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Tel: +44 (0)1925 830344 Fax: +44 (0)1925 830058

www.komatsu-mining.de

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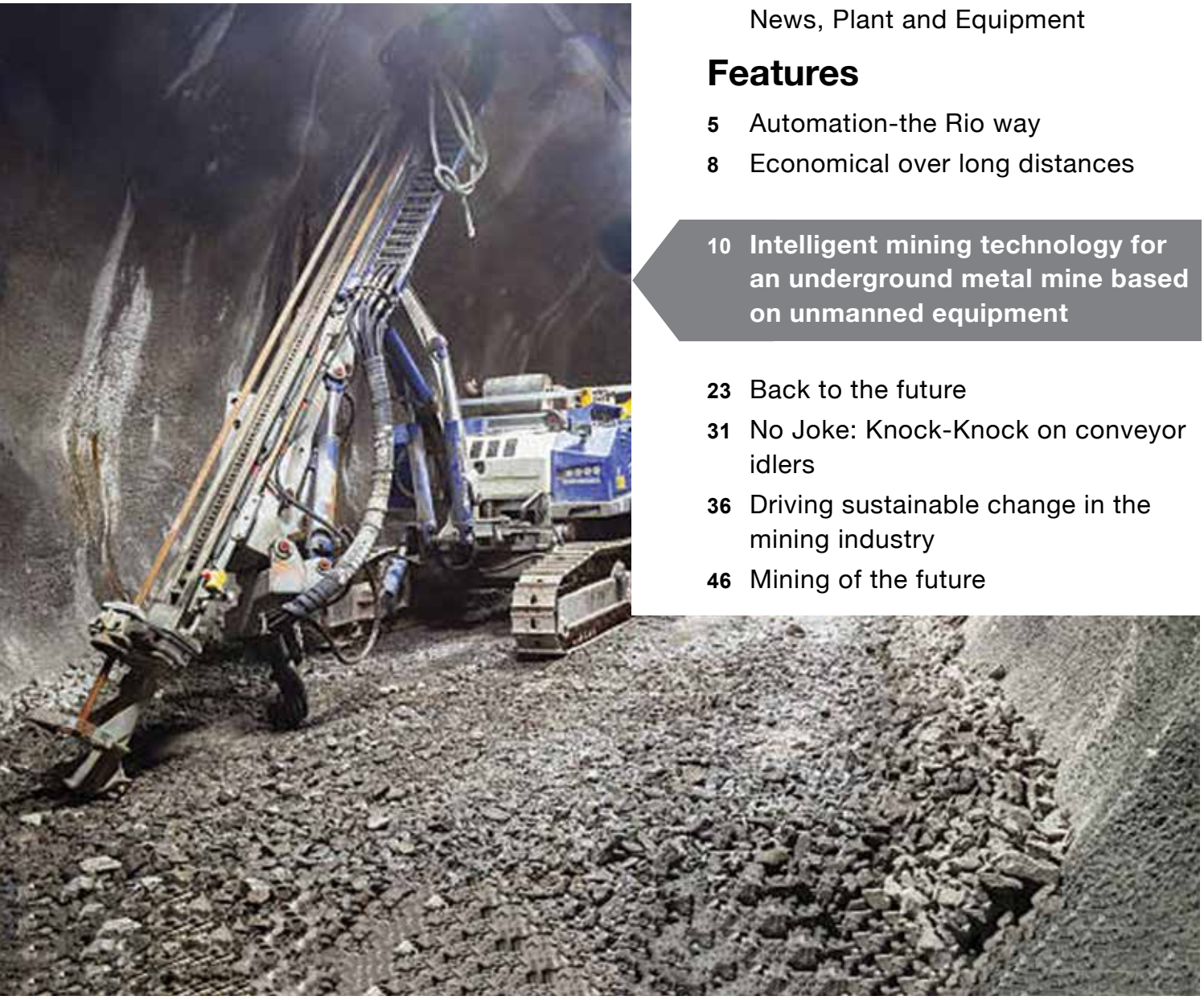

Managing Director and Publisher: Trevor Barratt

International Sales:

Gordon Barratt	+44 1909 474258	gordon.barratt@tradelinkpub.com
Gunter Schneider	+49 2131 511801	info@gsm-international.eu

Graphic Designer: Sarah Beale sarah@g-s-g.co.uk

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Automation has been part of its business for more than a decade, and helps run safer, more efficient, and low-cost operations. Rio commented “We are removing driver error and improving safety by increasing the automation of trucks, drills and trains. Our Iron Ore business operates the world’s first fully autonomous, heavy-haul long-distance railway system – AutoHaul™ – which has so far travelled more than 7 million kilometres Across many of our operations, we are using remotely operated land rovers and drones to do risky jobs and keep our people safe – like checking high walls in open pits and parts inside big machinery”.

AUTONOMOUS TRUCKS

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In 2018, each truck was estimated to have operated on average 700 hours more than conventional haul trucks, with 15% lower costs – delivering clear productivity benefits. They also take truck operators out of harm’s way, reducing the risks associated with working around heavy machinery.

AUTONOMOUS TRAINS

AutoHaul™ is the world’s first heavy-haul, long-distance autonomous rail operation, which transports iron ore to Rio Tinto's port facilities in the Pilbara region of Western Australia. Our network includes about 200 locomotives on more than 1,700 kilometres of track in the Pilbara.

AutoHaul™ improves safety by reducing risk at level crossings and through its automated responses to speed restrictions and alarms. It also eliminates the need to transport drivers to and from trains mid-journey saving almost 1.5 million kilometres of road travel each year – a safety risk. And it delivers productivity and environmental benefits by using information about the train and rail network topography to calculate and deliver a safe, consistent driving strategy.

AUTONOMOUS DRILLS & CHARGE TRUCKS

We operate the largest autonomous drilling fleet in the world. We use 26 autonomous drills to safely and accurately drill blast-holes from a remote location. An operator, located at our operations centre, can plan activities for each drill for an entire shift remotely, rather than doing the work manually on-site. We have also introduced smart charge trucks, which automate the process of pumping explosives into drill holes. The trucks use computer systems and data analytics to determine the right amount of explosives to use for each drill hole, helping to reduce wastage and improve the effectiveness of the blast.

DRONES & REMOTELY OPERATED VEHICLES (ROVS)

We use drones and ROVs for real-time 3D mapping and equipment inspections, as well as checking slopes, crests and walls for safety risks like cracks and signs of rock movement.

One of the biggest benefits of our drones is safety. There are some jobs where it is better for drones to do it rather

than people – for example high wall mapping. By using drones, we are removing people from harm's way.

We are also using drones fitted with thermal diagnostic capability to identify equipment problems from the air. We can identify high friction rates on equipment in real time and notify the maintenance teams so the issues can be addressed.

The Drill and Blast team at our Oyu Tolgoi copper-gold mine in Mongolia are using drones to help them in the "blast clearance" process.

ROBOTIC PROCESS AUTOMATIONS

Bots come in all shapes and sizes, and are commonplace in our everyday work. Bots are what we call our robotic process automations (RPA), and they are already supporting our Iron Ore and Aluminium product groups and other support functions.

Our Information Systems & Technology team are making our jobs easier by developing and implementing this technology behind the scenes. Bots complete repetitive tasks for us like opening emails and attachments, data entry, moving files, filling in forms and making calculations.

At our Hope Downs 1 mine in the Pilbara, Western Australia, we developed an RPA responsible for logging the site's maintenance order requests. The bot is now saving our maintainers significant time each shift, and simplifying the shift handover process. There are bots doing scheduling, ordering, learning and development, maintenance, finance, marine, and core services in Iron Ore. More bots are in, or about to be in development, helping to make our jobs easier and more efficient.

MARK THE ROBOT: OUR LITTLE SUPERHERO

Deep inside our Bingham Canyon copper mine in Utah, western United States, we use a remote operated vehicle team – including drones and other equipment – to help keep people safe and save the business money. The newest team member is a robot named Mark II, designed, and built by our chief drone pilot, Matt Key, using an over-the-counter rock crawler and a 3D printer. Matt's ingenuity meant Mark II cost a mere $10,000 to build, a fraction of the $100,000 it could have cost to buy a similar robot. Mark II squeezes into small spaces and manoeuvres over tough terrain to test oxygen levels and collect soil and water samples.

OPERATIONS CENTRES

Our operations centres in Perth and Brisbane in Australia, and the Saguenay region in Canada enable all our mines, ports, and rail systems to be operated from a single location. The teams work in rooms filled with screens that show the entire operation in action – in real-time. Using tools like predictive maths, clever computer code and powerful software, our operations centres help us identify opportunities for improvements and efficiencies – from finding the best way to get ore from the ground to improving the way we make products.

HELPING SKILL THE WORKFORCE OF THE FUTURE

In Western Australia, where automation may have a disruptive impact on our communities, we launched a partnership with the government of Western Australia and South Metropolitan TAFE (Technical and Further Education) to develop the first nationally recognised courses in automation. This partnership aims to train and certify people in new skills, making them easily transferable – so that people can follow opportunity wherever they find it.

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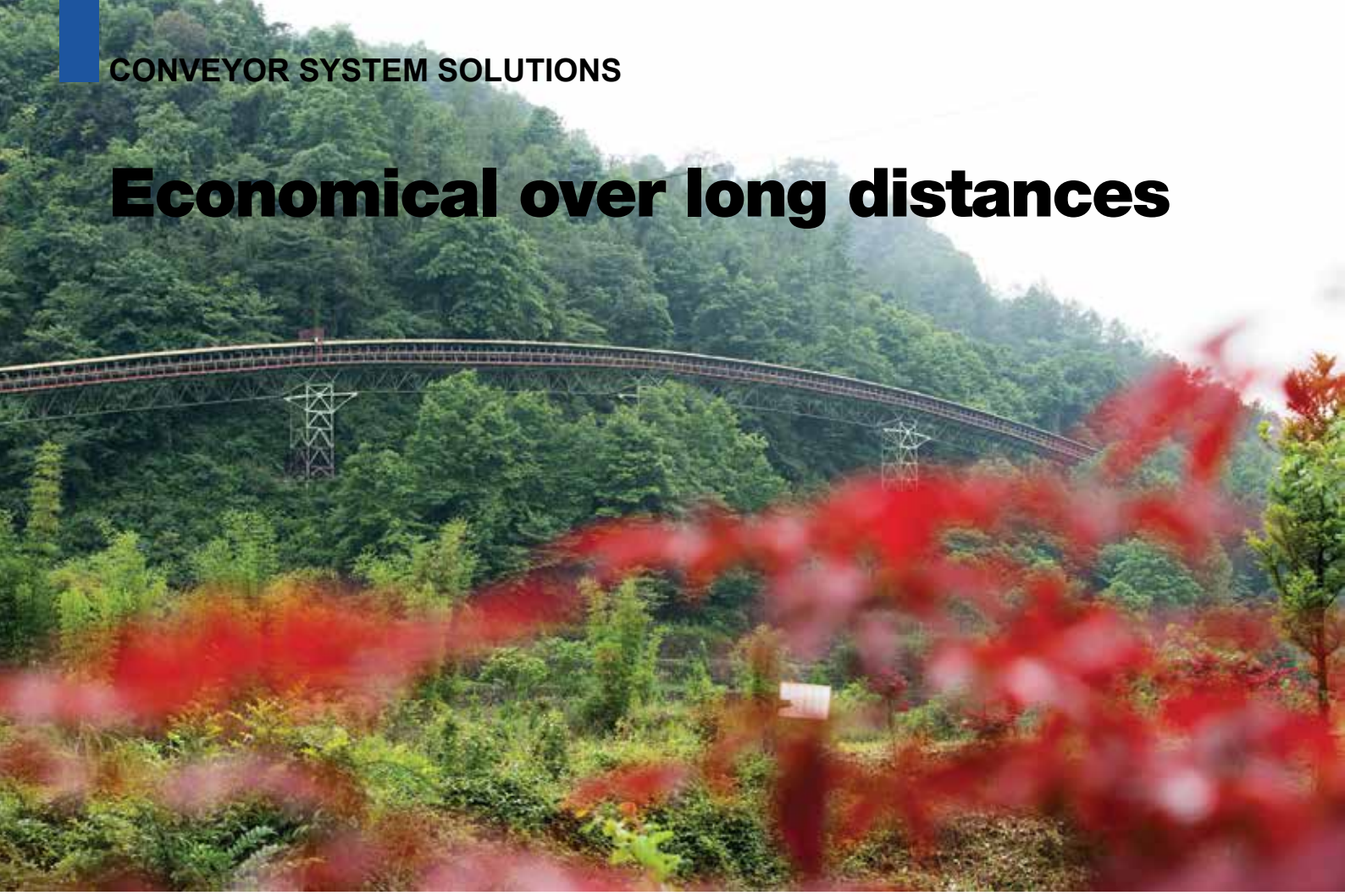

Whenever technically possible, the conveyor is adapted to the topography.

Mined raw materials travel along extensive transport routes. Conveying and loading systems enable a safe, efficient and environmentally friendly handling of these materials. At MINExpo 2021, the international tradeshow platform for the mining industry, which will take place from September 13th to 15th in Las Vegas/USA, BEUMER Group will present efficient system solutions with overland conveyors, Pipe Conveyors and ship loaders.

Overland conveyors and Pipe Conveyors by BEUMER Group enable mine operators to create individual routes for the transport of raw material with steep angles of inclination and narrow curve radii that are adapted to the respective task and topography. When planning these systems, the system provider also relies on camera-equipped drones for planning, implementation and documentation. Using special software solutions, the engineers evaluate the aerial photographs photogrammetrically to generate digital terrain models.

