this end, the mining industry is finding that automated scraper strainers are one of the simplest, most cost-effective methods to remove both micron-



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sized particles and oversized dirt and debris. This is helping to streamline water straining for immediate reuse. It also provides a critical first step in multi-step water treatment systems that can reduce clogging, fouling, and maintenance while increasing production.

One example is the automatic scraper strainer from Acme Engineering, a North American manufacturer of industrial self-cleaning strainers. The motorised unit is designed to continually remove both very large and very small (100 micron) suspended solids from water that can accumulate in a mine, pit, or sump. Cleaning is accomplished by a spring-loaded blade and brush system, managed by fully automatic controls.

Four scraper brushes rotate at 8 RPM, resulting in a cleaning rate of 32 strokes per minute. The scraper brushes get into wedge-wire slots and dislodge resistant particulates and solids. This approach enables the scraper strainers to resist clogging and fouling when faced with large and high solids concentration. It ensures a complete cleaning.

Blowdown occurs only at the end of the intermittent scraping cycle when a valve is opened for a few seconds to remove solids from the collector area. Liquid loss is well below 1% of total flow.

The technology is even being used to filter and reuse water from a virtually unused resource – accumulated water at the bottom of mines, which until now has mostly been an impediment to efficient production. "Automated scraper strainers are being used to remove rocks and suspended solids from the water that usually collects at the bottom of mines. The filtered water is then pumped back to the surface for continual reuse," says Robert Presser, Vice President of Acme Engineering, an ISO 9001:2015 certified manufacturer of environmental controls and systems with integrated mechanical, electrical and electronic capabilities.

According to Presser, to increase reliability in rugged mining conditions, the industry is using the automatic scraper strainer in an innovative way with an eductor, a type of pump that does not require any moving parts.

"Mine operators are using an eductor at the bottom of the strainer to pressurise the blow down line to send the evacuated solids [from the strainer] relatively far away. Since the eductor has no moving parts, operators don't have to worry about small bits of rock and particles damaging an impeller like they would on a typical pump," explains Presser. He adds that operators must use a ³/₄-inch low flow water line at about 75 PSI to inject motive water into the eductor to move the solids down the blowdown line.

As mining operators seek to comply with environmental standards and do more with less, those that take advantage of advanced strainers to reuse their existing water most efficiently will cost effectively achieve both these aims while improving their process.

The heart of the mine.

The lifeblood of your mine relies on the healthiest of hearts. GEHO pumps all day every day. Supported by Synertrex[®] real time performance data and unrivalled aftermarket service from the Weir Minerals global network, GEHO[®] positive displacement pumps have been trusted across the globe for over 100 years. With up to 98% availability and outstanding efficiency that could cut your energy usage & carbon emissions by up to 50% and reduce water consumption by up to 30%, GEHO[®] pumps are simply unbeatable.







Automatic Iubrication

he discussion in the industrial maintenance world today is predominantly focused on plant and equipment reliability. The real meaning of equipment reliability is often hidden behind other terms like World Class Maintenance, Asset Efficiency, Proactive Maintenance, Predictive Maintenance, Lubrication Management, Lean Manufacturing, TPM and even 5S (Sorting, Straightening, Systematic cleaning, Standardizing, and Sustaining). However, irrespective of what companies choose to call it, they all have fundamentally the same objective.

"Equipment reliability is a maintenance strategy or culture which, when implemented successfully, will assist in reducing maintenance costs, improving equipment uptime and lowering the overall costs of production."

A key contributor to a mine's productivity is its heavy mining equipment. To keep all components of mining machinery running optimally throughout their complete lifetime, automatic lubrication is essential. It cuts the cost of maintenance, repair, supplies and downtime and increases equipment reliability and availability.

In mining, heavy-duty and high-temperature lubricants, hydraulic fluids and multifunctional oils have to resist

high mechanical and thermal loads as well as the rough ambient conditions. The industry is continuously seeking improved lubricant solutions to each part of its operational requirement, specifically because it has a direct bearing on the wear and tear of the equipment, which in-turn impact the life-span which impacts the profit margins. Apart from economic benefits, lubricants need to comply with special standards and safety regulations combined with ecofriendly considerations.

Reliable and cost-efficient lubrication under extreme conditions requires not only the use of high-performance lubricants, but also expert knowledge with regard to their appropriate application. Lubricant manufacturers have continued to improve their products to meet the needs of bigger, faster machines. Although most lubricant suppliers are not lubrication system specialists, many have the resources to provide technical support, offering sound advice for selecting the products best-suited for the applications.

The products commonly used in mining equipment can be divided into three groups: heavy-duty lubricating oils, such as EP oils for enclosed gear drives; multipurpose engine, circulating and hydraulic oils for engine, bearing lubrication and fluid power; and general purpose grease, for normal industrial bearing applications and specialised mining products. Walking draglines may require lubricants for the very large plain bearings that support the entire frame of the unit as it moves through the walking process.

These lubricants may have a high concentration of lubricating solids or soft metals dispersed into a stiff grease and delivered in small bags (for the walking mechanism without an automatic delivery system) just ahead of the peak loading area. This grease is referred to as a Walking Cam lubricant.

An effort to reduce the number of lubricants on a machine has driven the development of multipurpose products designed to meet several different applications from a single lubrication system. The various components to be lubricated may include the open gears, guide rails, main table bearings and various smaller slides and bearings.

