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Reliable solutions

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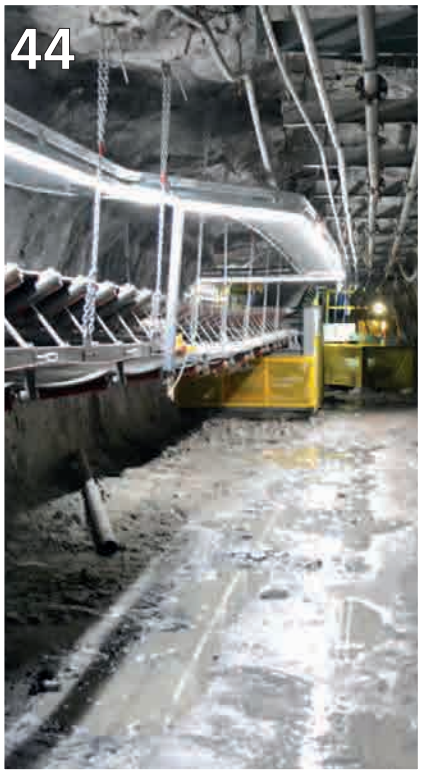

COVER: Hitachi

Hitachi's EX1900-6 ultra-large mining excavator loads an EH1100-5 rigid dump truck at the Shubarkol Komir coal mine in Kazakhstan. The company owns four Hitachi mining excavators and 14 rigid dump trucks, and finds the machinery to be ideal for its mining operations. Shubarkol Komir cites excellent levels of productivity and reliability as the main benefits of these machines. In addition, the new EH1100-5 offers a more comfortable and safer working environment, and easier access for maintenance, than previous models.

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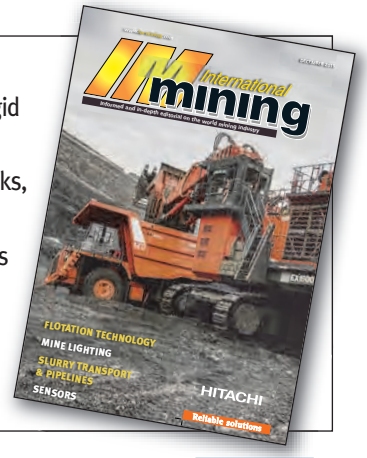

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Sensing change

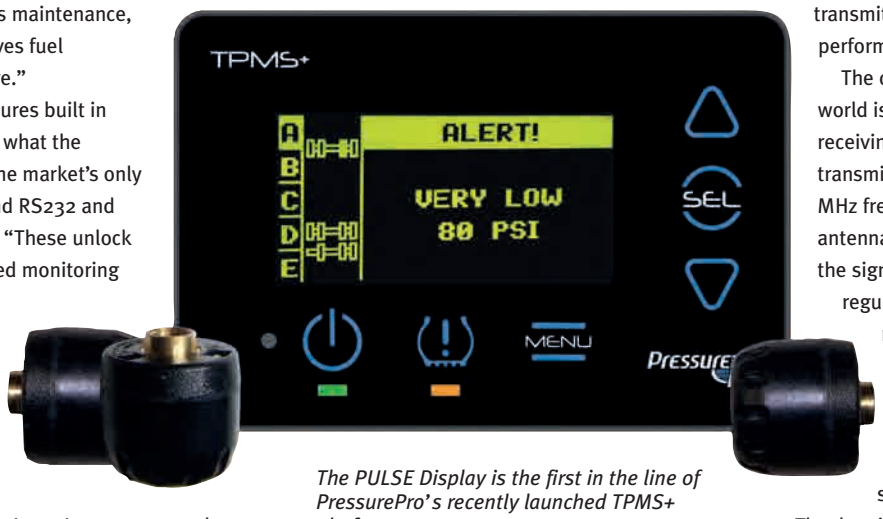
Scantech has supplied over 40 Geoscans to the iron ore industry since 2003

Paul Moore reviews sensor technology in some very different areas of mining and minerals processing, from mining tyre monitoring to gas detection underground

The use of tyre pressure monitoring systems (TPMS) has become more widespread in the mining industry in recent years, as mine operators and contractors have started to understand and interpret the data better and get the resulting safety and efficiency benefits. **Advantage PressurePro** told ***IM*** that it continues to provide the mining industry with market leading TPMS technology with the release of its PULSE Display. The first in the line of its recently launched TPMS+ platform, PressurePro PULSE "not only offers customers real time tyre performance information including instantaneous tyre pressure and temperature readings, it also gives users the market's most comprehensive and fully customisable alert offerings including two low pressure alerts, a high pressure alert, high temperature alert, fast leak alert and a market first cross axle alert, arming users with the data needed to catch and correct tyre issues before they become unsafe or costly. This not only helps keep operators and maintenance workers safe, but extends tyre life, decreases downtime, reduces maintenance, cuts waste, improves fuel efficiency and more."

PULSE also features built in data logging, with what the company says is the market's only SD card export, and RS232 and J1939 capabilities. "These unlock numerous advanced monitoring options for users including remote monitoring options alongside industry leading communications providers including Isaac Instruments and Trimble and the ability to analyse historical data. This is critical, as it unlocks the next generation of tyre maintenance for fleets, allowing users to identify location or vehicle specific trends from which tyres are performing best under certain conditions, which drivers or vehicles are experiencing heightened or low tyre problems and why and more, allowing fleets to utilise that information fleet wide. In short, these capabilities reveal the data needed to start moving tyre maintenance practices from reactive to proactive, which is a game changer."