The product range of the system supplier includes stackers and bridge reclaimers for storage yards, whether with or without blending bed systems. They stack bulk material and guarantee a maximum blending effect. Users can also efficiently homogenise large quantities of different bulk materials and bulk material qualities and thus ensure the uniformity of the raw materials used. For efficient loading, BEUMER Group also offers ship loaders with fixed booms and extendable telescopic belt conveyors. To supplement these, users can also procure bulk loading heads which they can use to load bulk materials into silo vehicles quickly and without dust.

With BEUMER Group, the customer receives everything from one single source, starting from inquiry to technical dimensioning and site installation. If desired, the system supplier continues to support the operator with its comprehensive range of services after commissioning of the system to ensure high levels of machine availability during the entire running period.

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Intelligent mining technology for an underground metal mine based on unmanned equipment

This article analyses the current research status and development trend of intelligent technologies for underground metal mines in China, where such technologies are under development for use to develop mineral resources in a safe, efficient, and environmentally friendly manner. We analyse and summarise the research status of underground metal mining technology at home and abroad, including some specific examples of equipment, technology, and applications. We introduce the latest equipment and technologies with independent intellectual property rights for unmanned mining, including intelligent and unmanned control technologies for rock-drilling jumbos, down-the-hole (DTH) drills, underground scrapers, underground mining trucks, and underground charging vehicles. Three basic platforms are used for intelligent and unmanned mining: the positioning and navigation platform, information-acquisition and communication platform, and scheduling and control platform. Unmanned equipment was tested in the Fankou Lead-Zinc Mine in China, and industrial tests on the basic platforms of intelligent and unmanned mining were carried out in the mine. The experiment focused on the intelligent scraper, which can achieve autonomous intelligent driving by relying on a wireless communication system, location and navigation system, and data-acquisition system. These industrial experiments indicate that the technology is feasible. The results show that unmanned mining can promote mining technology in China to an intelligent level and can enhance the core competitive ability of China's mining industry.

INTRODUCTION

With the world's rapid economic development, the demand for mineral resources is increasing. It has been forecast that the depth of more than 33% of the metal mines in China will reach or exceed 1000 m within the next decade. Deep underground mining will become the trend of metal mining in China[1]. To overcome the disadvantages of traditional mining methods, such as excessive resource consumption, poor operating environments, low production efficiency, high safety risks, high production costs, and severe pollution, it is essential to develop an intelligent mining technology for underground metal mines that provides complete safety, environmental protection, and efficiency[2,3]. Some developed countries have done a great deal of work in the field of intelligent mining for underground metal mines over many years, and thus have considerable experience in this field. At the beginning of the 21st century, Canada, Finland, Sweden, and other developed

countries made plans for intelligent and unmanned mining. At the Stobie Mine, an underground mine belonging to the International Nickel Company of Canada, Ltd. and a typical example of such an automated mine, mobile devices such as scrapers, rock drills, and underground mining trucks are operated remotely and workers can operate the equipment directly from the central control room on the surface[4]. According to the Canadian government's 2050 long-range plan, Canada intends to transform one of its underground mines in the northern part of the country into an unmanned mine. The plan states that all devices will be controlled from Sudbury via satellite in order to achieve intelligent and unmanned mining. Another intelligent mining program covering 28 topics – including the real-time process control of mining, real-time management of resources, construction of a mine information network, and application of new technology and automatic control – was carried out in Finland. Sweden has developed the Grountecknik 2000 strategic plan for mine automation[5-7], and veteran mining equipment companies such as Atlas Copco are actively developing a series of unmanned underground mining equipment and related control systems that can be used to implement the strategic plan. One of the most famous institutes in unmanned vehicles, the Commonwealth Scientific and Industrial Research Organisation of Australia, is making great efforts to achieve the intelligent mining of underground mines, with a particular focus on the unmanned control of various types of equipment[8].

Although these developed countries have already invested a considerable amount of time and money into the study of intelligent mining, only a few related studies have been carried out in China, especially in the field of intelligent equipment and platforms. In order to rapidly advance its intelligent mining capabilities, China is supporting many intelligent mining projects, including the Key Technology and Software Development for Digital Mining project and the High-Precision Positioning for Underground Unmanned Mining Equipment and Intelligent Unmanned Scraper Model Research project. In particular, a project titled Intelligent Mining Technology for Underground Metal Mines was established during the 12th Five-Year Plan, in order to promote intelligent mining technology to a certain extent. This article introduces several research achievements and their applications in this project. Trackless mining equipment such as rock-drilling jumbos, down-the-hole (DTH) drills, underground scrapers, underground mining trucks, and underground charging vehicles have been developed using intelligent technologies. Suitable communication techniques, sensors, artificial intelligence, virtual reality, information technology, and computer technology for mining equipment and platforms have been implemented. The experimental results indicate that some of the system's functionalities are innovative and show good performance.

INTELLIGENT MINING

Mining is one of the oldest industries in the world. Mining production techniques have passed through a rapid change from artificial production, mechanised production, and on-site remote-control production to intelligent and fully automated production. In order to move the mining industry forward, mechanisation tools have been developed, single-equipment and independent systems have been automated, and the entire mining production process has been highly automated[9]. By integrating information technology with the industrialisation of mining technology, intelligent mining technology has been rapidly developed, based on mechanised and automated mining, as shown in **Figure 1**. This has resulted in the gradual upgrading of intelligent processes in mining equipment; unmanned and centralised mining equipment have now entered the stage of practical application, which will significantly advance the automation and information technology used in mining[10].

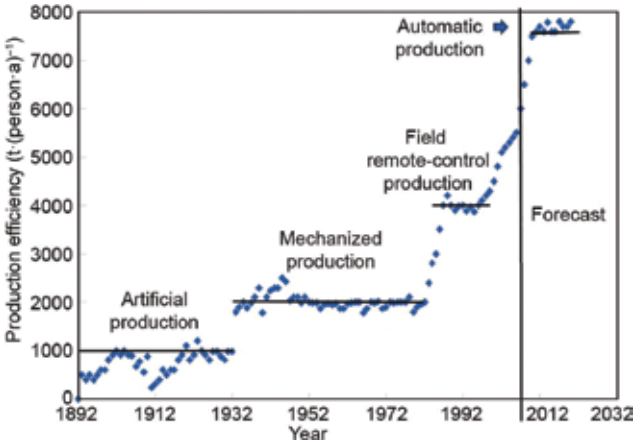

Figure 1: A comparison of production efficiency and mining technology development.

Integrated communication, sensors, artificial intelligence, virtual reality, information technologies, computer technologies, and unmanned control equipment were combined in order to achieve intelligent mining technologies, as shown in **Figure 2**. Such technologies are based on precise, reliable, and accurate decision-making and production process management through real-time monitoring; they allow mine production to be maintained at the optimum level, and lead to improved mining efficiency and economic benefits. In this way, green, safe, and efficient mining can be achieved.

Taking a typical trackless mining technology as an example, intelligent mining technology can be divided into three layers – the control layer, transport layer, and executive layer[11].

As shown in **Figure 3**, the executive layer mainly consists of trackless mining equipment such as rock-drilling jumbos, DTH drills, underground scrapers, underground mining trucks, or underground charging vehicles. The transport layer mainly includes a ubiquitous information-acquisition system, wireless communication system, and precise positioning and intelligent navigation system. The control layer is designed as a system-level platform, and is responsible for intelligent mining process scheduling and control. This is the core of the entire system, because all intelligent mining-related functions and control ideas are implemented through this platform. First, a reasonable mining plan is designed by analysing the reserves of mine resources and geological conditions in combination with the underground production schedule. Next, an intelligent scheduling and control platform is developed. Control instructions for the equipment are sent through the transport layer to a specific piece of equipment in order to perform a mining task at a specific position and time. Within the executive layer, the control layer collects current information on the tunnel and basic information about the vehicle in real time; this information can be used to determine the location of the equipment or adjust it at any time until that entire stage of the mining plan is successfully completed.

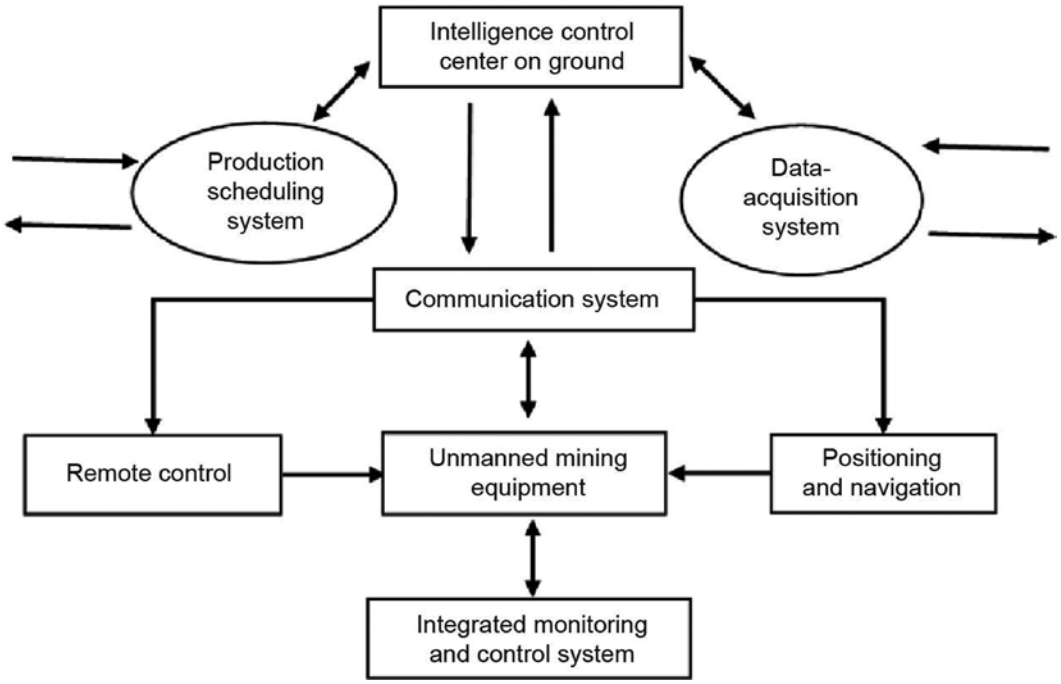

Figure 2. The fundamentals of intelligent mining.

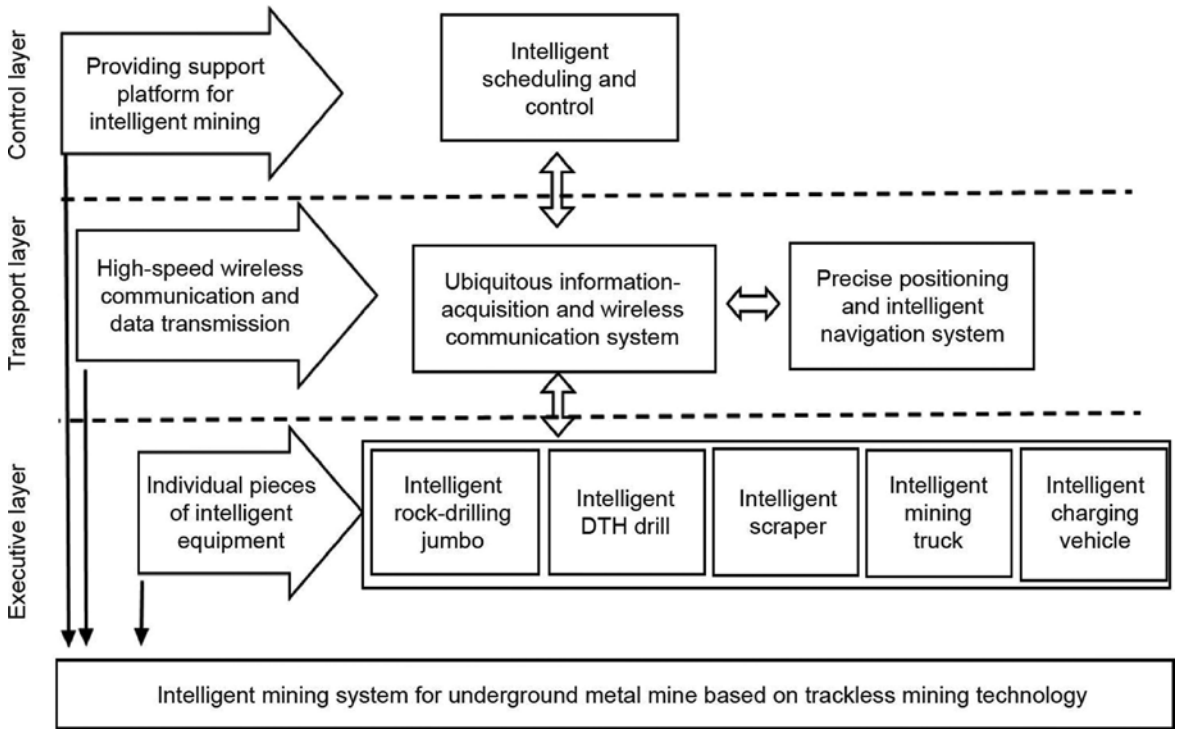

Figure 3: A diagram of intelligent mining technology.

UNMANNED EQUIPMENT

Intelligent trackless mining technology is based on intelligent unmanned equipment at the executive layer, such as rock-drilling jumbos, DTH drills, underground scrapers, underground mining trucks, or underground charging vehicles. The functions of intelligent and unmanned mining equipment differ according to the different tasks each piece of equipment must carry out.