This presents a variety of challenges to tackle with one or two products. Specialty product manufacturers strive to meet the wide range of challenges with a single product.

More recently, independent lubrication service consultants are becoming a viable alternative to the industry. Utilizing an independent consultant offers a mine the ability to purchase the product of choice based strictly on quality and product cost, but without any possible hidden costs of product-service combinations or cost-per-hour contracts.

The operators purchase the lube products for the equipment based on equipment criteria and purchase the service of a consultant based on experience and costs. This platform is a unique and upfront approach to product-service combinations. When considering an independent lubrication service consultant, check the individual's references supporting his/her abilities and knowledge.



The key to increase equipment reliability is effective and clean average lubrication film thickness.

As the industry continues to evolve, expect to see continued evolution in all aspects of the industry and allied fields. With global positioning satellites (GPS) offering the potential for remotely operated equipment, computer systems taking lubrication systems to new levels of control, manufacturers continuing to meet the demands of an ever-changing and competitive industry, one thing should always remain the same.

When it comes to the development and application of lubricating products, providing the cleanest possible environment, storing the products properly, reducing rehandling and applying the right product – in the right amount, in the right place, at the right time – will always be the necessary criteria, no matter how many times these practices are reinvented.

Many companies set out on the pathway to achieve an ideal conceptual definition(s) and invest in people and technologies as their defined processes require, however the lubrication component of the strategy, is more often than not, low on the appreciation scale and consequently their efforts do not always meet the expectations.

Our experience shows that companies at World Class or Best in Class levels, focus at great length on the management of their lubrication activities, because they understand the effect lubrication has on equipment life.

WHAT IS LUBRICATION RELIABILITY?

All investigations conducted today on why bearings fail, will reveal the alarming fact that over 60% of the damages are lubrication- related. The bearing is the rotating core of the machine and if we can reduce the lube-related failures we will directly improve the equipment reliability, not to mention the resulting reduction in bearing consumption.

LUBRICATION

Bearings and other rotating components need a good lube film thickness to separate the metal components and to reduce wear. However, generating a good film thickness is a chemically complex mechanism which is dependant on many factors, such as degradation of the lube, contamination in the lube, effective replenishment of the lube and no mixing of lubes.

So when the lubrication works in a *reliable way*, the equipment reliability will improve, meaning that a *Lubrication Reliability strategy* is all about ensuring that effective machine lubrication occurs within the machine resulting in reduced wear and failures.

IT IS ALL ABOUT LUBE FILM!

It is imperative to discuss what causes wear and equipment breakdowns. SKF has stated that, *"bearings can have an infinite life when particles larger than the lubricant film are removed"*, meaning that removal of abrasive particles will prevent bearing wear.

In a bearing with a good average lubrication film thickness, the metal surfaces are separated. The average thickness of this separation or film is very small, about one twentieth of the thickness of a human hair (**Figure 2**).

The analogy is that when a 50-micron particle of hard contaminate goes through the bearing, it is like driving your car over a 1 meter diameter boulder. When there



Lubrication film thickness is 1/20 of the thickness of human hair).



Filter ratings vs. cycles to fatigue failure. Ref Dr. D. P. MacPhearson of Westland Helicopters Ltd.

are hard contaminants in the oil and they are greater in size than average lube film, then three-part abrasive wear starts to happen. This then leads to surface indentation and scratching, which is a process that can lead to bearing or component failure.

A good average lubrication film thickness in a machine or component is the result of a lubricant operating with an effective viscosity. Assuming that the right lubricant viscosity has been selected in the first case, then if the oil is kept clean (meaning that there is a very low level of abrasive particles in it and there is no degrading of the chemical composition of the oil), then the lubrication will do the job, which is to provide an average lubrication film thickness that will separate the metal components and eliminate or reduce wear.

Viscosity changes are the result of oil degradation, contamination or both. Oxidation is one of the main causes of a viscosity change as it will initially cause an increase of viscosity, and as the oxidation increases the viscosity will then begin to decrease to a dangerous level. The decrease of a lubricants viscosity is the most dangerous effect to any components reliability as it can lead to the breakup of the lubricating film generation process and increase the wear potential.

The objective of this article is not to understand the chemistry of all the factors that affect the lubricants ability to do its job, as that is a whole discussion of its own, but more about how to understand what we must do to manage or maintain a good operating lubrication viscosity. Below are five key points to consider in the efforts to use lubrication reliability as a strategy to improve equipment reliability:

- 1. The lubricant film is what ensures the separation of metal surfaces, thereby preventing wear and reducing friction.
- 2. When the oil is contaminated with hard particles greater in diameter than the average lube film thickness, then three part abrasive wear will occur, also leading to wear and increases in friction.
- 3. Chemical changes of the lubricant will also affect the viscosity of the lubricant.
- There should be processes in place to ensure that a low level of contamination is present in the operating lubricant.
- There should be processes in place to know when chemical changes are happening to the lubricant in operation.

LUBRICATION CHALLENGES

Each piece of mining equipment made by different original equipment manufacturers (OEMs) has its specific lubrication requirements. OEMs define the minimum requirements for lubricants or greases, but not all products that meet these standards deliver the same level of performance.