Good data relies on the collection device, so considering the type and location of tyre sensors is of paramount importance. TPMS sensors can either be mounted inside the tyre chamber or attached directly to the valve. Valve-mounted sensors carry the advantages of easy installation and simple replacement, however, **Kal Tire** argues that they can easily sustain damage. "The stem of the tyre is particularly vulnerable and the sensor will be subject to the same external forces as the rest of the tyre.



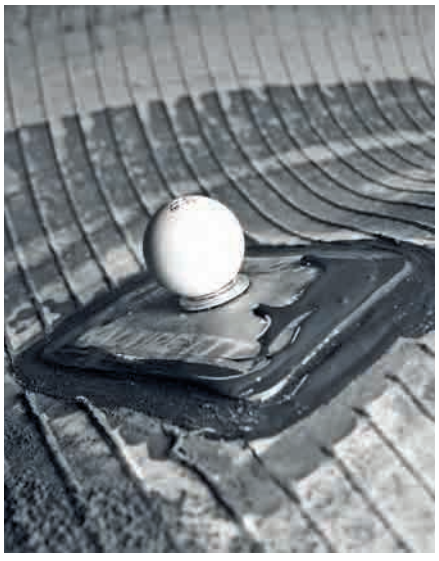
The PULSE Display is the first in the line of PressurePro's recently launched TPMS+ platform

Externally-mounted sensors do not give a true reflection of the tyre's chamber temperature, as they could be mounted several centimetres away from the inner chamber and therefore could read temperatures several degrees different from the true chamber figure. External sensors can also be affected by influences such as weather and ambient temperatures. This temperature inaccuracy inevitably leads to the calculated cold pressure (CCP) being imprecise. A live CCP is a key factor for tyre fitters as it allows tyres to be inflated and deflated accurately without the need for on-the-spot manual calculations, or waiting for tyres to return to an ambient temperature." When safely running tyres to their maximum capacity, accuracy is essential. Sensors should be within ±1°C and ±1 psi, verified by an independent third-party expert.

Kal Tire's TTT system utilises a sensor mounted internally onto the tyre sidewall via a custom-made patch, to accurately monitor the pressure and temperature of mining tyres. "The environment of a tyre chamber is a hostile place, and when liquid additives are introduced it can become extremely testing for any electronic devices. TTT's sensor electronics are encapsulated by a polyurethane resin, moulded to give its distinctive golf ball-like shape. In addition, its double O-ring design ensures that the integrity of the sensitive electronics are not compromised by liquid or vapour ingress."

TTT sensors are calibrated using two-way (or bi-directional) communication techniques to ensure a high level of accuracy all the way across the pressure and temperature range. The calibration process involves the sensors being subjected to the full range of operational pressures and temperatures while they are 'questioned' periodically. Any discrepancy between the actual and reported data is transmitted to the sensor and adjustments are performed by the sensor as necessary.

The company told ***IM***: "The best data in the world is useless if there is no reliable way of receiving and reporting it. TTT's sensors transmit data on the industry-standard 434 MHz frequency, using a unique sensor antenna design that maximises the quality of the signal while remaining within FCC regulations for low power transmitters. The result is that even the largest tyres on the largest vehicles have minimal effect on the reception. The sensor signals are collected by a custom-designed receiver antenna, tuned specifically for those transmissions. The data is then interpreted and displayed using



A Kal Tire TTT sensor installed in a mining tyre

a range of methods including a dedicated Base Station, a web based TTT Console and an interactive driver display."

The air inside an OTR tyre chamber is not thin. It is a harsh environment of compressed air, liquid additives and rust inhibitors, subject to pressure and temperature changes that constantly challenge the viability and service life of mining vehicle tyres. But this is where **RIMEX** says its TyreSense wheel sensors thrive. As the core component of TyreSense TPMS, each wheel sensor is individually configured for a specific tyre on every vehicle. The sensors are designed to withstand extreme internal tyre conditions, respond to fluctuations, and transmit precise pressure and temperature data every three seconds, within two psi of actual pressure levels. In addition to pressure and temperature, the TyreSense system measures and records up to 75 other variables, including location, speed and ignition cycles.

RIMEX told ***IM***: "With respect to tyre efficiency and productivity, heat is the primary threat. The Tonne Kilometre Per Hour (TKPH) rating is a manufacturer's formula that predicts a tyre's maximum heat build-up capacity. When a tyre reaches its TKPH rating under operation, it should be at its maximum (critical) operating temperature. But TPKH is only a theoretical calculation. TyreSense, on the other hand, uses actual 'in situ' information from tyre sensors. The key question is whether there is a relationship between the temperature inside a tyre chamber and that on its tread. In fact, studies do demonstrate a correlation, and one which ties chamber temperature more and more closely to tyre temperature as it approaches its critical threshold. So, it is evident that wheel sensors can play a valuable role in preserving the viability of tyres in motion."

In response to the severe environment inside a tyre, RIMEX's Magmount technology allows sensors to be securely mounted to wheel rims by magnetic force. "This means no more precarious patches to glue inside the tyres. Robust sensors are magnetically fixed in place, and resist breaking free and being buffeted by slurry in the tyre chamber – a problem with patch-mounted sensors when they separate. Additionally, with magnetic sensors, tyre handlers are relieved of time consuming installation and potential manual error."