Intelligent rock-drilling jumbo

Rock drilling is the key process in mining, and plays a very important role in productivity, cost, and efficiency. Different geological conditions require different mining methods, and different methods require different types of rock drilling. A hydraulic rock-drilling jumbo is needed for medium-length hole drilling (i.e., depth of 20-30 m, diameter of 60-100 mm)[12]. An intelligent and unmanned rock-drilling jumbo

Figure 4: Remote control platform on the surface with on-site audio and video signals.

has been designed to support intelligent mining technology and efficiently complete drilling work.

Remote control and a virtual-reality display were the first basic technologies implemented in the unmanned hydraulic rock-drilling jumbo. **Figure 4** shows the initial unmanned control platform for the jumbo on the surface. The virtual prototype display system, including on-site audio and video signals, is well-integrated in order to increase the feeling of immersion while performing remote-control operations.

Furthermore, the rock-drilling jumbo is autonomously controlled and operated in the tunnel under the guidance of a positioning and navigation system. By coordinating the positioning system and altitude control system, the jumbo can achieve autonomous driving to the location from the dispatch layer. This is a major step toward achieving continuous operation without interference. Given the coordinates of the drilling-hole position in the three-dimensional (3D) digital map of the mine, the identification of the stope top and floor and the accurate positioning of the rock-drilling system can be achieved independently. This provides a basis for unmanned operation. The intelligent control flow diagram is shown in **Figure 5**.

The rock-drilling parameters are independently adjusted according to the rock conditions. The intelligent rock-drilling jumbo (shown in **Figure 6**) is equipped with components for intelligent blockage prevention, rock-characteristic acquisition, and frequency matching; an automatic rod function; and a fully automatic drill-pipe bank. The hole-blasting parameters are specified independently, according to the scheduling system that is used, in order to ensure continuous drilling.

INTELLIGENT DTH DRILL

A DTH drill is needed when the rock-drilling jumbo cannot be used, such as in an ultrahigh section with large-bore deep-hole drilling (i.e., depth greater than 30m, diameter of ϕ100-150 mm). The disadvantages of the DTH drill are its lack of safety, low ease-of-operation design considerations, insufficient matching of structure and parameters, oil leakage, and seepage. The existing DTH drill has low automation and is inefficient[13]. Therefore, an intelligent unmanned DTH drill was designed to support the intelligent mining technology.

The first features that were implemented in the new DTH drill were intelligent autonomous driving and a hole-positioning function. Like an intelligent rock-drilling jumbo, an intelligent DTH drilling machine should be capable of drilling holes in a predetermined position according to the requirements of the mining design. An autonomous driving function is needed for when the equipment is in drilling operation. The structure of a four-wheel independent steering system is shown in **Figure 7**; this system was developed and applied to the new DTH drilling machine in order to ensure free turning in a narrow space.

Another feature to be applied was the automatic matching of the rock-drilling parameters with intelligent control technology.

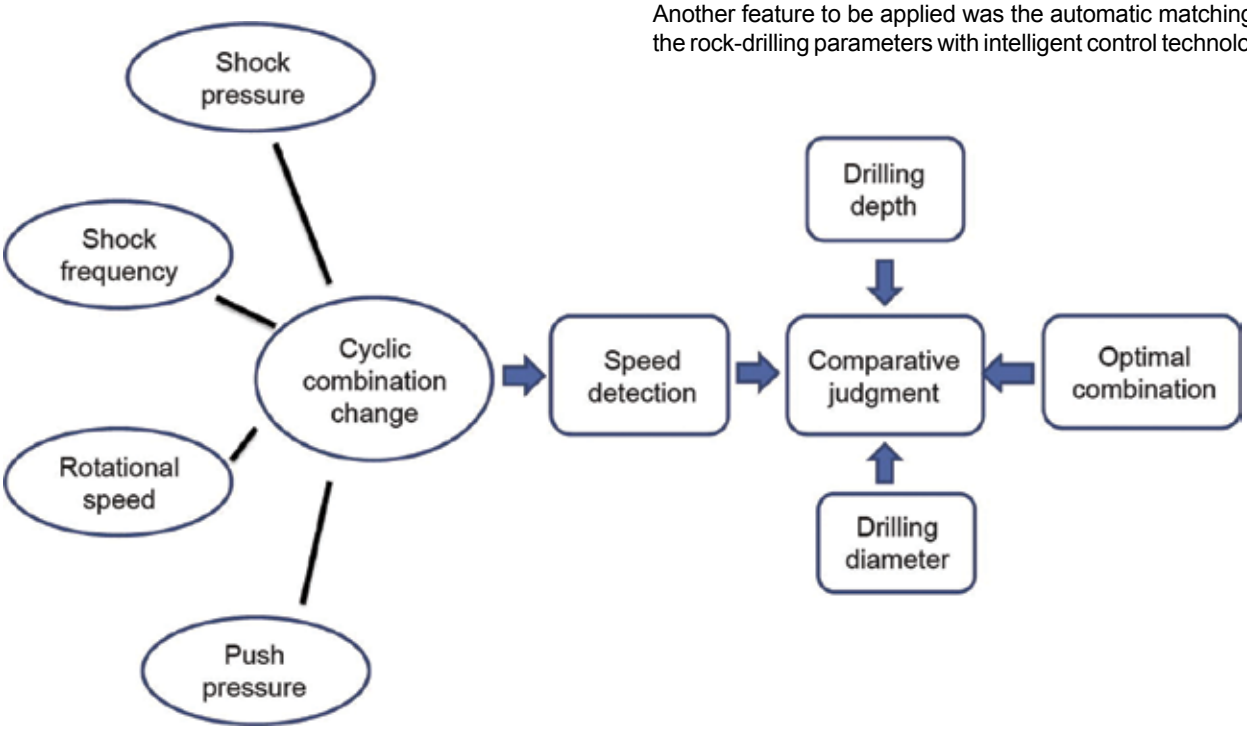

Figure 5: Intelligent control flow diagram of hydraulic drilling.

Figure 6: Intelligent rock-drilling jumbo.

The effect of the working parameters on drilling efficiency was analyzed by evaluating drilling parameters such as axial thrust, rotary speed, rotary torque, impact pressure, impact frequency, and rock-drilling pressure. A theoretical calculation model or empirical formula was deduced for each parameter selection, and the key parameters affecting drilling efficiency were determined. The optimal drilling parameters for the matching method were selected, including air pressure, gas volume, and propulsion force. The drilling efficiency was then optimised by intelligent control of the operation parameters.

The third feature was anti-deviation control technology, as shown in **Figure 8**. Blasting can be directly affected by many factors, such as the positioning accuracy of the drill point, depth of the hole, and declination of the hole. An intelligent DTH drill should control the drill pipe in real time in order to avoid large errors that will affect the subsequent blasting[14].

The final features were multiple drill-pipe storage, automatic sorting, and anti-blocking resistance rod technology. **Figure 9** shows the operation of an intelligent DTH drilling machine. The characteristics of the DTH drill determine that if the hole is 60m deep, then at least 40 drill pipes are needed every time. Therefore, multiple drill-pipe storage and automatic sequencing feed-rod technologies were designed in order to improve the operational efficiency of the equipment. By analyzing the mechanism of the drill rod, the parameters of the control function of the DTH drill rod can be established in order to avoid blocking of the rod during the automatic sorting process.

Intelligent underground scraper

Since the first successful testing of the ST-5 scraper by Wagner in the 1960s, scrapers have been widely used in underground mining because of their high efficiency, flexibility, maneuverability, and low cost. With the rapid development of electronic and information technology, intelligent control technologies for the underground scraper have been rapidly developed. The operation of the underground scraper has gradually changed from manual to remote control. At present, it is known as the fourth-generation autonomous scraper[15-18].

The main task of a scraper is the repeated transportation of ore between the loading point and the dumping point.

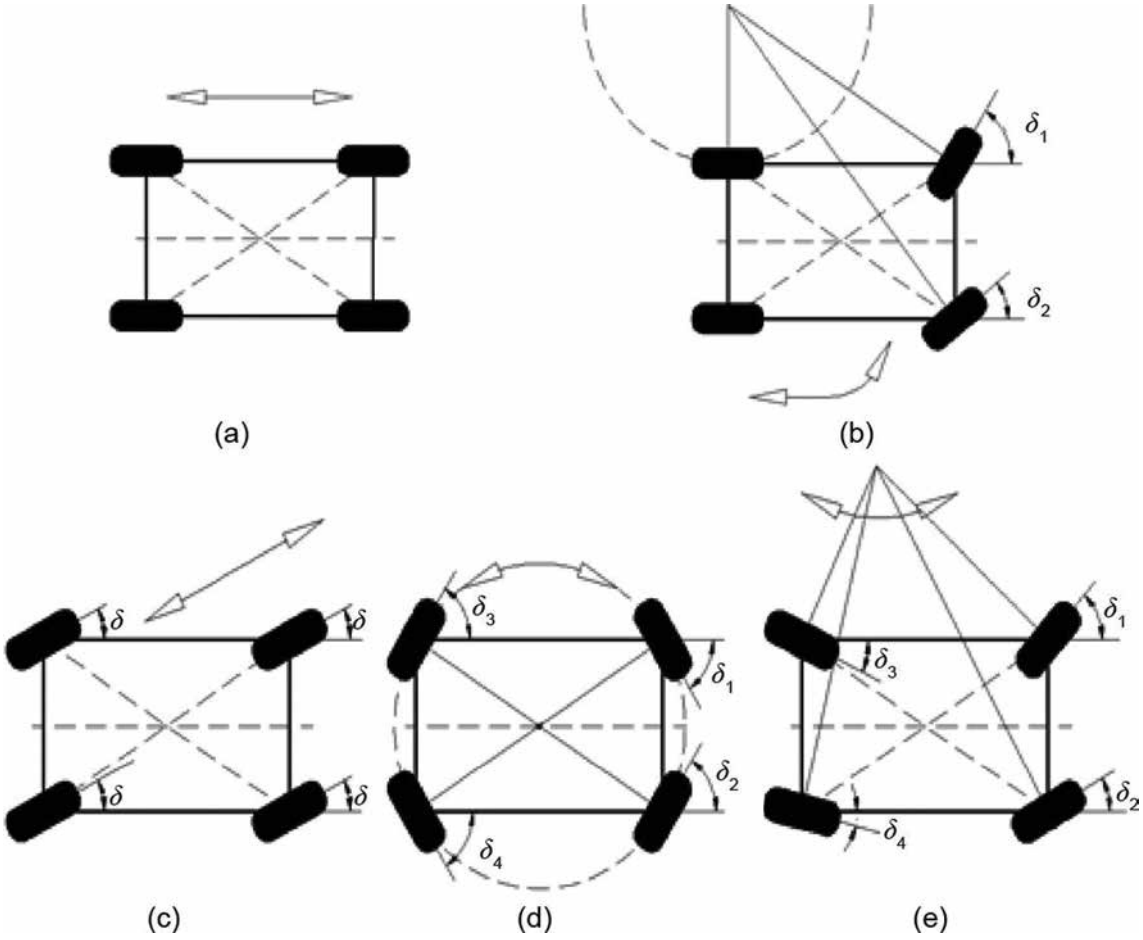

Figure 7: The structure of a four-wheel independent steering system. (a) Straight driving; (b) front-wheel steering; (c) oblique driving; (d) point-turn motion; (e) four-wheel steering. d: the angle of the four wheels; δ_1 and δ_2: the angles of the forward wheels; δ_3 and δ_4: the angles of the backward wheels.

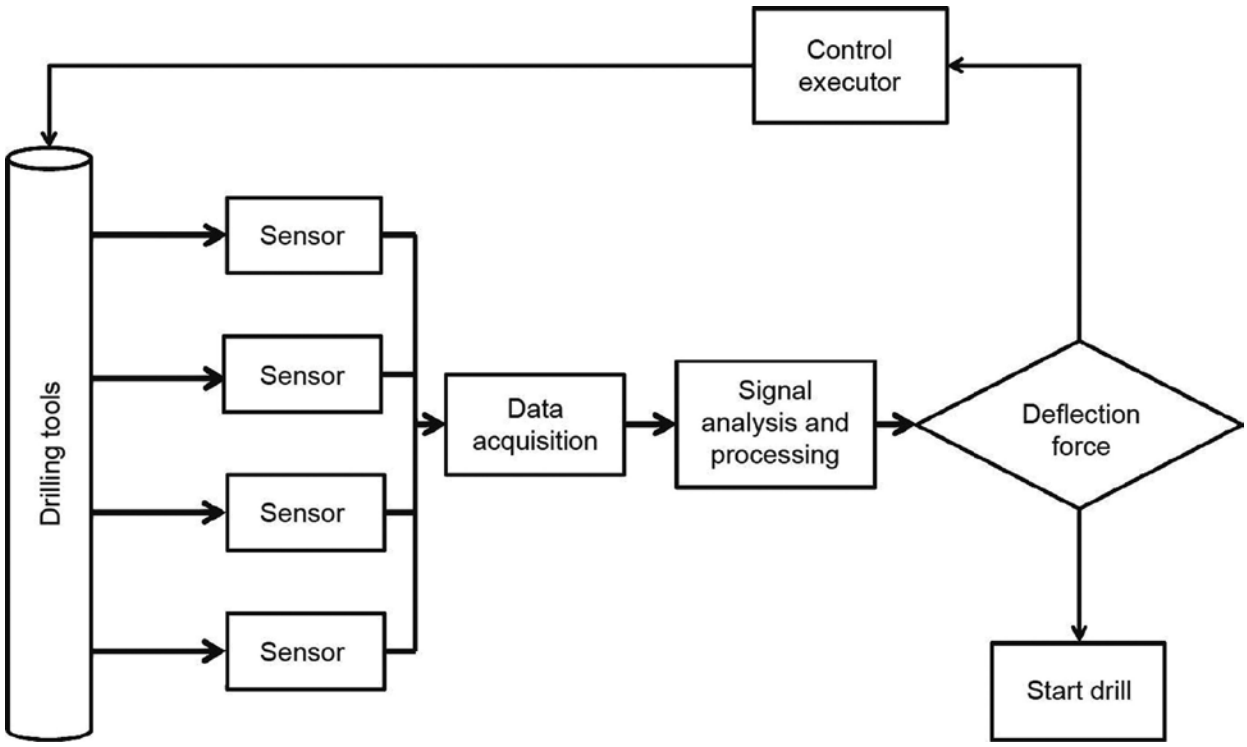

Figure 8: Anti-deviation control flow diagram of the drilling rod.