Choosing the correct lubricant or grease often depends on a combination of the equipment's design characteristics, operational parameters and environment. Factors like temperature, humidity and location (altitude/underground) all pose different challenges for lubrication. Below are three of the primary lubricant applications in the mining industry, along with some examples of specific lubrication challenges. In all cases, selecting the right lubricant is a critical first step in improving productivity and realising significant savings. Effective engine lubrication is critical to protect high-cost equipment, and minimise downtime due to frequent oil changes, maintenance or even component failures.

VISCOSITY CONTROL IN EXTREME CONDITIONS:

Engine wear as a result of metal-to-metal contact can occur at low speeds, high loads, or cold starts. The lubricant helps keep moving parts separated to avoid wear. At engine start-up, particularly in cold climates, the oil must remain thin enough to circulate quickly to protect critical components. Once the engine is operating under full load, the oil needs to remain thick enough and provide the necessary protection to help prevent abrasive wear.

In gear motors, the lubricant must help improve bearing life and give excellent protection against wear and pitting. Transmission oil helps keep moving components apart, such as gear teeth and rolling elements, thereby avoiding metalto-metal contact and wear. Selecting a product that has the optimal viscosity for the application, along with the required additives to protect against wear and corrosion can have a major impact on equipment life. Viscosity and shear stability are also critical for performance at a range of temperatures.

SOOT GENERATION:

Accumulation of soot in the engine can lead to oil thickening and abrasive wear. This is a particular challenge in underground mines, at high altitude, and when exhaust gas recirculation (EGR) is applied as an after-treatment system. Extended periods operating at idle load makes an engine susceptible to higher rates of soot generation.

CORROSION PROTECTION:

Gases and acids are generated as a natural by-product of the combustion process. The lubricant neutralises these acids to help avoid corrosion. This is particularly important in engines with Babbit-based plain bearings, which can be very susceptible to acid attack.

LONG OIL LIFE:

Oxidation, soot accumulation and oil thickening, and the build-up of acids in the lubricant all contribute to oil aging. High quality synthetic engine oils with the right base oil and additive technology -including anti-oxidant



additives -can maintain performance characteristics for longer time in the presence of contaminants and byproducts. Oxidation stability and corrosion protection are also important to maintain oil performance. High quality transmission and gear oils with good oxidation resistance can resist degradation and break-down over time, thereby reducing downtime required for frequent oil changes

FRICTION CHARACTERISTICS

Powershift transmissions use a series of friction plates to help engage and disengage gears. The lubricant plays a critical role in transmitting frictional force, so its frictional properties are important for effective operation. Too little friction, and the plates can slip making gear changes difficult. Too much friction and excess heat generation can cause damage to equipment and shortened lubricant life.

Lubrication by Grease application in the mining sector can be a specialist technical area, where selecting the right grease for the right application can be critical to avoid costly equipment failures and unplanned downtime. This is particularly true for open gear applications, which are exposed to the elements in extreme conditions, and where contamination poses a significant challenge.

WEAR PROTECTION IN SEVERE OPERATING CONDITIONS

Temperatures

As open gears are exposed in all climatic conditions, the grease's viscosity and pumpability is critical. In extreme cold, it must remain fluid enough to flow through grease lines to protect components, while in extreme heat it must remain thick and adhesive enough to stay on equipment surfaces.

Contamination

Contamination ingress is the direct cause of about 40% of open gear failure. Exposure to high levels of dust, dirt, slurry, rain and snow means open gears require greases that can maintain an adequate lubricant film and continue to flow while flushing out contamination.

Pressure and shock

In differential gears, specific contact pressures can be so high that the transmission oil is squeezed away, allowing

Grease Type	Base Oil Viscodity (40°C)	Speed Fator (NDM)
Slow-speed, high-pressure, industrial grease	1,000- 1,500 cSt	50,000
Medium-speed,high- pressure, industrial bearing grease	400-500	200,000
EP, NLGI #2, multi-purpose grease	100-220	100,000- 200,000
High-speed, high- temperature, ling-life greate	<70	600,000
High-speed, long-life grease	15-32	>1,000,000

LUBRICATION

metal-to-metal contact. The use of extreme pressure additives helps prevent the contact areas of the teeth micro-welding together.

To help keep equipment operating at maximum efficiency, greases must be specially formulated to withstand the high load, extreme pressure, and shock-loading faced by mining machinery on a daily basis. Application – Misapplication is the cause of around 40% of open gear failure. Even a perfect lubricant cannot protect equipment if it is not applied in the right volume at the right time. Lubrication systems must be maintained and fine-tuned to ensure correct application happens.

Misalignment

Two perfectly aligned gears have a contact ratio of 100%. If misalignment causes the contact ratio to drop below 85%, the load and stress on the gearing will increase. This overloads the gears and the lubricant film and can result in sub-surface cracks and pitting, which significantly reduces component life and may result in gear failure.

The Modern Art of Lubricating Mining Equipment







From this primitive beginning, mining tools have evolved into massive machines. Rock drills, front-end loaders, electric cable and hydraulic shovels – some boasting bucket sizes in excess of 50 yards – and mammoth trucks and draglines, such as the Bucyrus International, Inc. 2570WS, have introduced unprecedented levels of productivity for equipment owners and unprecedented challenges for the maintenance staffs.

Greatly increased component sizes and load limits have placed tremendous responsibility on the machinery designer and the lubricant system manufacturer, to design and engineer systems that can be counted on to effectively lubricate and sustain these machines.

These machines are often as large as houses, with some booms extending nearly 300 feet. Depending on the type of machine, whether it is a shovel or a dragline or a drill, the machine's key components may be either electrohydraulic or electromechanical.