Another advancement stemming from sensor technology is automated tyre inflation, which significantly reduces the downtime demanded by mechanical or manual airing up. RIMEX's Inflation Station, for example, rapidly delivers uninterrupted air flow, governed by precise and continuous data from the wheel sensor. The station also enables preset and remote controls, keeping personnel a safe distance from potential hazard zones.

Finally on the near future, RIMEX states: "In further optimising the data gathered by wheel sensors, geo-fencing will become a feature of mining fleet management. A Global Positioning System (GPS) will define virtual perimeters at work sites. Such geo-fenced areas could include speed zones, loading zones and no-go zones. If a vehicle crosses over a geo-fence boundary, an alert will be triggered and elicit a response to maintain the safety of the site. The future of wheel sensors in the mining industry is

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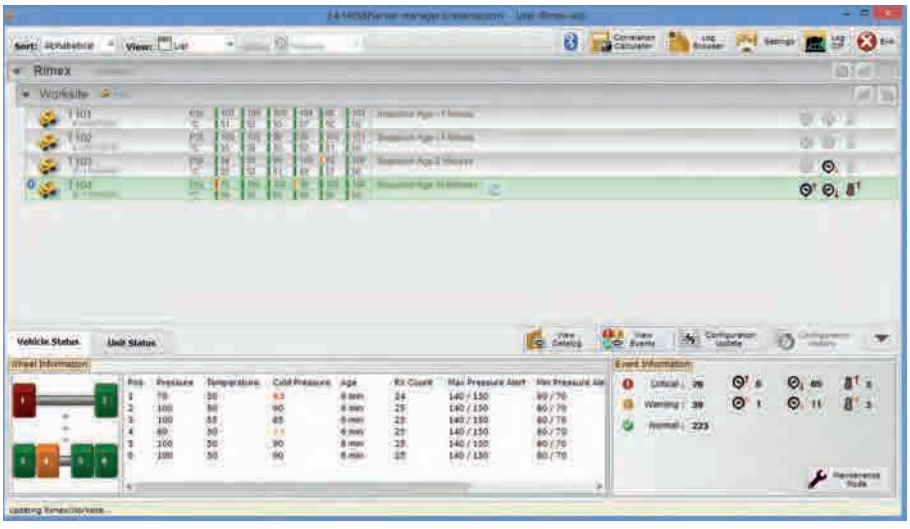


Real time information from RIMEX TyreSense sensors

undeniably positive, promising substantial benefits as we continue to capitalise on the power of sensor technology."

In July 2015, **Michelin** launched its latest offering, the MEMS (Michelin Earthmover Management System) Evolution3. Given that safety and reliability are core values for Michelin, the Clermont manufacturer says it followed an integrated approach, by designing the sensors and analytical software itself. There are two sensor models: conventional sensors and sensors for water-ballasted tyres with additives, isolated in a capsule filled with an inert liquid. Monitoring of each tyre is through a unique identifier, which allows analysis throughout its entire life to improve performance in the mine. The system offers real time data recording, allowing reactive monitoring of alarms; with connection and data transfer via 3G or Ethernet; and sending of multichannel real-time alerts. Michelin MEMS is available for rigid dump trucks using tyres with a diameter from 49 in and up to 12 tyres per vehicle. Michelin XDR2 and XDR250 tyres are pre-equipped for MEMS Evolution3: a factory integrated patch allows the rapid installation of MEMS sensors.

Underground gas and humidity sensors

Developing fit-for-purpose products that utilise sensors requires an in-depth knowledge of sensing technology as well as the ability to identify the correct sensor and integrate it with the electronics and intelligence enabling the desired final product in terms of information, automation and most importantly, increased safety.

South Africa-headquartered **Booyco Electronics** says it has established itself as a provider of sensors "that not only meet these exacting requirements but are also designed to operate in the often harsh operating conditions found in Africa in both underground and surface mines."

Accurate measurement of gases is made simpler with the South African manufactured ESI Smart Sensor. Significantly, this compact sensing unit, weighing only 1.8 kg, has the ability to measure one of 15 different gases from a single controller. "This feature sets the instrument apart from other such units currently in the market."

Gases that can be monitored using this EXia T4 Intrinsically Safe gas sensing instrument include oxygen, carbon dioxide, flammable gases such as methane and combustible gases such as carbon monoxide. The instrument also carries SANS IEC 60079 Part 0:2005, SANS IEC 60079 Part 11: 2007 and IEC 60529 (IP code) approvals and offers ingress protection to IP56.

The ESI Smart Sensor has a localised information display making it simple to read, and it can also accommodate other sensors with analogue outputs, such as air velocity sensors or smoke detectors. In addition, the ESI Smart Sensor can easily be connected to a fire detection system with reporting and display on SCADA package.

When it comes to handheld gas detection devices, the Sentient from Booyco was specifically developed to improve safety in confined spaces, and this handheld multi-gas sensor measures relative humidity as a standard offering.

The Sentient is a low maintenance unit without any buttons and is operated using an innovative "tap" sensor ensuring that the instrument remains watertight. Another unique feature is its "drop protection" capability that automatically switches the device off should it be dropped.