Figure 9: Operation of the intelligent DTH drilling machine.

Therefore, the first task of an intelligent scraper is to achieve unmanned driving during ore transportation. Recognition of the tunnel environment is achieved by a body-loading sensor, and a positioning and navigation system is used to assist in the operation of the scraper. **Figure 10** shows the driving algorithm of an unmanned scraper.

Another typical task of a scraper is shoveling ore, which may include automatic weighing. The main purpose of automatic weighing is to obtain real-time data and automatic statistics for the ore. Automatic weighing technology can obtain statistics for the class report, daily report, and monthly report, and can transfer this data to the central control room through the communication network. It can also enable managers to grasp the status of underground production in real time.

An intelligent underground scraper can automatically drive to a preset fixed point in order to dump ore, by relying on the positioning system, navigation system, and wireless communication system after the dispatch instruction has provided a specific dumping point. This is the basis for continuous unmanned mining with scrapers. An intelligent underground scraper does not operate within the view of its operator, and failure information cannot be observed in real time; therefore, it must be able to perform in an intelligent manner using the fault-diagnosis function[19,20]. The vehicle should be able to follow remote-control instructions from the surface such that the scraper can be controlled at any time. **Figure 11** shows the intelligent underground scraper and its remote-control platform.

Intelligent underground mining truck

An underground mining truck is the main transport vehicle for underground trackless mining, and has the advantages of mobility, flexibility, high efficiency, and economy. Mining trucks have been widely used to transport ore in underground mines. Use of an underground mining truck can significantly improve the production capacity and labor productivity, increase the production scale, and improve the mining technology and transportation system. To conserve energy and protect the environment, a double-power transmission underground mining truck can obtain electric energy using a diesel engine driving generator. It can also obtain electric energy from the frame system through a bow collector. The vehicle has two braking systems – electric and mechanical – as shown in **Figure 12**, which help to improve the degree of green mining and environmental protection.

A vehicle-control system combines the environmental information that is collected by various types of sensors. A machinelearning algorithm uses the vehicle state acquired by the articulated angle sensor to calculate the target output and control the actuator movement. **Figure 13** shows the distribution of sensors for unmanned driving. The system does not need the absolute coordinates of the vehicle; an unmanned driving function can still be achieved[21].

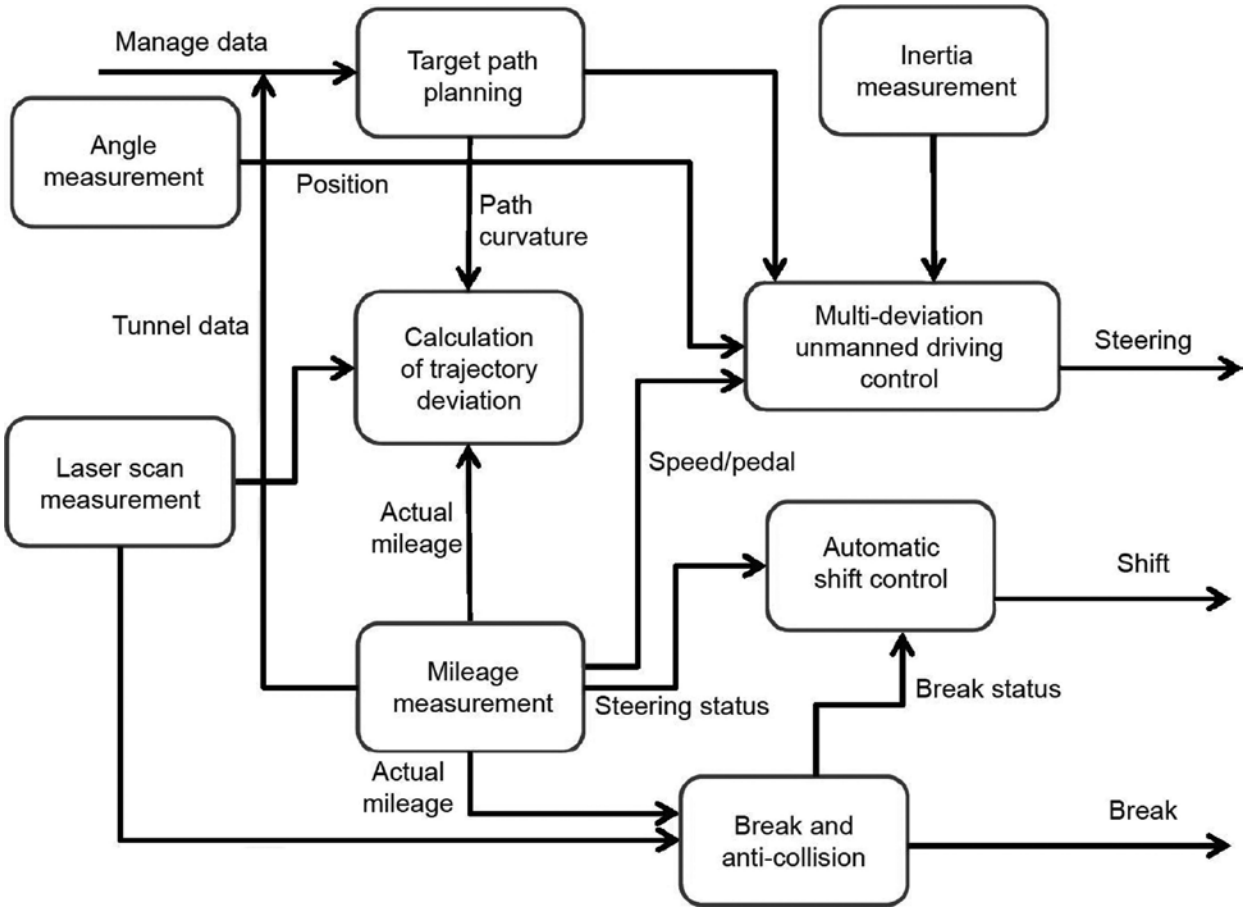

Figure 10: The driving algorithm of an unmanned scraper.

The first double-power transmission mining truck for use in an underground mine was designed in China for a full load of 35 t, a speed of 25km h-1, and a maximum climbing slope of 21.8%, as shown in **Figure 14**. In addition to its unmanned driving function, the truck is capable of vehicle lane-space detection and intelligent auxiliary driving; it also has a remote-control function. The fully loaded autonomous operation speed is higher than 10km-h-1.

Intelligent underground charging vehicle

In underground mining, the four main processes are drilling, blasting, loading, and transportation. As a charging vehicle is essential for blasting, it is very important to develop automation operation for a charging vehicle. An underground charging vehicle is an integrated mechanical and electrical product that performs raw-material transportation, explosive mixing, and gun-hole loading. It has the characteristics of a compact structure, a high degree of automation, and a wide application range.

Figure 11: An intelligent underground scraper and its remote-control platform on the surface.

An intelligent charging vehicle system is shown in **Figure 15**. The pipe-reeling speed, pipe-feeding speed, and charging speed can be digitally controlled, and the reeling and feeding speeds are automatically matched with the charging speed and hole diameter. A fully coupled charge is achieved in order to improve the blasting effect. The safety protection system performs online monitoring and fault diagnosis of the charging system. Remote fault diagnosis, remote scheduling, remote management, and the upload and delivery of production tasks and data can be easily achieved using an intelligent scheduling system on the surface.

A charging vehicle uses wireless and intelligent control technology to achieve remote control and intelligent hole searching. The start and stop of a charging system, key process parameters, temperature, pressure, and flow are displayed on the remote control. The automatic feeding and reeling system, automatic delivery, charging of

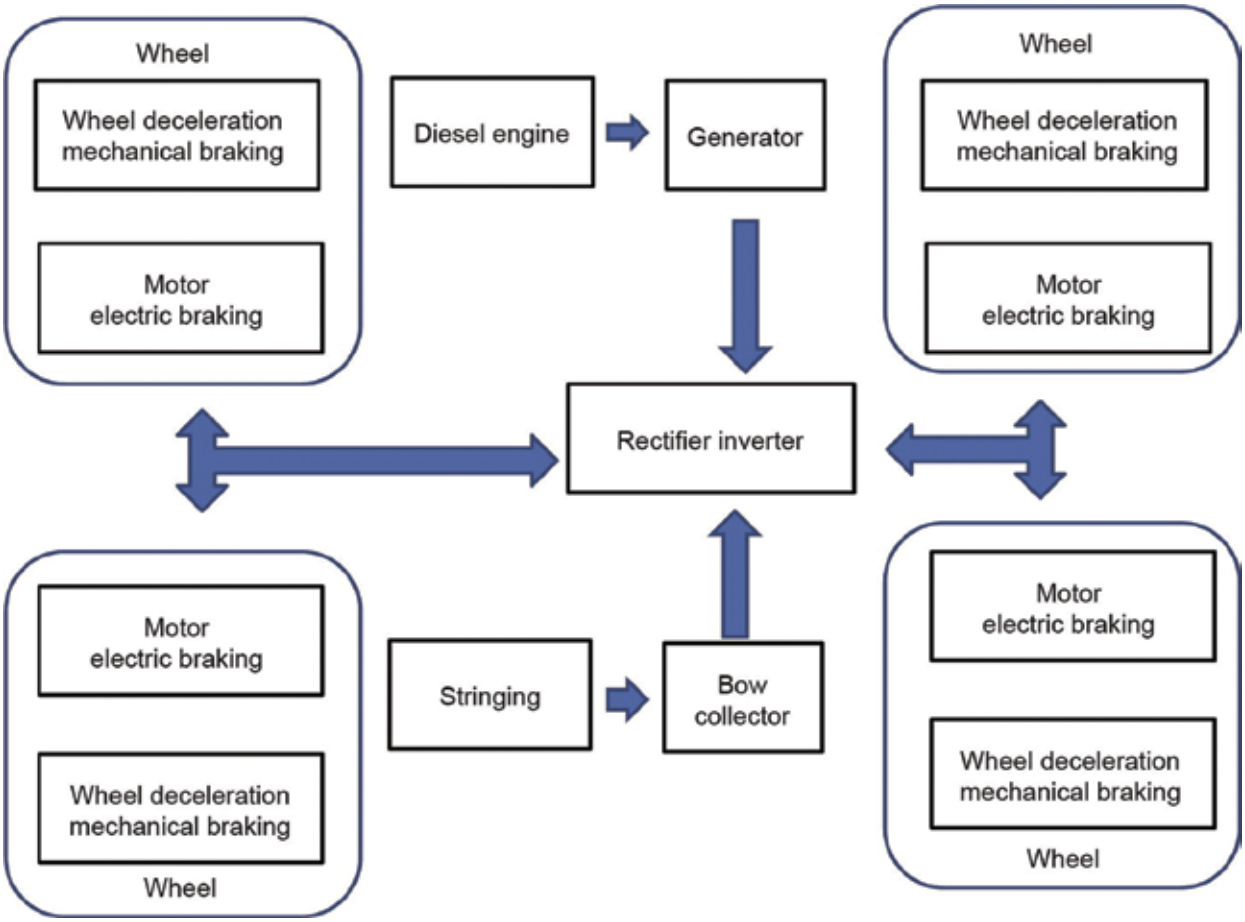

Figure 12: A system block diagram of the double-power transmission underground mining truck.

hole depth, and single-hole charging during the delivery of pipeline are designed to support intelligent charging[22].

A wireless remote-control technology is used for the vehicle, and remote control and complete unmanned driving can be achieved using a positioning and navigation system and a wireless communication system. Coordinates can be accepted from a scheduling system, and the vehicle can then autonomously drive to the designated location point of the hole and complete the charge. **Figure 16** shows the operation of a charging vehicle in a tunnel.

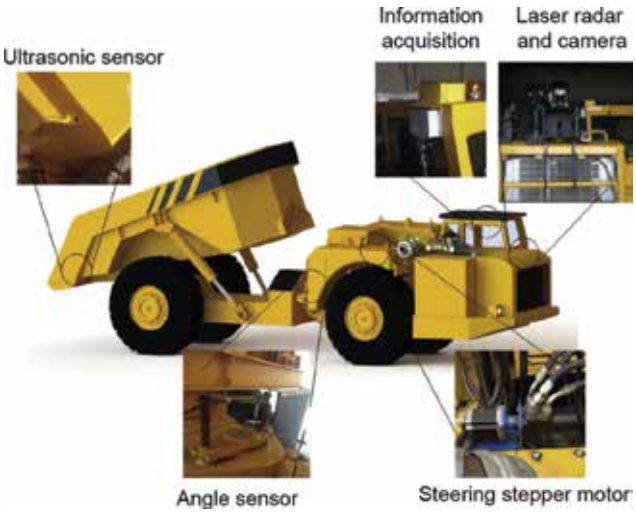

Figure 13: Distribution of the sensors for unmanned driving.