For instance, the P&H 4100XPB shovel is driven solely by electric motors (no diesel engines) to turn the cab and operate the lift, while the Komatsu Demag Model H655S employs state-of-the-art electrohydraulic systems.

Some draglines have huge hydraulic systems and electrically driven gears, with sump capacities into the thousands of gallons. The rolling stock, including bulldozers and large haul trucks, are powered by diesel engines. Many of the loading and hauling equipment designs incorporate hydraulic systems powered by diesel generators.

As one might expect, effective lubrication of these heavily loaded components is absolutely critical to efficient, reliable, economical operation of a mine site. As the machines have grown in size and sophistication, the manufacturers of lubricant products and delivery systems have had to work equally hard to match the new requirements.

There are two equally important aspects of lubrication effectiveness in the strip mine: the delivery system and the lubricant.

LUBRICATION SYSTEMS

Lubrication distribution systems have improved greatly over the years. Reasonable facsimile of what would have been used on the Bucyrus 24 dragline in the early 1900s. The lower funnel-shaped half of the unit would be threaded into a port in the bearing housing. The upper cylindershaped half would be full of multipurpose grease (MPG).

Turning the upper cylinder clockwise would lower the cylinder onto the funnel-shaped portion, forcing (extruding) the lubricant stored in the reservoir of the cylinder portion through the funnel into the bearing.

The lube tech would make routine lubrication checks throughout the machine. As required, these lubricators would be turned to ensure the lubricated components received adequate replenishment while in use.

THE LUBE SYSTEMS OF TODAY

Today's centralised lubrication systems factory-installed on mining machinery have greatly minimised the need for lube techs in most cases. These computerised systems are now capable of dispensing the right product, in the right amount, to the right point, and at the right time.



There are a number of centralised lubrication system manufacturers that offer a wide range of system types and designs to meet the needs of practically any mining application.

Most lubrication systems consist of a grease pump, a motor to drive that pump and some sort of injector or valve to control or measure lubricant volume. Most utilise a programmable logic controller (PLC) to program the frequency of the lubrication replenishment cycle. As sophisticated as some of these systems are, maintenance and proper set-up is essential to ensure that their benefits are realised.

UPGRADING

With the advancements in centralised lubrication systems, serious consideration should be taken when selecting a system or upgrading an existing system. Although the system's operation is generally quite simple and effective, performance limitations can have detrimental effects to lubricated components, such as the impact of changing lubricant viscosity.

If a lubrication system is modified to accommodate more lube points or there is a need to change a lubricant product, it is strongly recommended that both the system manufacturer and lubricant manufacturer be consulted before such changes are made.

LUBRICANTS

Lubricant manufacturers have continued to improve their products to meet the needs of bigger, faster machines. Although most lubricant suppliers are not lubrication system specialists, many have the resources to provide technical support, offering sound advice for selecting the products best-suited for the applications.

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LUBRICATION



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This presents a variety of challenges to tackle with one or two products. Specialty product manufacturers strive to meet the wide range of challenges with a single product.

Despite the large volumes involved in filling a dragline during a lubricant change, given the product sophistication, some of these products may cost as much as \$2.50 per pound. Management of the lubricant consumption to control costs becomes an integral part of the sourcing process.

LUBRICANT MANAGEMENT - SUPPLY AND DELIVERY

Vendors offer various options for purchase and delivery of these products, ranging from simply purchasing and managing the distribution of lubricants throughout the mine site, to programs offering on-board delivery, lubrication system set-up and long-term maintenance.

CONCLUSION

Lubrication practices within a plant have a direct effect on plant and equipment reliability. When the lubrication is working effectively, wear will be reduced and equipment reliability will be improved. A Lubrication Reliability strategy focuses on all parameters that protect the average lubrication film thickness thereby reducing component wear and increasing equipment reliability.

Eriez: Advancing mining for 80 years

Eriez is a world leader in magnetic separation. flotation, metal detection and material handling equipment technology, and has built of a workforce of more than 900 individuals located throughout 12 wholly-owned international subsidiaries on six continents.

Over eight decades, Eriez has worked diligently to advance the mining, processing, packaging, food, recycling, aggregate and metalworking industries it serves.

Company process engineers and scientists have developed many product breakthroughs in the areas of rare earth magnets, superconducting technology, flotation, vibratory feeders, metal detection, auto scrap recycling equipment, suspended electromagnets, eddy current separation, and proprietary manufacturing techniques.

Eriez is proud to be a family-run company. With original founder O.F. Merwin's grandson Richard Merwin currently serving as chairman.

Richard's late father, Bob Merwin, had a global vision for Eriez and took the company into international markets in the 1950s.

"Our Board of Directors, past and present, has embraced and supported

deliberate and bold ongoing initiatives for global strategic growth," Merwin said.

"Their consistent, sound and ethical guidance is a major factor in Eriez's continuing success.'

Eriez president and chief executive officer Lukas Guenthardt said Eriez is lucky to have ownership and a Board of Directors who value long-term investments and profitable growth over short-term profits.

"We have worked hard at building and maintaining loyal customers that value the quality and trust the reliability of our products and services," he said.

"With a focus on continuous product advancement and market expansion. both domestically and overseas. Eriez is poised to thrive for years to come."

While product innovation has been paramount to achieving and growing Eriez's position as a global leader, management asserts that it is the team of people who really make the difference.