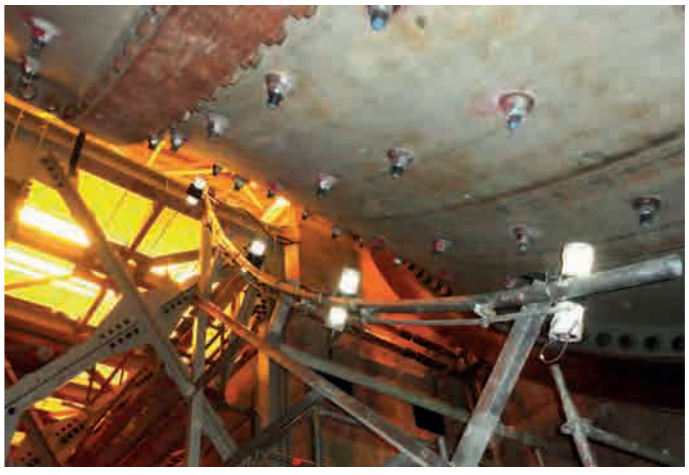
Developed for use in underground mining as well as on surface plants, the Sentient is IP68 rated and is also available with Fire Patrol capabilities. The Fire Patrol Sentient unit has a bright red seal and is inserted into outstations located in specific areas underground or on surface. The device then records date, time, gas and humidity measurements at that specific location.

The handheld sensor is equipped with a downloading network configuration capable of gathering information from up to 500 Sentient units in a matter of minutes. All the equipment can be connected via a network to a Sentient downloading server, where specialised software enables various reports to be generated, such as detailed information on gas detected in the underground environment, peak values, TWA values, pre-shift tested values, calibration reports and "no movement reports." In addition, Sentient software is web-based, making it possible to email these reports to relevant personnel automatically.

Mill sensors

In June 2015, **FLSmidth** released its new generation Impactmeter, a mill performance instrument that monitors the charge dynamics

The Booyco Sentient is a low maintenance unit without any buttons and is operated using an innovative "tap" sensor ensuring that the instrument remains watertight



Impactmeter acoustic sensors installed on a SAG mill

inside SAG mills and promotes equipment protection, increased milling efficiency and decreased operational costs. FLSmidth told ***IM*** that this innovative sensory system, with its redesigned HMI, "has already proven its capability in mining settings to prevent undesirable impacts that result from mill charge, while increasing liner system life and lowering grinding media consumption."

The acoustic sensors of the Impactmeter are positioned on a determined arc surrounding the mill shell. The sensors are enclosed in specially designed, environmentally secure enclosures that are suited to the extreme conditions of a milling operation. Eight acoustic sensors are installed for bidirectional mill operation, four at each side of the mill in symmetric angles. Mono-directional mills use four sensors.

The sensors provide acoustical information to a processing unit. Proprietary software and algorithms isolate high energy impacts inside the mill from low energy impacts and other charge noise. The impacts are partitioned into two categories – critical and standard – and are counted to provide a quantitative measure of their occurrence. The critical impacts result mainly from balls striking mill liners.

A data acquisition system, comprised of an industrial quality chassis with data acquisition cards, processes the analogue sound signals received from the acoustic sensors, converting them to digital signals. This system also provides the required Ethernet connection and fibre optic convertor to deliver the information to the processing unit. The components are enclosed in a Nema 4x, IP66 rated cabinet.

This newest generation Impactmeter includes a redesigned HMI, based on FLSmidth's proprietary Expert Control and Supervision (ECS) solution, a platform designed for the mining and cement industries. The communication protocols to integrate the Impactmeter with other Process Control Systems, including OPC, Modbus RTU/TCP and several native PLC drivers, are built as part of the solution.

The company states: "The Impactmeter can be operated as a stand-alone system, allowing an operator to manually react to the impact conditions. In this instance, the instrument provides impact data but does not control the mill. Instead, mill function continues to be managed by the mill control system. However, the Impactmeter provides the operator with valuable information that may be used to improve mill performance. The Impactmeter may also be installed to operate in conjunction with and as part of an advanced process control system, providing additional flexibility to the milling operation. When integrated in this way, the acoustic signals provided by the Impactmeter allow the advanced process control system to make small and frequent adjustments to mill operational conditions that improve ore reduction and energy efficiency. At the same time, the elimination of ball-on-liner impacts helps to prolong liner life and extend production between mill relining campaigns, further adding to mill

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availability and reduced operational costs."

FLSmidth says it has successfully proven that critical impacts can be reduced more than 40% by combining Impactmeter and its ECS/ProcessExpert system, an advanced process control platform for minerals processing.

Process sensors

Mettler Toledo's pH sensors can be used in a variety of mining applications, including mineral flotation and leaching. Exposure to aggressive process conditions in these applications directly impacts the lifetime of a chemical sensor. High and very low pH values adversely affect pH electrodes, as do elevated temperatures. Even the toughest pH electrodes will eventually show signs of wear and tear. A significant issue in the operation of in-line process analytical measurement systems is not knowing when these pH sensors will require maintenance or if a sensor is going to fail unexpectedly.

Mettler Toledo has a solution to this in the form of its Intelligent Sensor Management (ISM®) technology and Sensors That Learn™. The ISM technology features the world's first learning sensors for process analytics. Advanced algorithms allow sensors to learn process conditions within one day. "A major advantage of this learning technology is sensor lifetime monitoring. The ability to accurately forecast a sensor's remaining life decreases maintenance costs associated with unnecessary sensor replacement and minimises unexpected process shutdowns due to sensor failure. New ISM algorithms launched in 2015 allow pH sensors to actually learn from the conditions in a process." Sensors That Learn delivers more accurate sensor health diagnostics, quicker than previous versions, and enhances the consistency of sensor lifetime information.

iSense software is a support and maintenance tool for ISM sensors. When an ISM sensor is connected to a PC running the software, all relevant data is displayed on the software's iMonitor screen using simple colour coding, allowing at-a-glance evaluation of the probe. Should the diagnostics recommend that the sensor needs servicing (such as calibration), iSense guides operators step-by-step using simple animations to a successful end result. A newly released version of iSense offers features such as transferring learned data on applications between sensors to provide the highest assurance of sensor performance from first installation.