BASIC SYSTEM PLATFORMS

Positioning and navigation platform

The positioning and navigation platform consists of a precise positioning system and an intelligent navigation system. The precise positioning system can provide position and altitude information to the underground mining vehicle. The intelligent navigation system consists of two key modules for path planning and path tracking. The path-planning module helps to find the navigation path of the mine vehicle according to the dispatch instructions, and the path-tracking module helps to automatically move the mine vehicle to the target position along the planning path.

Taking a point and line as the basic geometric representation, a two-dimensional (2D) navigation map

Figure 14: An intelligent underground mining truck.

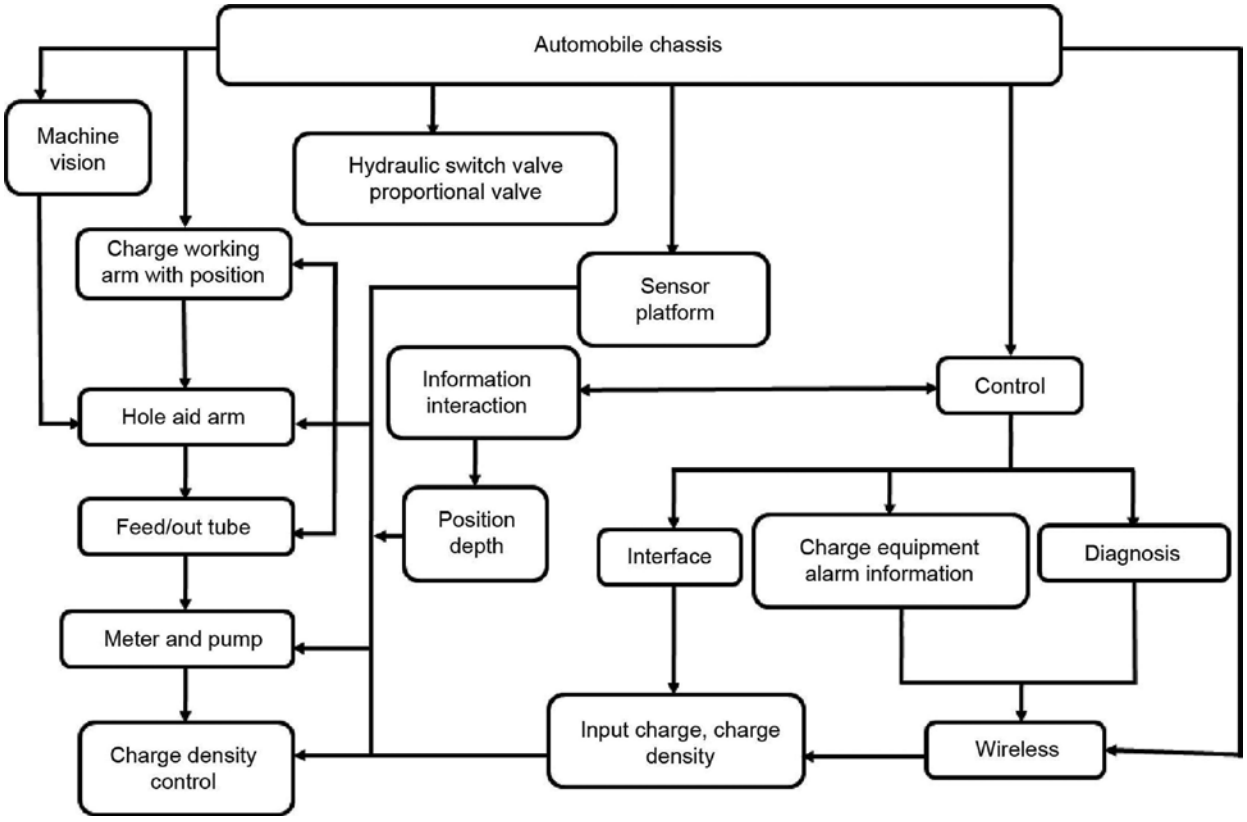

Figure 15: Design of an intelligent charging vehicle system.

was built, and accurate drawing of the underground map and detailed incorporation of the navigation information were achieved. This provides a basic map platform for the precise positioning and intelligent navigation of the mining equipment. Real-time high-precision positioning information was obtained by combining laser-positioning data with ultra-wide-band (UWB) auxiliary positioning data, as shown in **Figure 17**. The positioning system consists of a high-precision laser-positioning base station system, a vehicle machine vision system, and UWB wireless positioning technology. The positioning accuracy can reach up to 100 mm. A reasonable and smooth planning path can be searched for on the electronic map using the path-planning module, based on the breadth of the first search, the dichotomy, and the symmetric polynomial curve-smoothing method. Hybrid architecture and a real-time reflection control system were used to achieve accurate tracking of the planning path using the positioning information[23,24].

Figure 16: An intelligent underground charging vehicle.

Information-acquisition and communication platform

The main function of the information-acquisition and communication platform is to obtain intelligent mining data. The underground intelligent equipment, scheduling and control system, information-acquisition system, and data communication system work together using the same communication protocol within the framework of intelligent mining technology, as shown in **Figure 18**. Thus, the extendibility, reusability, and standardisation of intelligent mining technology have been achieved. Independent underground functions, geographically dispersed sensors, trackless equipment, production equipment, and local control systems were combined to form the basis of intelligent mining technology for an underground metal mine.

The basic functions are provided by a ubiquitous underground information-acquisition and control device. The real-time highprecision acquisition and rapid reliable transmission of analog, digital frequency, and video and audio frequency are achieved using a high-frequency embedded processor and distributed architecture, as shown in **Figure 18**. The architecture can be configured with various pieces of underground equipment, a digital mine system, a mining production system, and an environmental monitoring system, and information can be uploaded efficiently. A non-differential data-transmission channel is established between the equipment and the communication system using CAN, RS485, Ethernet, and other data-transmission methods. A multilevel composite network architecture based on distributed technology permits the achievement of seamless roaming and redundant transmission technologies between the base stations during the movement of the underground vehicle. The underground wireless network has no blind area coverage, and has a

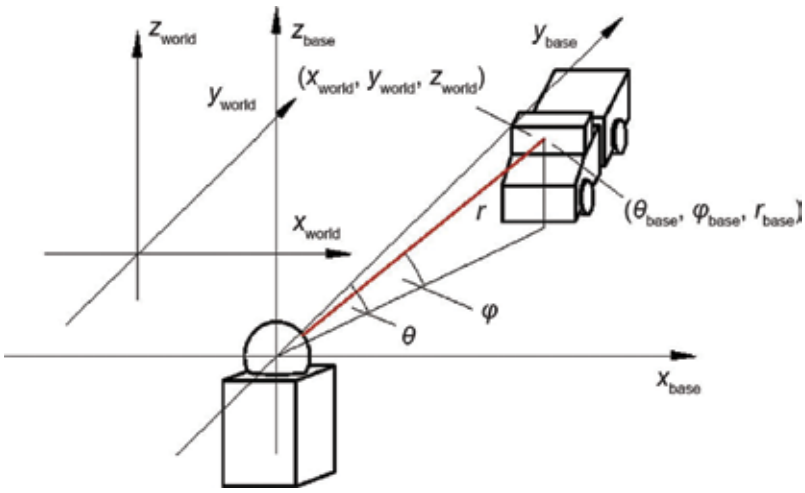

Figure 17: Positioning information obtained by the laser system and UWB system. x_{world}-y_{world}-z_{world} is the world coordinate system; x_{base}-y_{base}-z_{base} is the local coordinate system; θ is the pitching angle and φ is the roll angle; r is the distance between the laser and the equipment; and (θ_{base}, φ_{base}, r_{base}) is the location of the equipment in the x_{base}-y_{base}-z_{base} coordinate system.

high transmission rate and very reliable communication. This network provides a fast, efficient, and reliable data-supporting platform for the remote operation of mining equipment[25].

Fast mobile switching of underground wireless communication terminals is very important, as shown in **Figure 19**. Multi-frequency cross-networking was used to overcome the communication interruption problem for underground equipment in motion. Seamless mobile handover of the operation process of intelligent equipment was achieved. The communication system overcame the communication-rate bottleneck of traditional wireless devices and achieved a wireless link rate of up to 600 Mbit s-1 using 802.11n technology. The automatic identification, classification, and transmission of underground intelligent equipment business data were fully supported. A stable network communication platform was thus provided for the remote control and autonomous operation of the equipment.

Scheduling and control platform

The intelligent scheduling and control system plays an important role in the performance of mining. An intelligent software platform and management center are key features of an intelligent mining system. Based on the actual demand of underground metal mine production scheduling and process control, the intelligent dispatch of an underground metal mine based on a data warehouse was achieved by implementing key technologies such as the organisation and management of multisource data, 3D visualisation of resources and mining environment, dynamic simulation of production processes, and intelligent dispatch and control systems.

The scheduling and control system also performs the functions of organising and managing mine data, modeling and updating resources, identifying the mining environment, automatically producing the mining plan, and intelligently dispatching the production process[26]. The platform can provide information on the 3D environment simulation, simulation of equipment condition, real-time status of equipment, intelligent scheduling of equipment, device real-time video, and location. An integrated intelligent scheduling and control platform for intelligent mining was built using this system, as shown in **Figure 20**.

EXPERIMENT

An intelligent mining system was built in the middle part of the Fankou Lead-Zinc Mine in China. Centralised control, high-speed communication, autonomous driving, and the intelligent operations of an underground scraper, a mining truck, a rock-drilling jumbo, and a DTH drill were tested. The framework diagram is shown in **Figure 21**.

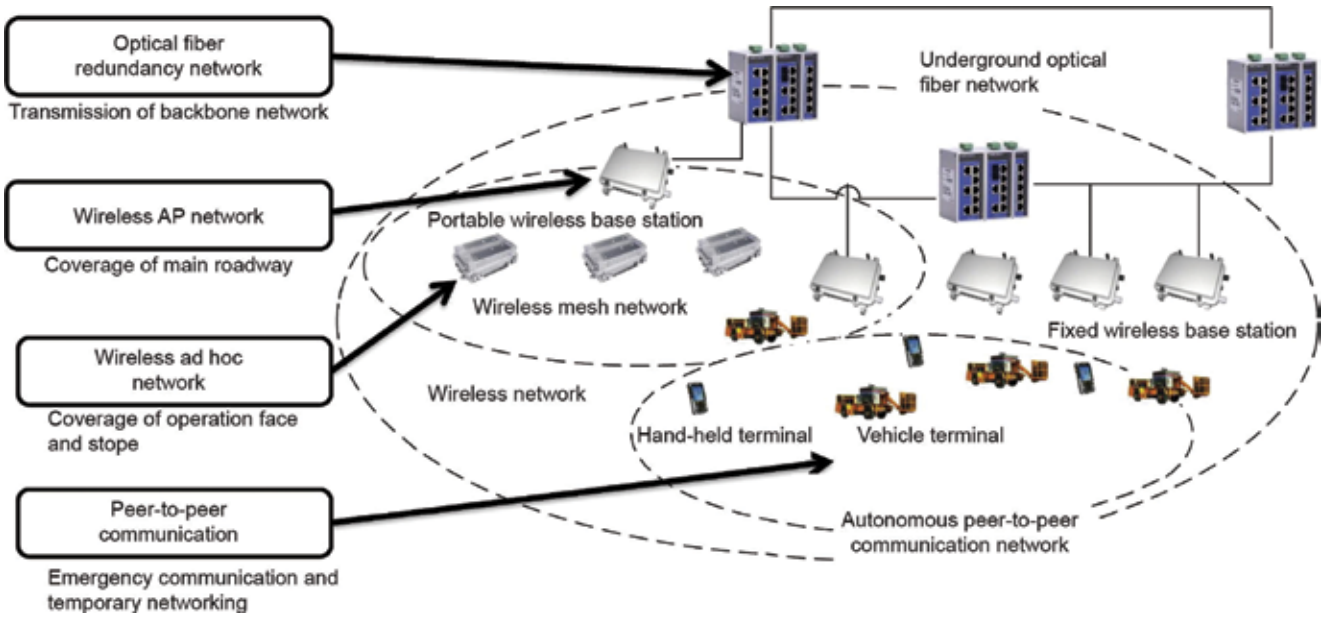

Figure 18: Architecture of an underground wireless communication system. AP: access point.

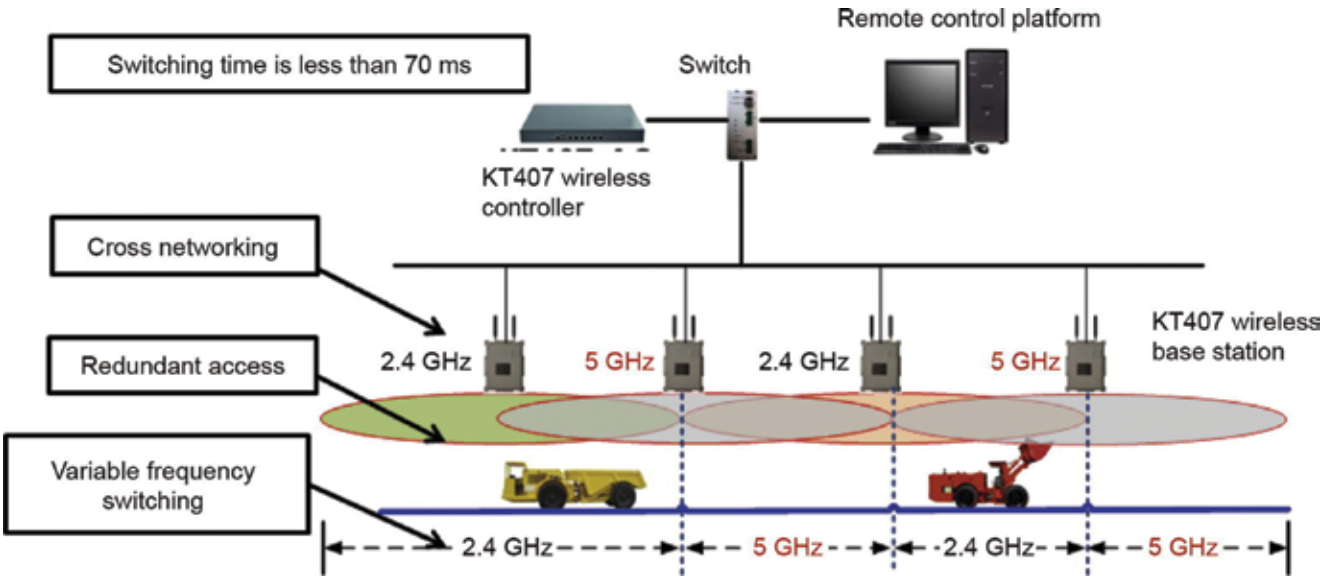

Figure 19: Fast mobile switching of underground wireless communication terminals.