"The integrity, commitment. responsiveness and unmatched customer service provided by our outstanding staff is what truly keeps us on the leading edge," Guenthardt said.

Eriez employees give generously of their financial resources, time and talents to philanthropic causes.

"As a corporation and as individuals, we are dedicated to making a lasting, positive impact on the well-being of the communities where we live and work. We believe this approach produces an atmosphere where businesses and communities can collaborate and prosper," Guenthardt said.

Another contributing factor that helps Eriez flourish is its heavy focus on marketing communications. Eriez senior director

of global marketing and brand management John Blicha said the company puts a strong emphasis on sustaining maximum customer engagement.

"We believe in making significant investments, both in terms of time and finances, to advertising, branding, public relations, trade shows, digital marketing and customer education," he said.

Blicha said the company has some special events planned throughout the course of 2022 to commemorate this milestone anniversary and recognise customers and employees for their loyalty and partnership.



Rusal exports first Guinea bauxite in nearly a month, data shows

Russian aluminium giant Rusal, whose global operations have been hobbled by the war in Ukraine, has exported its first bauxite shipment from its mines in Guinea in nearly a month, an analysis of shipping data showed.

Unlike a number of other Russian companies, Rusal is not the target of sanctions, although its billionaire founder Oleg Deripaska is.

However, Russia's invasion of Ukraine and the backlash against it have wreaked havoc on Rusal's supply chains.

Refinitiv shipping data showed that a vessel departed Guinea's Kamsar port recently after being loaded by a transshipping vessel known to operate on behalf of Rusal. Bauxite exported by Rusal

via Kamsar comes from its Dian-Dian operations, which typically feed the company's Aughinish refinery in Ireland.

The shipment marks the first export of aluminium ore from Dian-Dian since 12 March. Rusal's Kindia operations - its other Guinea bauxite mines - last exported on 26 February. Rusal had previously said it planned to resume exports from Dian-Dian by the end of March.

Roughly half of Rusal's production of the aluminium ore bauxite came from its mines in Guinea last year.

That output is even more critical now that Australia - the world's top bauxite producer - has banned exports to Russia and Anglo-Australian miner Rio Tinto said it would sever ties with Russian businesses.

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2022











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BOOK EARLY FOR Expo Katowice (September), Bauma (October) and Imme Kolkata (October)



MINING & QUARRY WORLD













NEWS, PLANT AND EQUIPMENT

Mineral Resources responds to global lithium demand

Mineral Resources (MRL) will increase production from its Wodgina and Mt Marion spodumene mines in Western Australia in response to unprecedented global customer demand for lithium products.

MRL managing director Chris Ellison said that the growing demand for lithium has been driven by the strength of the electric vehicle market.

"This demand has resulted in a substantial increase in lithium prices, with pricing expected to remain strong for the rest of this decade," he said.

Alongside Albemarle, MRL decided to accelerate the resumption of production from Train 2 at Wodgina, with the first spodumene concentrate expected in July 2022.

The company's preparations to recommence operations at Train 1 are well underway,

with first spodumene concentrate from this train now expected in May 2022 - previously estimated at the third guarter of 2022.

Each train has a nameplate capacity of 250,000 dry metric tonnes of 6% product.

MRL and Albemarle agreed to review the state of global lithium market toward the end of this calendar year, to reassess the timing for the start-up of Train 3 and the possible construction of Train 4.

MRL and its 50/50 joint venture partner Jiangxi Ganfeng Lithium (Ganfeng) agreed to upgrade the Mt Marion procession facilities, given the positive metallurgical test work results and the completion of project studies at the mine.

This is expected to result in the immediate increase in Mt Marion's spodumene concentrate of production



capacity from 450,000 to 600,000 tonnes per annum of mixed grade product by April 2022.

A further expansion comprising of a dense media separation (DMS) plant upgrade, a new crushing circuit and an upgrade to the mine camp should increase installed plant capacity to a run rate of 900.000 tonnes per annum mixed grade by the end of 2022.

"I'm proud of the great work our team have done at Wodgina and Mt

vaccinations for the local

communities." Randell

Indonesia's first private

coal miners, has been

operating for more than

20 years. The company

produces more than three

million tonnes of coal per

annum from its mines

in the East Kalimantan

Harum, one of

said.

to significantly expand our spodumene supply from these Tier 1 mines in Western Australia, we look forward to creating many more long-term jobs and supporting the surrounding communities for decades to come," Ellison said. "With a world-class

Marion. As we continue

portfolio of highest-quality, long-life lithium assets in a Tier 1 mining jurisdiction. we are well-positioned to capitalise on the continued growth of the global electric vehicle market."

Thiess gets \$300m renewal in Indonesia

CIMIC mining services provider Thiess has been awarded a \$300 million three-year contract renewal to provide mining services at Harum Energy's Mahakam Sumber Jaya (MSJ) coal mine in East Kalimantan, Indonesia.

Thiess will continue providing mine design and planning, drill and blast. overburden removal. load and haul. asset maintenance and management, rehabilitation, water management and haul road maintenance services, commencing April 1, 2023.

Thiess executive chairman and chief executive officer Michael Wright said the company was proud to continue its longstanding relationship with Harum Energy at MSJ, where it has worked to

deliver sustainable mining services since the mine was developed in 2008.

"This contract enables us to continue our record of delivering certainty for our client, with a clear focus on safe and sustainable production and rehabilitation," he said.