The mining industry also relies on level measurement for a number of applications. In recent years, non-contact level measurements have gained more and more interest due to their simplicity and reliability. In this particular environment, where sensors are prone to damage, not being in contact with the material to perform the measurement is especially useful. Amongst non-contact level measuring instruments, laser level sensors have found many applications in this industry.

The ABB LM80 laser level transmitter is specifically designed for heavy industrial applications, such as here in a rock crusher level control application

One of the benefits of laser level measurement products is their great reliability since they are positioned away from the falling material preventing any damage. Also, their remote installation makes them easier to install and access. Efficient level measurement for blocked chute detection or crusher level control, for instance, pays for itself rapidly by enabling a continuous production and preventing the equipment being broken.

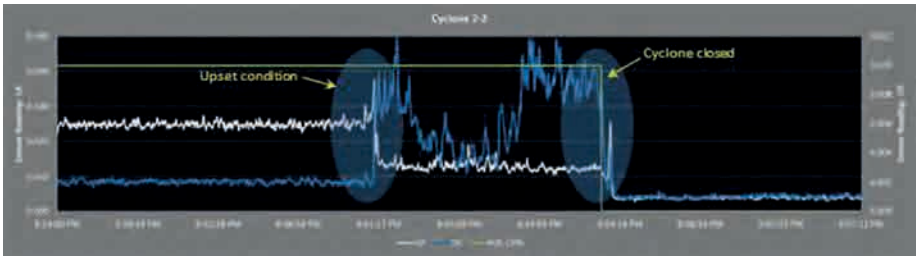
Crusher level control with the **ABB** LM80 laser level transmitter is a typical application. Nicolas Ho, Product Manager for Laser Level and Volume Measurement at ABB told ***IM***: "Level measurement allows process optimisation and prevents overfilling which could cause problems. The laser beam detects the rock level accurately, even in the presence of dust. This technology is immune from the effect of noise, vibrations, ambient air conditions, and the material angle. Furthermore, since the laser beam is narrow, being only a few centimeters in diameter even at more than 30 m, it does not interfere with the vessel side or other obstructions." Blocked chute detection is another typical application. The ore delivery needs to be stopped rapidly if a chute is blocked, which could cause significant damage otherwise. The laser beam allows level measurement deep in the chute even if the space is limited. The technology also responds rapidly (1 second or less) to sudden level changes, which is required as clogged chutes can fill quite fast.

"Also, the laser level transmitters perform very well for liquid level measurements in mines. For instance, pump box level control is required for process optimisation and overflow prevention. The top of a pump box is often filled with several pipes of incoming liquids and significant splashing can occur at the surface. These are challenging conditions for non-contact radars or acoustic sensors since they generate large beams that will be reflected by these obstructions. A sensor with a narrow beam is the ideal solution in many situations."

The ABB LM80 laser level transmitter is specifically designed for heavy industrial applications. Its rugged enclosure allows it to withstand being hit by falling rocks and its explosion proof certification is a necessity for many mining applications. The LM80 also comes with a variety of accessories made to perform in a mining environment. Dust tubes, attached to the front of the instrument prevent dust from reaching the lenses and a heated lens option can be used to prevent the formation of condensation, which would be detrimental to sensor operation. "In conclusion, the LM80 is not only an accurate laser level sensor, it also includes several key features that make it relevant for a variety of applications in the mining industry."

Emerson Process Management told ***IM***: "challenging economic conditions are usually a catalyst for process enhancements as manufacturers seek to reduce costs and improve operational efficiencies. The mining industry, in particular, has certainly taken an interest in gaining better process insight by utilising sensing technologies across their operations – but the feasibility of doing such is often another challenge to overcome. Remote operations, dirt and dust, corrosive chemicals and fierce impacts on mining equipment can make sensing difficult for miners to employ effectively."

Emerson says it is working with miners worldwide to overcome many of these challenges on applications ranging from vibration monitoring on electric rope shovels to wireless flow measurements across leach pads. "In some cases, new sensing technologies are required. In other cases, a little engineering ingenuity is all



Vibration technology from Emerson detects a process upset in a hydrocyclone

that it takes. For example, Emerson's mining centre in Santiago, Chile, in conjunction with a CORFO research and development grant from the Chilean government, is investigating new approaches with vibration measurements to identify operational issues within milling and grinding circuits. At our test installation in Chile, the technology is successfully helping the milling operation improve SAG throughput, determine grinding efficiency, reduce water use, and determine when liner and lifters require maintenance."

Another unique approach to problem solving with vibration measurements is the detection of roping and plugging in hydrocyclones. By installing vibration sensors on the overflow and underflow of a cyclone, the system can accurately predict the onset of both process conditions. Emerson's alliance partner, Portage Technologies has installed this solution at the Copper Mountain operation in British Columbia, Canada. Along with Portage's expert system, the mine is reliably detecting these conditions within seconds allowing them to switch cyclones before any impact to the downstream flotation circuit.