The industrial field-test results show that the integrated technology of underground intelligent mining based on unmanned equipment is very useful. The intelligent dispatch and control system runs stably and can achieve the remote monitoring and synchronous 3D-operation display of the down-hole equipment. The positioning and navigation system is capable of navigating the underground environment and operating the equipment. The path planning is reasonable, and position tracking of the equipment was achieved with 100 mm accuracy. The performance of the ubiquitous information-acquisition and communication system was excellent.

The intelligent underground scraper had many operating modes including autonomous, remote, and manual driving, and carried out the functions of fixed-point unloading and autonomous weighing.

Autonomous driving and intelligent operation of the mining truck, charging vehicle, DTH drill, and rock-drilling jumbo were achieved. Thus, intelligent mining technology for an underground mine based on unmanned equipment was verified.

CONCLUSIONS

Intelligent mining technologies for underground metal mines are the concrete embodiment of China's national policy of upgrading traditional industries through modern and cutting-edge technologies. Intelligent mining technologies integrate the applications of high-end technologies based on automation, information technology, digital and artificial intelligence, and many other new technologies, through multidisciplinary and multiple technology integration. Intelligent mining not only improves the effectiveness

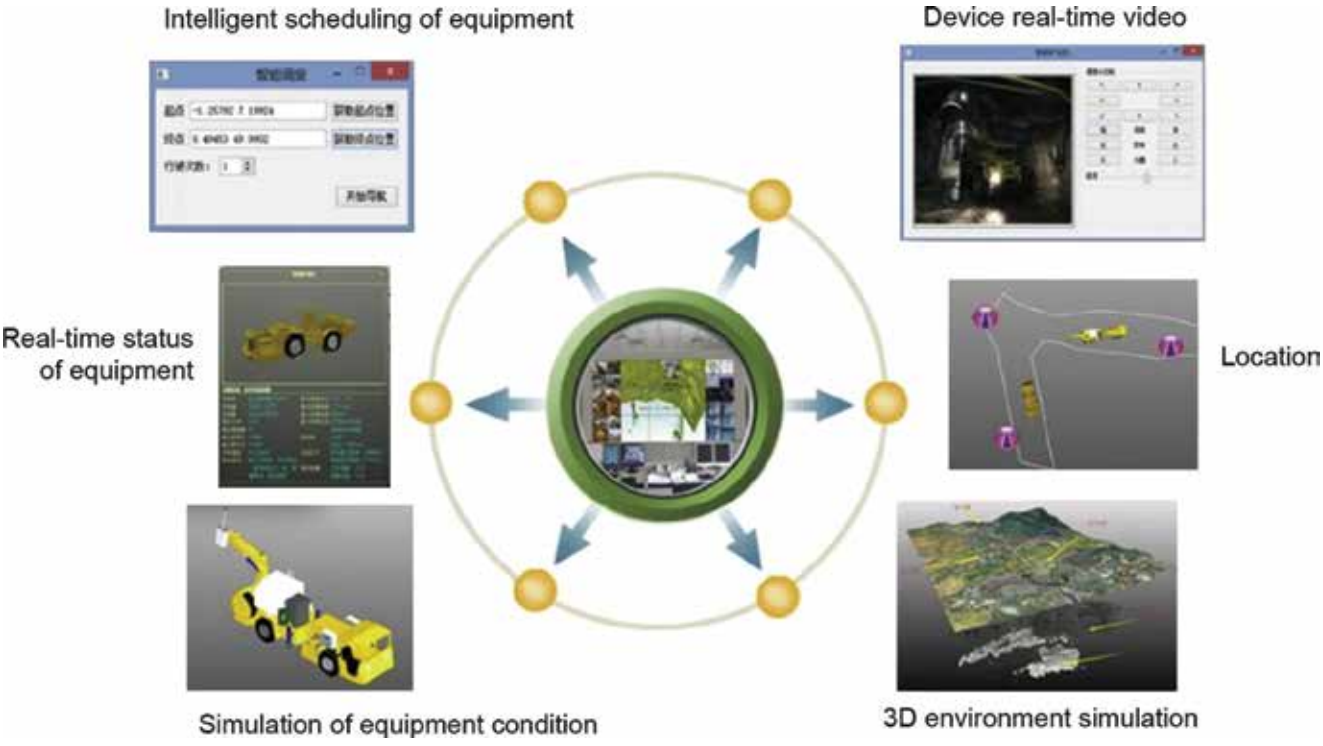

Figure 20: Diagram of the intelligent scheduling and control platform.

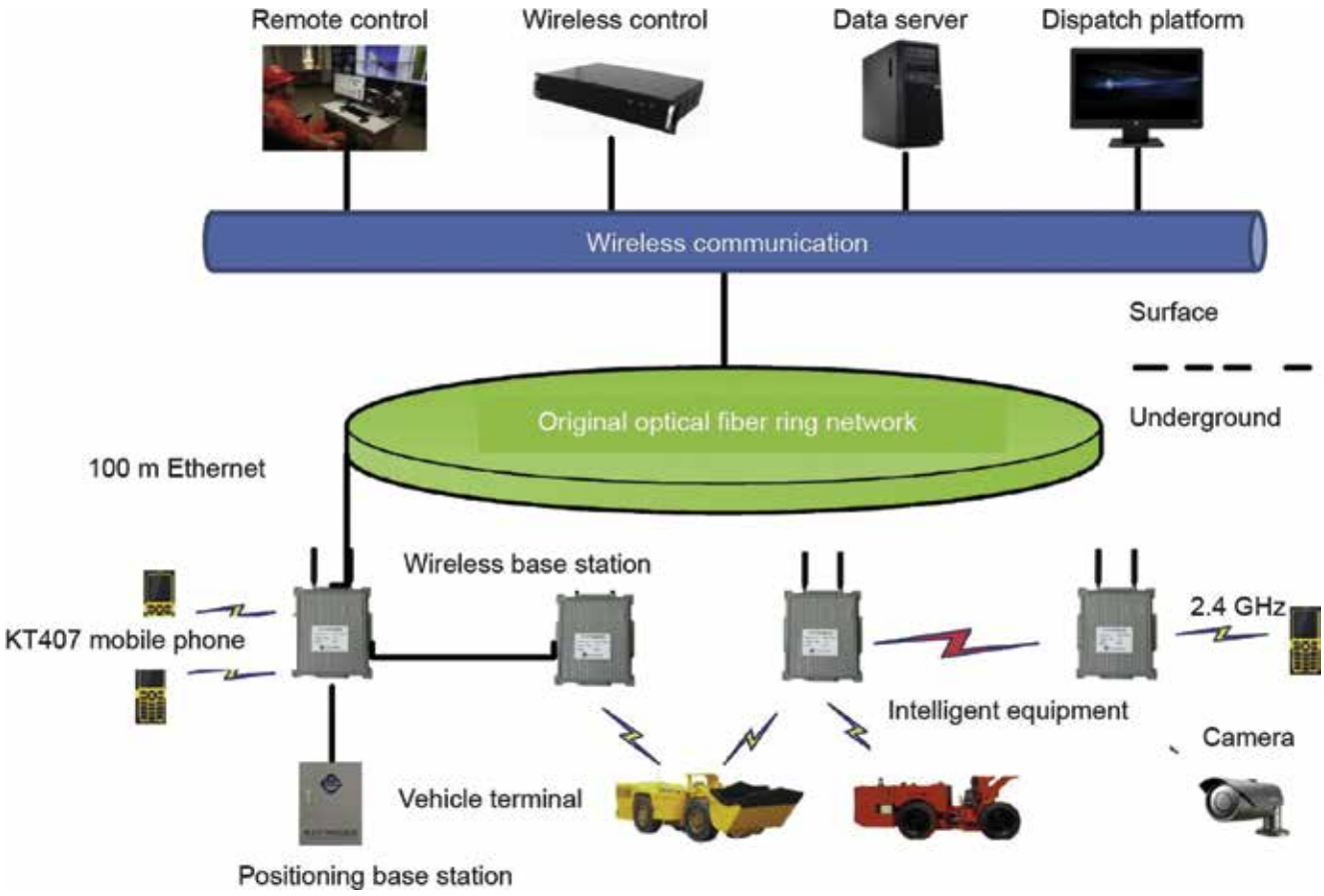

Figure 21: A framework diagram of an intelligent mining system test in an underground metal mine.

of mining equipment and the intelligent monitoring of mining processes, but also significantly improves mining efficiency, thus reducing the mining cost and improving the competitive ability of mining enterprises. At the same time, intelligent mining can reduce the number of field operations and the risk of disasters. In addition, intelligent mining is an effective way to achieve cleaner production and sustainable development of mines. In intelligent mining, the loss and dilution of ore mining are effectively controlled, and the amount of waste ore produced by mining is minimised, while the recovery rate is maximised. Thus, intelligent mining can effectively reduce the discharge of mine solid waste and significantly improve the utilisation rate of mineral resources. It can promote the efficient, safe, green, and sustainable development of mineral resources.

At the same time, intelligent mining will promote the development and enhance the core competitiveness of China's mining industry. The future application trend for underground intelligent mining is the economic, safe, and efficient mining of underground mines by relying on large-scale unmanned equipment, intelligent systems, and integrated optimal scheduling and production management. Potential for technology development lies in the combination of artificial intelligence and automatic mining. Of course, many shortcomings must still be remedied in the mining system; for example, the speed of unmanned equipment needs improvement. The reliability of the whole system needs to be verified by industrial experiments in order to meet the requirements of practical application.

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COMPLIANCE WITH ETHICS GUIDELINES

Jian-guo Li and Kai Zhan declare that they have no conflict of interest or financial conflicts to disclose.

REFERENCES

1. Chang D, Liu J, Mao N, Ge S. Measurement and analysis of virgin-rock temperature in Huanren metal mine. In: Proceedings of the Third International Symposium on Mine Safety Science and Engineering; 2016 Aug 13-19; Montreal, QC, Canada; 2016. p. 204-7.
2. Liu J, Mao N, Chen X, Chang D. Research on geothermal distribution of Hongtoushan underground metal mine. In: Proceedings of the First International Conference on Information Sciences, Machinery, Materials and Energy; 2015 Apr 11-13; Chongqing, China. Paris: Atlantis Press; 2015. p. 541-4.
3. Cheng X, Zhang Y, Feng M, Shang T, Yuan K. Combination study on underground trackless equipment for efficient mining. Non-ferr Metall Equip 2015:41-51. Chinese.
4. Walker S. Underground mining technology: safe working conditions and higher productivity. Eng Min J 2012;6-8:12-5.
5. Gu DS, Zhou KP. The development theme of modern metal mining. Metal Min 2012;7(7):1-8. Chinese.
6. Jonathon R, David R, Chad H, David H. Sensing for advancing mining automation capability: a review of underground automation technology development. Int J Min Sci Technol 2014;24(3):305-10.