Thiess executive general manager - Asia Cluny Randell said the contract renewal was great recognition of the team's ability to partner and grow together with the client and deliver long-term performance and productivity gains for Harum Energy.

"We look forward to continuing our strong relationship with our client and the community of Kutai Kartanegara, where we've worked together during COVID-19 to provide

region.

Thiess has an 80-year mining history delivering the full suite of mine services, and challenging ideas, creating solutions and managing performance to help its clients achieve best-practice resource recovery, increase productivity and optimise cash flow.



for spool and hoses while increasing productivity and safety on slurry pipelines



Intelligent equipment monitoring provides pipeline operators with increased control over performance and maintenance schedules, reducing operating costs and unplanned downtime.

Weir Minerals, global market leader in premium technology and mining solutions, is launching Synertrex[®] IntelliWear[™] – a new digital wear monitoring system for spools and hoses in slurry pipelines. Developed by the Weir Minerals digital specialists in Chile, the intelligent system addresses the increasing demand for optimisation and safety within the mining industry. With the continual move towards digital solutions, Weir Minerals recognised the need to support customers with their ongoing maintenance. Renowned for their dedication to customer

service, the company developed a solution that enables mine sites to monitor the condition and wear performance of their hoses and spools via a network of smart sensors connected to their DCS (Digital Control System).

Equipment health is of the utmost importance, with many operators looking to streamline their operations for increased productivity and reduced downtime. The Synertrex[®] IntelliWear™ monitoring system allows pipeline operators to check their equipment in the critical wear areas and perform predictive maintenance prior to any unplanned disruptions and downtime. With planned repair and replacement of equipment, the benefits to customers are invaluable. Unscheduled stops are reduced – leading to reduced costs of operation and maintenance. Most importantly, safety on site is increased, as spools and hoses are replaced prior to failure, thus removing the risk of slurry leakage which can cause injury to workers on site and the environment.

Eduardo Putz, Synertrex and Mechatronics **Champion Latin America** says:

Synertrex IntelliWearmonitoring system enables our customer to have much

NEWS, PLANT AND EQUIPMENT

Synertrex[®] IntelliWear[™] technology delivers digitised monitoring

more control over their equipment. With smart sensors they are able to analyse wear life, plan maintenance and control stock. The ability to prevent non-scheduled maintenance further supports our customers in their sustainability goals. The Synertrex

IntelliWearsystem has been developed and rigorously tested in a range of slurry conditions and mill circuit arrangements. We are confident our platform will deliver a significant positive impact on our customers' operations.

The system is comprised of an intelligent digital sensor integrated into Weir Minerals' Linatex® and Vulco® hoses and spools. A central control panel captures information in a single location, and a dashboard allows for visualisation and analysis of the equipment data via the Synertrex[®] digital platform. Digitalisation enables our customers to continue their normal operational duties, while large amounts of data is automatically analysed and interpreted in the background via the Synertrex - platform.

A conductive wire is installed in the rubber lining at various levels of thickness. As the lining wears, it activates sensors to indicate the extent to which the rubber liner has been worn and in turn

how much life is left. An easy-to-use digital traffic light system has been developed which enables quick visual identification of the condition of the hose or spool. Less than 50% wear is green, between 50% and 70% wear is yellow, greater than 75% wear is red - indicating it is time for preventative maintenance. The conductive wire is installed along the entire Linatex[®] or Vulco[®] spool or hose, throughout its diameter.

The central monitoring panel collects data from the sensors in the field and sends it to the Synertrex[®] platform which allows operators or maintenance personnel to view it. Information collected can also be uploaded to the cloud to be viewed on a live dashboard which is automatically updated every two minutes. The intelligent system enables operators to view real-time wear information from any device remotely - ensuring continual monitoring and better control over their equipment. This control allows for optimisation, improved performance and the elimination of unwanted operating conditions.

The Synertrex[®] IntelliWear™ wear monitoring platform is available across the Weir Minerals network initially in the Americas, Africa and Asia Pacific.



Bokoni platinum mine is an opportunity

The Bokoni platinum group metals (PGMs) mine being acquired for R3.5-billion by African Rainbow Minerals (ARM) hosts South Africa's second largest PGMs resource, with ready-built mining and processing plant infrastructure on site.

Bokoni provides greater exposure to palladium and is close to ARM's Modikwa and Two Rivers PGM mines. It lifts the JSElisted company's combined PGMs resource base by 135% to 266-million ounces of four-element (4E) PGMs.

In addition to moving ARM's PGMs portfolio down the cost curve, it also boosts attributable production and life-of-mine by 137% to 636 000 oz of 6E PGMs production a year from 2026.

"Bokoni is a large high-grade opportunity," was the headline of a slide ARM flashed on to computer screens during its presentation of dividendyielding half-year financial results.

It followed an opening slide, which displayed this comment from ARM executive chairperson Dr Patrice Motsepe in bold type: "We are pleased to have signed the agreement to acquire the Bokoni Platinum Mine. Development of the mine will allow us to scale our PGM portfolio and create value for shareholders and other stakeholders."

Completion of the transaction is expected during 2022 after obtaining regulatory approvals including South African competition authorities approval and consent in terms of Section 11 of the Mineral and Petroleum Resources Development Act.