In addition to bringing innovative approaches to difficult applications, Emerson says it continues to develop new sensing technologies for mining applications. "A good example is Emerson's new 3D solids scanner used for level measurements in storage silos, bins, and stockpiles, regardless of ore or mineral. Radar, ultrasonic, and laser are single point measurements currently used today in these applications. The combination of irregularly shaped ore piles and dust often cause these technologies to provide very inaccurate levels because they miss things like material buildups or cavities. Using acoustic technology, these 3D scanners are able to provide a complete three-dimensional view of solids storage, helping miners better manage inventories."

CiDRA says its CYCLONEtrac™ Classification Optimisation family of products are "novel, complete turn-key systems that enable reliable optimisation of classification at the individual hydrocyclone level." Both the CYCLONEtrac Oversized Monitoring system (OSM) and CYCLONEtrac Particle Size Tracking system (PST) provide "reliable, real-time coarse particle monitoring and particle size tracking on individual hydrocyclones." These systems enable plant operators to reduce process upsets, improve closed circuit grind and classification, and maximise mineral recovery. The company says that CYCLONEtrac systems are truly groundbreaking as they enable long-term sustainable continuous improvement strategies while improving and maintaining plant recovery.

The CYCLONEtrac OSM system is based on a non-invasive clamp-on sensing ring designed for use in primary grinding. The system monitors the flow of coarse particles ≥6 mm (pebbles) reporting to the overflow pipes of individual hydrocyclones, which indicates poor classification performance. The value of this technology lies in enabling operators, or automated control systems, to take immediate action to avoid prolonged periods of lower recovery through the early detection and isolation of pebble events.

The CYCLONEtrac PST system is based on a clamp-on design with a sensor that is in contact with the slurry that has been designed for primary grinding. The PST system tracks a key particle size parameter (eg P80, % +150 µm) of individual hydrocyclone overflow streams. This real-time feedback can be used to control a closed circuit grind process such that the desired particle size reports to the downstream flotation process, thus maximising plant recovery. "The CYCLONEtrac PST system is the only system of its kind available today. The value of this technology lies in its ability to track the particle size of the entire overflow stream in real time, thereby enabling improved mineral recovery while maintaining or increasing plant throughput."

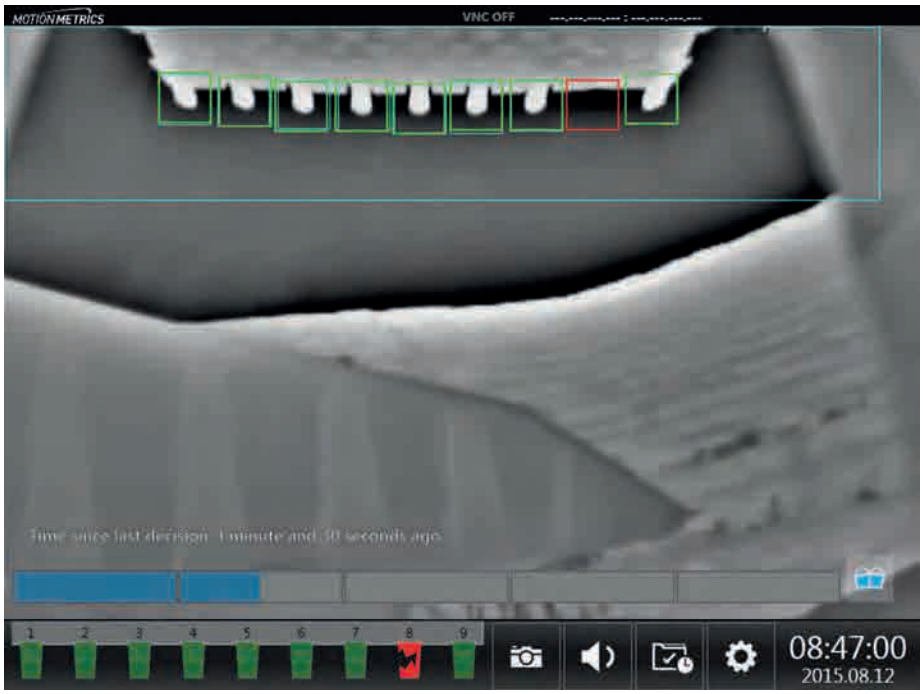
CiDRA concludes: "CYCLONEtrac systems have been designed to provide operators with actionable information that can be used to increase plant throughput, recovery, and equipment availability. CiDRA offers these systems as complete solutions so that operators can focus on bringing sustainable value to their enterprise."

The CYCLONEtrac system monitors the flow of coarse particles ≥6 mm (pebbles) reporting to the overflow pipes of individual hydrocyclones, which indicates poor classification performance

Maintenance sensors

Motion Metrics has announced the launch of its new Missing Tooth Detection system for loaders – LoaderMetrics™ 2.0 – which now uses thermal cameras to detect missing teeth. The use of thermal cameras offers several advantages over traditional cameras including the ability to better distinguish metal components from dirt or rocks.

"As a loader digs, the teeth are the first to engage the material being excavated and consequently, they exert the bulk of the force. The large force being exerted by the teeth on the material causes a high amount of heat generated due to friction. By placing a thermal camera beneath the bucket looking upwards, the camera has a clear view of the underside of the teeth during the dumping cycle. As the dumping cycle immediately follows the digging cycle, the teeth are still hot. Through the thermal camera, the



Using thermal imaging, MotionMetrics' LoaderMetrics detects a missing bucket tooth

teeth stand out as the warmest objects in the scene, making them easily identifiable."