7. Gustafson A, Schunnesson H, Galar D, Kumar U. The influence of the operating environment on manual and automated load-haul-dump machines: a fault tree analysis. Int J Min Reclam Environ 2013;27(2):75-87.
8. Frank N. LHD automation DAS the way to go. Austra Min 2003;8:38-9.
9. Wang LG. Digital mining technology and upgrading of mine technology in China. World Non-ferr Metal 2015;7:13-8. Chinese.
10. Carter RA. Equipment selection is key for productivity in underground loading and haulage. Eng Min J 2014;215(6): 45-7.
11. Gustafson A, Lipsett M, Schunnesson H, Galar D, Kumar U. Development of a Markov model for production performance optimisation. Application for semiautomatic and manual LHD machines in underground mines. Int J Min Reclam Environ 2014;28(5):342-55.
12. Prasad BNVS, Murthy V, Pandey SK. Investigations on rock drill ability applied to underground mine development vis-à-vis drill selection. In: Proceedings of the Conference on Recent Advances in Rock Engineering; 2016, Nov 16-18; Bengaluru, India; 2016.
13. Hwang UK, Lim JH. Optimisation of down-the-hole hammer using experimental design method. Trans Korean Soc Mechan Eng A 2016;40 (6):603-11. Korean.
14. Hwang UK. Modelling and test of down-the-hole hammer. J Drive and Control 2015;12(2):34-8. Korean.
15. Dindarloo S. Reliability forecasting of a load-haul-dump machine: a comparative study of ARIMA and neural networks. Qual Reliab Eng Int 2016;32(4):1545-52.
16. Jonathan MR, Elliot SD, Peter IC, Pavan S, Graeme JW, Jock C. Autonomous control of underground mining vehicles using reactive navigation. In: Proceedings of the 2000 IEEE International Conference on Robotics and Automation, 2000 Apr 24-28; San Francisco, CA, USA; 2000. p. 3790-5.
17. Paraszczak J, Gustafson A, Schunnesson H. Technical and operational aspects of autonomous LHD application in metal mines. Int J Min Reclam Environ 2015;29(5):391-403.
18. Chen M, Wang L, Jia M, Chen Z, Liu L. An overview of autonomous navigation techniques and development trend for underground LHD. Chin J Safety Sci 2013;23(3):130-4. Chinese.
19. Mbhalati W. LHD optimisation at an underground chromite mine. J S Afr Inst Min Metall 2015;115(4):313-20.
20. Chi HP, Zhan K, Shi F. Automatic guidance of underground mining vehicles using laser sensors. Tunn Undergr Space Technol 2012;27(1):142-8.
21. Zhao X, Yang Y, Li L, Zhang W, Zeng J. Path tracking control for autonomous underground mining articulated dump truck. Electroteh Electron Auto 2015;63(3):75.
22. Wang M, Zang H, Gong B. General situation of intelligent development of underground charging vehicle. Min Tech 2016;16(1):70-2.
23. Fei M, Yang H, Gu Q, Meng Y. Navigation path planning of underground unmanned LHD vehicle based on improved A⁄ algorithm. Trans Chin Soc Agr Mach 2015;46(7):303-9. Chinese.
24. Alshaer BJ, Darabseh TT, Momani AQ. Modelling and control of an autonomous articulated mining vehicle navigating a predefined path. Int J Heavy Veh Syst 2014;21(2):152-68.
25. Yu L, Zhang Y, Lu D. Development of mine integrated spatial information measuring instrument. Metal Min 2014;43(5):118-20. Chinese.
26. Chen ZQ. Research on key technologies of intelligent operation for underground metal mine [dissertation]. Changsha: Central South University; 2014. Chinese.

Back to the future

How combining the best of the past with the very latest technology has created the best for the future

A BRIEF HISTORY OF CONVEYOR BELTS

Primitive conveyors have been around since 1790. The invention of vulcanised rubber in 1844 was a significant milestone. In 1892, Thomas Robins began a series of inventions that led to the development of a conveyor system used for carrying coal, ores and other products. In 1901, Sandvik invented all-steel conveyor belts. Shortly after this, in 1905, Irish-born mining engineer Richard Sutcliffe invented the first rubber conveyor belts for use in underground coalmines. They revolutionized the mining industry, rapidly replacing men and pit ponies that had, until then, been pulling and pushing heavily laden carts on rail tracks. Since those formative years, conveyors have become essential equipment across a wide spectrum of different industries.

As with any kind of production line, reliability and efficiency is of critical importance. The very first conveyor belts were made using what would now be regarded as a very primitive form of rubber that was sensitive to temperature changes, becoming rigid and brittle in cold environments and literally melting in hot conditions. The rubber covered a single-ply jute or hemp (sackcloth) or cotton fabric carcass, usually joined together by what is now termed as a 'finger splice' jointing method. Apart from not being particularly strong, their inherent weakness was that moisture penetration would cause the jute or cotton to rot.

The invention of nylon in 1935 by American scientist W.H Carothers and the first commercial polyester fiber, developed by a group of British scientists in 1941, led to the gradual replacement of cotton plies with the much stronger and more durable nylon and polyester fabric plies most commonly used nowadays. Over broadly the same period, natural rubber (NR) was replaced with synthetic rubber, most commonly in the form of Styrene- Butadiene rubber (SBR) and Nitrile rubber (NBR) because of its far greater adaptability and durability. The modern day conveyor belt had been born.

INCREASED DEMANDS

As industry and the commercial environment because increasingly competitive, the demand to maximize output and handle highly aggressive materials also increased. Set against this was the need to minimise costs, which opened the door to the large-scale 'economy' manufacturers of South-East Asia. As a result, the conveyor belt market has become dominated by low-grade 'economy' imported belting. In fact, with only one exception, European belt manufacturers supplement their production by importing from Asia and re-selling under their own brand. This also enables them to compete at the low-price end of the belting market.

An exception to the rule – 100% made in The Netherlands.

To many, the use of imported ‘sacrificial’ belts is an irresistible but never-ending cycle.

However, one major European manufacturer, Dunlop Conveyor Belting in the Netherlands, remains the exception to this practice. Instead, they manufacture every belt they sell using their own facilities. Dunlop’s market approach is based solely on quality and ‘lowest lifetime cost’ rather than the lowest selling price. Their USP (unique selling proposition) is that they only supply belts that will provide the longest possible operational lifetime.

CONTINUOUS IMPROVEMENT

Nowadays, the phrase ‘continuous improvement’ is perhaps more often used by marketing executives but it remains appropriate when describing the ethos of the R&D engineers and technicians at Dunlop. In their constant search for belts that can handle even the most aggressive materials and harshest working conditions without the need for frequent repairs and replacements. they continue to produce a steady flow of new, improved belt constructions. Alongside that, there is perhaps an even faster flow of new rubber compounds capable of meeting demands that not so long ago would not have been thought possible.

Different industries have, of course, different needs and this is certainly the case when it comes to quarrying and opencast mining, where an estimated 75% of belts have to be replaced prematurely as a result of damage. To many, the use of low price imported ‘sacrificial’ belts proves to be an irresistible but never-ending cycle. The lower the quality then the lower the ability of the belt to resist damage. The ultimate goal for the R&D team at Dunlop’s headquarters in Drachten was therefore to develop an affordable super-tough belt.

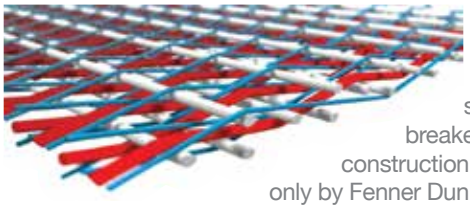
Interestingly, in order to meet this huge technical challenge they decided to throw the rulebook out of the window. Their approach was not only to harness advances in science and technology but also to combine them with what had worked most successfully in the past. The result was the creation of a new and unique super-strength single-ply belt, which they have called Ultra X, which is already changing traditional thinking.

BACK TO THE DRAWING BOARD

The biggest challenge for the Dunlop engineers was to design a belt that had a much higher resistance to impact, ripping and tearing compared to conventional belting while at the same time maximising of production efficiency. “On demanding applications where ripping and tearing and impact is the biggest problem the key to solving the problem lies in the construction of the carcass. Because we had already developed the the hardest wearing and longest lasting rubber compounds it meant that our engineers and technicians could concentrate on the design of the carcass construction. ” explains Rob van Oijen, Dunlop‘s manager of application engineering in the Netherlands.

The answer was discovered in their Fenner Dunlop sister company’s in-house fabric weaving facility in the USA who had developed an amazingly tough patented fabric. The specially woven fabric uses crimped warp polyester yarns to provide high strength and low stretch. These combined with strong 'binder' and 'filler' yarns to create a super-strength ‘breaker weft construction’ that could be used to produce a single-ply belt carcass with exceptional strength and stability under load characteristics.

Throughout its development, sections of belt carcass were repeatedly tested to destruction, including measuring the tear resistance according to the international EN ISO 505 standard. The tests revealed that the (Ultra X) fabric possessed more than 3 times greater longitudinal rip resistance, up to 5 times better tear resistance and a far superior resistance to impact compared to traditional 3-ply or even 4-ply belting.



The big secret – a super-strength breaker weft construction' fabric made only by Fenner Dunlop.

DESIGNED FOR THE TASK

As every site manager will know, even the strongest, heaviest belts can be ripped, torn or punctured by heavy, sharp materials falling from height or foreign objects becoming trapped. “Accidental damage is something that all conveyor operators have to contend with” says Rob. *“Objects get trapped and belts can be destroyed very quickly. Fitting low grade ‘sacrificial’ belts is a false economy, especially when you calculate the cost of frequently having to repair and ultimately fit replacement belts plus the cost of downtime then it really does not make economic sense”*.

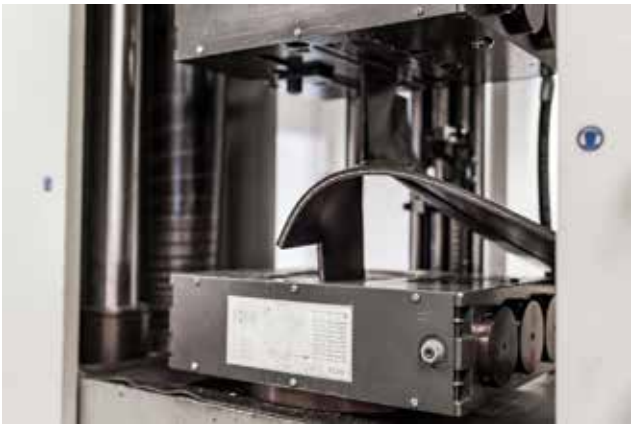
When belt damage is a frequent occurrence, it is a common misconception that increasing the cover thicknesses and/or the number of plies is a solution but that is simply not the case. Ironically, belts that are too thick can result in other problems such as lack of troughability and steering and handling difficulties. All the experience and evidence points to the fact that where ripping and tearing is a problem the only effective solution is to fit a conveyor belt that has been specifically engineered for the purpose. Such belts can have a level of resistance against ripping and tearing and cope with the impact of heavy objects falling from a high drop height that are several times higher compared to belts that use a conventional fabric ply construction. However, in the shorter term, some operators are genuinely unable to afford the initially higher price normally associated with such specialist belts.

A QUESTION OF STRENGTH

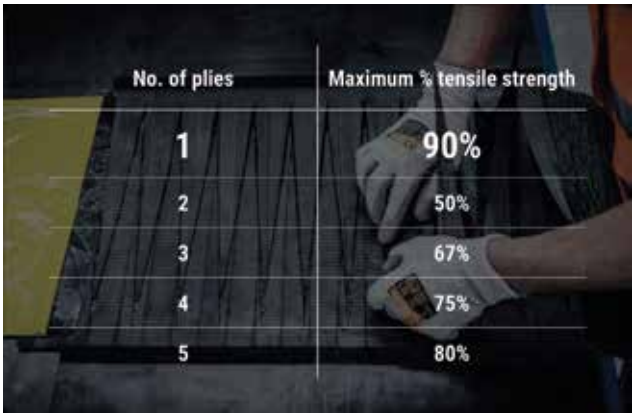
So far, Dunlop have made Ultra X available in two strengths - Ultra X1 (Type 330), which is designed for users of EP315/2 and 400/3 conventional ply belts and Ultra X3 (Type 550), which is designed to replace EP500/3, 500/4, 630/3 and 630/4 ply belts. The fact that Ultra X is a single-ply construction belt designed to replace conventional two, three and four-ply belts has certainly raised a few eyebrows. The first question that seems to be how a single-ply belt can provide sufficient tensile strength and yet still have such high levels of rip, tear and impact resistance? Rob van Oijen, manager of Dunlop's application engineering department explains how and why.

"We keep coming back to the unique fabric that we are using, which is able to withstand the kind of punishment that would destroy a normal belt, Ultra X also has amazing tensile strength. The longitudinal tensile strength of the X1 is 330N/mm and the X3 has a longitudinal strength of 550N/mm. We stepped away from the conventional multi-layer belting for good reason. A single-ply construction requires a finger-splice joint to be made and although they take about 30% longer to make, the enormous advantage of finger splice joints is that they retain up to 90% of the belt's tensile strength. This is why finger splicing was the standard method used to connect the very earliest conveyor belts. It worked then and it certainly works now! By comparison, a 2-ply step splice only retains a maximum of 50% and a 3-ply step joint only achieves a maximum tensile strength of 67%".

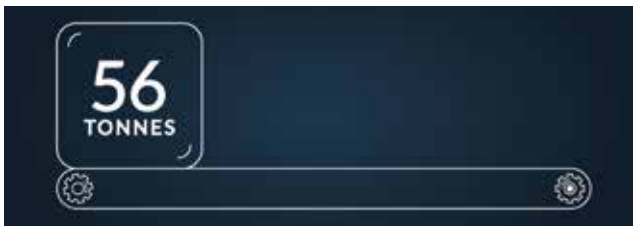
"The higher level of splice efficiency combined with the tensile strength of the X1 and X3 effectively creates equivalent tensile strengths and belt safety factors that are more than comparable to 3 or 4 layer conventional belting".



EN ISO 505 tear resistance testing.



Finger splice joints provide the greatest strength.



An Ultra X3 single ply belt can pull up to 56 tonnes.

Rob freely admits that finger splices are more costly but in his experience this reduces quite significantly with growing experience and the much longer operational lifetime being experienced more than compensates for the higher splicing cost. "The technical and economic arguments in favour of finger splicing are unquestionable. Finger splice joints are stronger and more durable. Ultra X has an appreciably better performance compared to conventional ply belt so the need to repair and re-splice joints is much less frequent".

"To help our customers we supply the splice kits including finger pattern templates, materials and tools, a guide manual and a training film. We even provide training and supervision where warranted". For those who still want to avoid finger splicing, the good news is that Ultra X also possesses excellent mechanical fastener retention. There certainly does not appear to be any question mark against the overall strength of Ultra X because, as their promotional film proudly states, an Ultra X3 single ply belt is able to pull up to 56 tonnes in weight.