In the six months to the end of December, PGMs contributed 46% of the diversified mining company's earnings before interest, taxes, depreciation and amortisation (Ebitda), followed by iron-ore's 42% to Ebitda and manganese's 10%

Regarding Bokoni, Motsepe added: "It's a mine that hasn't been operational but it's an exciting opportunity and we're committed to growing Bokoni in the medium term."

In the short term, the focus will be exclusively on Bokoni's high-grade upper group two (UG2) reef, said ARM CEO Mike Schmidt. The mineral resource is 64% UG2 and 36% Merensky, with the UG2 prill split being 49% palladium and 8% rhodium.

As of December 31, 2020, Bokoni's measured,



indicated and inferred mineral resources totalled 153-million ounces of fourelement (4E) PGMs, at a grade of 5.87 g/t, with the UG2 grade of 6.56 g/t 4E considerably higher than the Merensky grade of 4.94 g/t 4E.

A new wholly owned subsidiary of ARM Platinum has been established to acquire 100% of the shares and claims in Bokoni Platinum Mines Proprietary Limited – Bokoni Mine – from Anglo American Platinum Limited and Atlatsa Resources. ARM Platinum will

ultimately own 85% of Bokoni Mine. Acquiring 5% each for a nominal price will be:

- a local community special purpose vehicle;
- an employee share ownership plan special purpose vehicle; and



 a black industrialists' special purpose vehicle.
The financial statements show ARM as having

show ARM as having more than enough cash to settle the total purchase consideration of R3.5billion, but it was stated during the presentation that ARM was being advised on this.

A 23-year sale of PGMs concentrate between Bokoni Mine and Rustenburg Platinum Mines Limited on commercially agreed terms has been finalised.

A definitive feasibility study (DFS) is expected to be completed in 12 months, with R5.3-billion of development capital in real 2021 terms being spent over three years.

The DFS parameters involve the deployment of a mechanised on-reef mining method utilising existing proven technology, targeted steady state operational costs of less than R12 000 per 6E ounce (in 2021 terms), steady state production target date of 2028, steady state production of about 300 000 oz of 6E PGM contained in concentrate a year, and steady state production of 255 000 t of chromitite concentrate a year.

Schmidt said ARM would initially focus exclusively on Bokoni's high-grade UG2 reef, where the combined palladium and rhodium accounts for 57% of the UG2 prill split, which provides for a favourable basket price. The plan is then to preserve the current Merensky infrastructure at Brakfontein shaft, thereby providing good opportunity to mine Merensky into the future, said Schmidt, who added that early mining opportunities at Middelpunt Hill are currently being assessed.

The Ebitda split by commodities showed that ARM's PGMs business is growing.

We will grow the PGMs but side-by-side with that, we will also grow the ironore and manganese. Over time the plan is that the iron-ore and manganese should continue to be a strategic part of ARM's long-term future, but the PGMs will grow significantly in terms of our plans and specifically the Bokoni transaction so that we can get the full benefits of being a diversified mining company.

The Ebitda split shows PGMs as contributing 46% of earnings in the first half of ARM's financial year to 30 June, with iron-ore at 42% and manganese at 8%.

In addition to the acquisitive Bokoni growth project, organic growth projects include the Two Rivers Plant Expansion for an additional 40 000 oz to 60 000 oz of 6E PGMs a year. Plant commissioning is scheduled for the third quarter of ARM's current financial year. Another PGMs growth project is the Two Rivers Merensky project for an additional 182 000 6E PGM ounces. 1 600 t of nickel and 1 300 t of copper a year. Plant commissioning for this project is in the second guarter of ARM's 2024 financial year.

Bokoni's targeted steady state production of 300 000 6E PGM ounces a year is in 2028, with important plans to ensure that in the short to medium term, it derives revenue and income from Bokoni.

Metso Outotec receives major order for Planet Positive tailings filtration technology in Indonesia

Metso Outotec has been awarded a major contract for the delivery of sustainable tailings filtration technology to PT Huafei Nickel Cobalt's greenfield laterite nickel ore project in Indonesia. The hydrometallurgical plant has a targeted annual output of 120,000 tons of nickel metal and is expected to be in operation during the second quarter of 2023. The value of the order is over EUR 30 million, and it has been booked in Minerals' Q1/2022 orders received.

Metso Outotec's scope of delivery consists of the engineering, manufacturing, and supply of the Planet Positive Larox[®] FFP3512 filters as well as installation and commissioning advisory services and spare parts. The fully automatic fastopening filter press (FFP) combines the benefits of membrane technology and sidebar design with high mechanical and process performance, providing safe and sustainable highvolume dewatering of tailings with low operating and life cycle costs. "For our customer, the



key criterion for selecting Metso Outotec's filtration technology was safe and sustainable tailings processing with proven service capability. In addition, we were able to meet the customer's wish for a quick delivery time. We are very pleased to have been chosen as the solution supplier, and we look forward to working together with our customer on this important project," says Jussi Venäläinen, Vice President, Filtration business line at Metso Outotec.

Metso Outotec's filtration product portfolio is the largest in the field and the energy, emission, and water efficiency is in a league of its own. Metso Outotec has carried out over 14,000 filtration tests and delivered more than 5,000 filters for various applications worldwide. Most of the filters are sold under the Larox® product name along with Metso Outotec corporate branding. Metso Outotec also accommodates all filtration related service and spare parts needs through its global service network.