One of the challenges of installing a camera beneath the bucket is its high susceptibility to dirt and debris. To address this issue, Motion Metrics developed an innovative lens cleaning system. The Lens Cleaning System uses anti-freeze wash fluid and pressurised air to remove dirt, mud, snow, grime and mist from the lens. The system is integrated into the LoaderMetrics system, so that the operator can trigger the lens cleaning process through the touch of a button on the in-cab operator display.

In addition to dirt and debris, the camera's location is also susceptible to large rocks falling from above, and being installed on the loader means that it will be subjected to extreme shock and vibration. These challenges require the use of rugged and durable components to ensure that the camera is reliable. A bracket made from 1.5 in steel bars secures the thermal camera in place and shields it from falling rocks. Dampers are placed as a shock absorbing mechanism to isolate the camera from the shock and vibration of the loader and ensure that clear images are captured.

"By leveraging artificial intelligence and machine learning techniques, Motion Metrics has developed an advanced image processing algorithm to automatically identify the location of each tooth in an image captured by the thermal camera. The combination of thermal cameras and advanced image processing techniques allows the system to continuously monitor the teeth, alerting the operator if a tooth is broken or missing. By preventing teeth from reaching downstream equipment such as crushers, equipment downtime and costly repairs can be minimised."

CRCMining states that fibre optic sensing technology is showing industry wide benefits in real-time monitoring of conveyor belts to reduce costly unplanned down times. "Currently, routine inspections of conveyor belts are carried out by maintenance staff, driving along conveyor belts trying to listen for malfunctioning rollers or using handheld thermal/acoustic devices to identify problems, but this isn't proving effective. When conveyors are unexpectedly shut down due to issues with rollers or sudden faults, miners need to locate the roller fault, isolate, dispatch, tag, repair and restart the conveyor – losing valuable production hours."

A team of researchers at CRCMining and the University of Queensland's FOSAL have been developing a Conveyor Condition Monitoring (CCM) system using fibre-optic sensing technology to improve the early detection of conveyor belt faults. This technology uses optical fibre installed on or near the conveyor structure to directly sense acoustic activity in real time, at metre intervals along the length of the conveyor.

CRCMining Project Leader Mohammad Amanzadeh said Distributed Acoustic Sensing (DAS) hardware is at the heart of CCM. "It is exciting technology which has been successfully deployed in various industries for remote production and condition monitoring of assets such as pipelines, wellbores, boarder securities, traffic flow and railway monitoring."

This advanced sensing system is capable of constantly monitoring an entire conveyor system for idler roller failures and is being further developed by CRCMining. By pairing this technology with event detection software, changes in equipment acoustic signatures can be identified to alert operators of impending roller failures and breakdowns.

"CCM is unique, as the sensor is flexible and robust, and it transforms a single mode optical fibre into a chain of microphones, measuring sounds/vibrations at discrete points along the length of conveyor system. The fibre is easily installed on the conveyor structure, requires low maintenance, and if the fibre is damaged, repair is as simple as re-joining the ends of the optical fibre."

DAS hardware is available off the shelf, however, has not been applied to mining conveyors. CRCMining is developing the technology further through various field trials facilitating software and algorithms to address the specific application challenges.

Amanzadeh said: "The researchers are trialling the use of fibre optic sensing technology to identify changes in temperature and noise along the conveyor belt to help detect potentially faulty components in real-time and post processing. The first site trial was at Queensland Bulk Handling (QBH) in 2014, and recently our team completed a site trial at Anglo American's Dawson mine in May 2015. In conveyors that span kilometres with thousands of rollers, real-time monitoring has the potential to significantly reduce costs in mining operations. CCM technology enables staff to prioritise maintenance repairs and identify types of faults in real-time along the conveyor belt. This will lead to an effective strategy in maintenance during planned down times and will reduce costly down-times, prevent catastrophic events, repairs and delays in production caused by rollers and pulleys."

It is anticipated CCM technology will reduce unplanned down times by 20 to 50% depending on the conveyor system. If a mine conveyor currently runs at a production loss of A$150,000 per hour this could escalate to millions lost in production each year due to unplanned stoppages. There are more savings expected with reducing labour hours, belt damage, safety incidents, and adding robotic solutions for roller change.

Current research involves conducting a more detailed trial and data collection using the DAS technology in an underground mine. This project phase is supported by CRCMining, ACARP, Anglo American, University of Queensland, OptaSense – QinetiQ, Machinery Automation Robotics, and QBH.

Conveyed product sensors

Henry Kurth, Minerals Consultant at Australia-headquartered **Scantech International** told ***IM***: "Sensing is not just about what we use to mine and the mine/processing environment. To us the key purpose of the resources sector is taking

material out of the ground and making it into a saleable product, obviously done safely, responsibly, ethically, sensitively and sustainably." Scantech focuses on conveyor mounted sensors that measure the quality, such as elemental content, moisture content, and ash in coal, so that measurements are available as early as possible in the process, such as after the sizer/crusher so the quality is known and can be managed.

This can be underground or on surface. "This greatly extends the ability to know material quality accurately beyond the slurry analysis systems that have been used for many years in flotation plants. Once it is in a slurry it is too late to try and change the grade." Minute by minute measurement increments from real time, continuous, non-contact, transmissive techniques gives very representative results on conveyed material that can be used for feedback to mining operations on quality mined; diverting waste so it is not processed, including mill feed and pebble recycle flows; diverting increments with high deleterious components to prevent plant upsets; and bulk sorting by diverting increments onto different stockpiles or to different processes, such as feed marginal ore to particle sorter, feed sulphide ore to flotation and oxide to leach.

It allows for blending ores to generate a more consistent feed quality and optimise feed chemistry (eg ore grade, pyrite, carbonate content [affects pH], etc. It allows operators to feed forward information by measuring after the crusher to let plant operators know what they will be getting into the mill (after the crushed stockpile) and any major changes in quality, geometallurgical domain, etc so they can optimise processing, reagent dosing, etc in real time. It offers another tool for ore reconciliation and metal accounting; while ensuring product quality meets specifications prior to shipment (eg during train loading), typically confirmed by sampling and lab results (for certification) after the train/ship has left.

"Knowing the ore and product grade in real time allows real time fine tuning of the process operations and results in increased metal recoveries, improved productivity, such as higher output for same feed tonnes by increasing average grade through waste removal, improved consistency of product quality such as fewer out of spec shipments, and better quality control generally as it is done in real time. These are process control technologies. While we acknowledge that sensors are important in other applications, the technologies we utilise here are all proven over decades in the coal and cement industries, which have been much lower value in terms of products, and the very conservative minerals industry is very slow to accept them. With paybacks at existing customer sites of a few weeks to a few months the technologies are seen as providing competitive advantages which some customers are not yet ready to share with everyone."

Scantech has over 60 installations of on conveyor elemental systems in iron ore, phosphate, manganese, copper and lead-zinc. "Our competitors are still focussed on the cement and coal sector applications of these technologies."

An example of an iron ore user is Fortescue Metals Group (FMG). As Fortescue enters a phase of asset consolidation and debt repayment over expansion, the business is commanding stronger performance through enhanced plant operating practices and minesite cost reduction initiatives. To this end, the strategic placement of instrumentation is an area being given greater consideration. Access to real-time information pertaining to conveyed materials is of major interest to operators for making timely process control decisions. A paper entitled *Geoscan On-Line Analyser use for Process Control at Fortescue Metals Group sites in Western Australia*, was presented by Dr Luke Balzan, Scantech Technical Consultant along with Billie-Jo Beven, FMG Principal Metallurgist and Scantech Product Optimisation Manager, Andrew Harris, at the AusIMM Perth Iron Ore conference in July 2015. The authors outlined how Fortescue has recognised the importance of accurate and up-to-date process information about their ores

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and hence, has adopted the use of Scantech's Geoscan mineral analysers at two of their mines.

There are two Geoscans at Cloudbreak; one on the ROM feed conveyor and another on the final product conveyor. These allow the in-feed material grade characteristics to be assessed. Moreover, the final product stream can be monitored to ensure product quality is maintained within acceptable quality tolerances. A third Geoscan is installed at Christmas Creek mine on a conveyor that transfers final products to stockyards; and a fourth at Christmas Creek is expected to be installed.

Scantech says it first recognised the potential for the use of its Geoscan analysers in iron ore many years ago and in 2003 became the first supplier of an on-belt analyser to this industry. Since then, Scantech has supplied over 40 Geoscans to the iron ore industry at locations around the world, as well as having installations in manganese and other base metals in addition to its coal and cement installations. "The application and usefulness of this equipment quickly became apparent, where analysis results from a Geoscan could be used in feedforward and feedback control systems. The technology also delivers significant gains in efficiency and processing performance with these benefits being well known and documented. The ability to make rapid changes based on results obtained in real-time has offered significant benefits to customers in a range of industries, with specific gains seen in diversion of on-grade material away from expensive beneficiation operations, reconciliation of grades from block-model information, accounting of upgrade factors, and diversion of waste from processing systems."

At Cloudbreak, Geoscans are situated on the run-of-mine (ROM) feed from the primary crusher, and on the final product conveyor. These two Geoscan locations allow CB to carefully monitor both the feed to and output from their ore processing facility (OPF). The ROM Geoscan (CV101) provides information that allows for accounting and tracking of feed grade, while the Geoscan on the product belt (CV107) is able to quickly determine and therefore ensure that product grade is within specification. An assessment of upgrade factors can also be generated, giving the site a metric to determine and potentially improve their processing efficiencies. At Christmas Creek, a single Geoscan monitors products generated from two ore processing facilities upon material movements to the stockyard, with a new Geoscan likely to be installed on the train load out (TLO) facility, thereby giving a measurement in real-time of whether a train is being loaded on-grade. Geoscan-derived data is used by Mine Quality in the first instance to gauge the performance of OPF feed blends against ROM stockpile grade estimates as derived from grade control data. Recent improvements at CB include improved visual tracking of online feed and product grades for several key elements using Babelfish, which allows for greater control and regulation of contaminant grades in final product. Recently developed is concurrent trending of CV101 feed grades against CV107 product grade information to assist in tracking OPF processing performance. Other areas of development include the estimation of real-time upgrade factors utilising a small time offset between Geoscan feed and product outputs to account for plant residence time. The next step will be to advance the development of a mobile application that allows for plant upgrades to be monitored remotely. Moreover, the installation and utilisation of Scantech through-belt moisture (TBM) analysers allows operations to monitor feed moistures for delivering high plant throughput rates and acceptable final product moistures.

"Improved monitoring of analyser outputs in addition to frequent evaluations and as necessary uploading of refined Geoscan calibrations has seen a renewed focus and reliance on Geoscan data by site teams. Real-time elemental information also provides an indicative tool that can be used for improved monitoring of processing performance and particularly the impact of scrubbing in delivering budgeted plant upgrades." ***IM***

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