Epiroc introduces new blasthole drill

Epiroc has introduced the DM30 XC blasthole drill that is suitable for a variety of multi-pass rotary and down-the-hole (DTH) drilling applications.

The leading productivity partner for the mining and infrastructure industries built the blasthole drill off the same proven platform as the Epiroc DM30 II, with the new DM30 XC offering 33% more power and many benefits to customers.

Designed for maximum productivity and efficiency due to increased rotary torque, increased pulldown and a larger hole range capability, the DM30 XC can achieve a total clean depth capacity of 45.1 metres for multi-pass applications and 8.5 metres for single-pass applications.

"The DM30 XC is built tough for the most demanding jobs, and high quality at an excellent value is what sets it apart from other drills in its class," Epiroc Surface division regional business manager Mark Stewart said.

"The drill is designed for mining so the structural components will hold up to the heavy-duty cycles required in a mining drill. The robust frame and tower weldments are manufactured to last the lifetime of the machine."

A 1363-litre fuel tank allows the rig to run for up to 16 hours before needing a refill for continuous operation, and the smaller, compact footprint of the DM30 XC makes it easy to manoeuvre on tight benches and simple to transport over between pits.

The DM30 XC is equipped with an electronic air regulation system (EARS) that provides low load start up and easy adjustment of bailing air to save horsepower and lower fuel consumption, extending power component life and decreasing total cost of ownership.

Epiroc's blasthole drills are designed for safety, productivity and reliability for rotary or DTH drilling applications.

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NEWS, PLANT AND EQUIPMENT



Vulcan signs first geothermal agreement at German lithium project

Vulcan Energy Resources has signed its first geothermal energy offtake agreement at its Zero Carbon lithium project, in Germany.

The company aims to produce both renewable geothermal energy and lithium hydroxide from the same deep brine source at its operations in Germany.

Vulcan announced that it had linked a supply agreement with German energy company MVV for the supply of 240 gigawatt hours a year of renewable hear, with the 20-year offtake agreement to start in 2025.

The offtake agreement would cover a minimum of 240 000 MWh a year to a maximum 350 000 MWh a year, with the heat to be supplied from Vulcan's planned geothermal wells in the area surrounding the city of Mannheim. Heat will be transferred via heating grids and a series of underground pipes that deliver hot water or steam to buildings in the local community.

"Vulcan is committed to playing a leading role in Germany's "Wärmewende", or heat transition as the country looks to reduce its reliance on Russian energy. This agreement represents a real and immediate step taken by a German

energy utility to achieve energy security whilst not compromising on climate goals." Vulcan MD Dr Francis Wedin said.

"We believe that geothermal renewable energy on a mass scale, combined with lithium extraction from the same deep geothermal source, can and will play an important part in achieving Europe and Germany's energy security and independence. We are proud to partner with MVV, a leader in German energy supply, dedicated to making a lasting and sustainable contribution to the local community through the provision of renewable energy and heat.

"Our binding offtake agreement for regional geothermal energy positions MVV to deliver secure. sustainable, economical and environmentally friendly heating for its industrial, commercial and private household customers. Vulcan intends to build several further distributed geothermal renewable energy plants across the Upper Rhine Valley region and we are in discussions with other regional communities regarding additional heat offtake agreements."

Sigma Lithium to start civil works at vast Brazilian project

Sigma Lithium has finished building the production plant foundation for Phase 1of its Grota do Cirilo lithium project in Brazil, the largest hard rock lithium deposit in the Americas.

The Canadian miner will now move to civil works. which will be followed by plant mechanical structure works in June. it said.

The company said that Phase 1 of the production plant has been designed to produce up to 240,000 tonnes per year of lithium concentrate. That's 9% more than its original production plan for the 1.2 billion-real project, which would be about \$257 million at today's exchange rate.

Sigma lithium plans to ramp up plant production to 460,000 tonnes per year or 66,000 tonnes of lithium carbonate equivalent - in phase II, which is slated to begin by the end of 2023.

Grota do Cirilo is the largest lithium hard rock deposit in the Americas, and the company has been producing concentrate of the battery metal at the site on a pilot scale since 2018.

The Vancouver-based miner expects to start production at Grota do Cirilo in the fourth quarter of this year, joining the ranks of commercial lithium producers just as prices of the metal skyrocket as supply struggles to keep up with electricvehicle demand growth. Leader EV maker Tesla (NASDAQ: TSLA) recently inked two supply deals with

developers of future projects in Australia, while Albemarle (NYSE: ALB) and its partner Mineral Resources (ASX: MIN) said this week they are speeding up the restart of their jointly owned Wodgina lithium mine in Australia.

Atlantic supplier

The proposed mine would be powered by a hydroelectric project located 50km (31 miles) away from the site and serve what Sigma dubs the emerging Atlantic supply chain for batteries and electric vehicles manufactured in North America and Europe.

Sigma expects a bifurcation in the market as growth outside of China accelerates with environmental factors including water, energy use and tailings becoming increasingly important to how producers are assessed.

The company's co-CEO, Ana Cabral-Gardner, believes that Brazil has the potential to become a "green lithium powerhouse".

Brazil is already a global case study in low carbon mobility powering cars with ethanol, biofuels and natural gas. With Sigma Lithium in the mix, the country now has one of the few companies globally that has proven its ability to produce lithium in an environmentally sustainable manner.

Sigma has been producing environmentally sustainable battery-grade lithium concentrate on a pilot scale since 2018.



WHAT'S GOING ON

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