ENDLESS OPPORTUNITIES

Yet another advantage is that Ultra X is flexible enough to be used on smaller drive pulley diameters, *"The X1 drive pulley diameter for over 60% rated tension can be as small as 315mm and the X3 drive pulley diameter, again for over 60% rated tension, can be as small as 400mm" says Sales & marketing director Andries Smilda. "Ultra X can run on the kind of mobile machinery that has always been notorious for having small pulley diameters where the dynamic stress placed on the inner carcass and splice joint by the continual flexing over small diameter pulleys seriously limits what can be fitted. Ultra X overcomes that problem".*

UNDER THE RADAR

When Dunlop first launched Ultra X it was a deliberately low-key affair and under the radar of most of the market. As Andries Smilda explains, they had many reasons for taking such a cautious approach. *"We knew from the years of research and intensive laboratory testing that we were onto something special. But Dunlop being Dunlop we still wanted to prove it in the field so we worked with several tried and trusted end-users". "Having sold many tens of thousands of meters has confirmed beyond doubt that Ultra X is all that we thought it would be and more. We have not had one single complaint or technical issue".*

Most significantly of all, Dunlop's claims seem to be supported by the growing evidence. Ultra X is now the belt of choice for a growing number of OEM's who have reported that Ultra X has more than doubled the average belt lifetime on their machines. In France, since replacing conventional multi-ply belts with Ultra X, a large aggregates quarry has seen an 87% improvement in productivity thanks to a dramatic reduction in stoppages caused by broken splices and other repairs. In Spain, one delighted operator has already seen a 50% increase in operating life..

A quarry in France has seen an 87% increase in output since fitting Ultra X belts.

COMPETING ON QUALITY AND PRICE?

Dunlop are very open about the need to be able to offer prices that are at least comparable (and often lower than) multi-ply belting. *"We would never would ever compromise on quality for the sake of being able to compete on price. That is simply not our culture. In any case, it simply is not necessary because there are several reasons that allow us to price Ultra X competitively"* says Mr. Smilda.

"Firstly, the single-ply carcass is made from fabric that we manufacture in-house. That is a big, big advantage in terms of quality and cost. Having a single-ply construction also helps to maximise efficiency of production because there are fewer calender runs. And having no rubber skim between the plies not only results in a thinner, stronger carcass, it also keeps the cost down. We are also making longer production runs at a maximum width of 2000mm".

A CULTURAL CHANGE?

To many, the idea that a single-ply construction belt can provide the necessary tensile strength while possessing considerably more resistance to ripping, tearing and impact is difficult to comprehend, especially while also competing on price, which is something Dunlop are not usually recognised for. However, conveyor operators can perhaps look beyond traditional beliefs and thinking then I strongly suspect that Ultra X really could be a real winner for them.

Leslie David

After spending 23 years in logistics management, Leslie David has specialised in conveyor belting for over 15 years. During that time, he has become one of the most published authors on conveyor belt technology in the world.

NEWS, PLANT AND EQUIPMENT

A&S International appointed as an ISO for SulNOx Group plc

Company will develop sales of unique fuel conditioners via global distributor network

A&S International Ltd ("A&S") is pleased to announce that it has agreed to become an Independent Sales Organisation ("ISO") for SulNOx Group plc. The A&S team has been in the industrial lubrication distribution business for 47 years and represents a range of machinery lubrication and bioremediation brands via a global network of more than 50 distributors. The strategic vision of SulNOx is to provide its unique proprietary environmental technology, to ISO's around the world with established distributor networks.

"As a business, we always search for specialist, unique & sustainable products that can reduce the maintenance & operating costs of our clients as well as importantly also helping the environment. Having watched the SulNOx product range grow the past few years, we are excited to be able to introduce these unique environmental products to our global distributor team – helping their clients to achieve their NET ZERO targets & meet ESG goals as soon as possible. We know that SulNOx compliments our other brands extremely well", said Angus Macdonald, one of the Directors & Co-Founders at A&S International.

A&S is already working with & providing SulNOx training for some of their key distributors around the world including Australia, Chile, China, Greece & Indonesia and are also developing new opportunities in the USA and LATAM. A&S's Australian, Chilean & Peruvian distributor teams will be specifically introducing SulNOxEco Diesel Conditioner to their mining clients in those particular territories – proving the product's capabilities of not only reducing the fuel consumption of mining fleets but also their emissions. At the same time their UK team is setting up evaluations in a variety of industrial sectors including bus & coach fleets, civil engineering, data centres & remediation firms.

Ben Richardson, the CEO of SulNOx commented, *"We are happy to be partnering with A&S International & its global distribution business. The SulnoxEco™ Fuel Conditioner is fully developed & proven in both diesel and petrol engines & is now being introduced to the enormous global market. A&S will be working to deliver this exciting proprietary technology in order to help their clients in industries such as mining achieve their NET ZERO ambitions immediately rather than having to wait for years."*

China Coal & Mining Expo 2021

China's 19th International Technology Exchange & Equipment Exhibition on Coal & Mining

Date: 26-29 October, 2021

Venue: New China International Exhibition Center (NCIEC)
Beijing, China

Host:
China National Coal Association

Co-host:
China National Coal Group Corp.

Organizers:
Together Expo Limited
China Coal Consultant International

Worldwide Enquiries:
Together Expo Limited
Hong Kong Head Office:
Room A, 16/F, Eastern Commercial Centre,
83 Nam On Street, Shau Kei Wan, Hong Kong
Tel : +852 2881 5889
Fax : +852 2890 2657
Email : info@together-expo.com
marjorie@together-expo.com
katherinelee@together-expo.com

Beijing Office:
Room 12A11, Building A, Kunsha Center, 16 Xinyuanli,
Chaoyang District, Beijing 100027, P.R. China
Tel : +86 10 8451 0286 / 8451 0267
Fax : +86 10 8451 0263
Email : info@together-expo.com.cn
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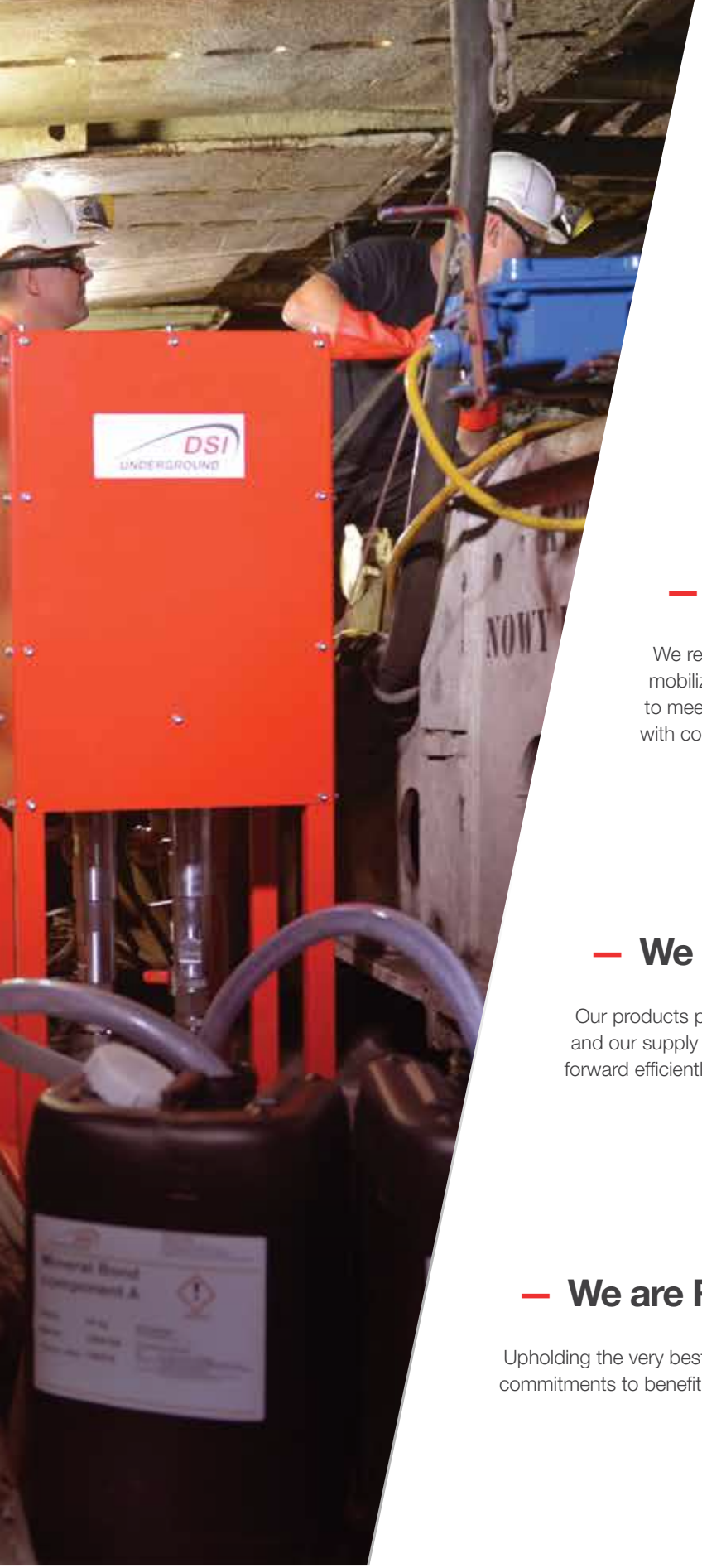

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No Joke: Knock-Knock on conveyor idlers

On any belt conveyor system that moves bulk materials, the belt must run straight and true to maximise its life, minimise fugitive material and safety hazards, and achieve high system efficiency. There can be many consequences of a mistracking belt, but all result in higher costs and increased maintenance. Even a slight belt misalignment can lead to a variety of issues, from small annoyances to full-blown catastrophes.

The most obvious effects include spillage and dust that require personnel to do cleanup, which is unproductive work that introduces risks from activities in close proximity to the moving conveyor. Spillage from non-centered cargo often gets into idlers and pulleys, reducing bearing life and causing them to seize, leading to friction damage on the belt and potentially starting a fire. A misaligned belt can also come in contact with the stringer, causing fraying, shredding or splice damage. Great lengths of valuable belting can be destroyed with surprising speed, and even the support structure itself can be damaged. A compromised bracket or support can cause a catastrophic idler failure, which could damage other components of the system and require extensive downtime to repair. Further, there is potential for injury from a damaged belt or loose idler not to mention the increased exposure to injury from too frequent a need to clean.

“I’ve been working around conveyors for 20 years, and I’ve seen thousands of belts,” observed Martin Engineering Process Engineer Dan Marshall. “I’ve seen just about every problem that can be caused by a mistracking belt, but one thing I’ve never seen is a belt that runs true right out of the box. All conveyors, no matter how well designed and built, have some belt wander.”

A wide variety of circumstances can lead to mistracking, and operators have tried many things to correct the alignment. Some have elected to place an obstacle such as a block of wood in the belt path, so it won’t travel too far out of line. This occasionally improves the situation, but more often it’s just temporary and the belt will eventually slice through the obstacle.

Many operators have realised that pivoting an idler is a quicker and more effective way to steer a belt. This common approach is called “knocking an idler,” striking it with a hammer to move it slightly and realign the belt.

Equipment manufacturers have also designed components to help align a belt, and these solutions can be successful in specific applications. They include specially-shaped rollers, angled idlers and devices that apply pressure to the belt edge to push it back in line.

“While these mechanisms can improve a belt that’s consistently off-center in one direction, they do not react to dynamic belt movement, meaning that they don’t correct intermittent belt wander,” Marshall continued. “To combat such changing conditions, engineers designed the tracking idler. Unlike the edge correction approach, the device senses belt movement in either direction, and pivots the idler slightly to steer the belt back into position. It doesn’t apply a great deal of force to the edges, which can damage a belt and splices. When the belt is running true, it remains centered, and when it senses a misaligned condition, it gently corrects the belt.”

Wooden block intended to limit belt wander.

"Knocking" an idler with a mallet to change its position.

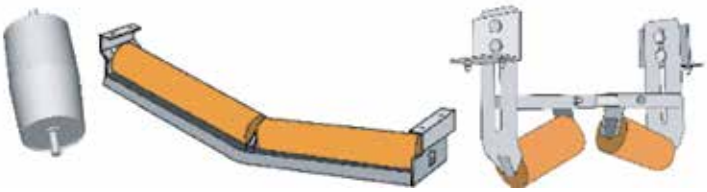
Unfortunately, to accommodate limited space availability, tracking idlers typically have short sensing arms. This requires a fairly large belt displacement to create a small movement of the idler. While these designs do tend to improve tracking, there are limits to how much correction they can deliver, and short sensing arms can actually pinch a belt if the idler pivots too far. To combat this, some operators choose to "tie off" a tracking idler to limit its movement. While the practice can help preserve the belt, it doesn't address significant mistracking.

To overcome the limitations of existing belt alignment devices, Martin Engineering has invented and patented a Multi-Pivot Belt Tracker, which employs sensors, pivoting idlers and geometry to align a wandering belt. The sensors avoid pinching the belt, and the engineered geometry amplifies any detected misalignment to create a greater pivot.

Multi-Pivot Belt Trainers use longer arms than other designs, positioning the guide rolls further from the pivot roller, as well as closer to the belt edge. The closer proximity allows guide rolls to sense very slight misalignments and make immediate corrections. Rather than waiting for a powerful mistracking force, the longer arms require considerably less pressure to move the pivot roller. The result is better correction with no pinch points and less wear on conveyor and tracking equipment, for a longer and more efficient service life. Specific designs are available for both the load-carrying belt path and the return run.

"Installing trackers is the economical solution, but operators should do a full analysis and consider also addressing other causal issues," Marshall added. "By focusing solely on belt alignment, plant personnel may miss other opportunities to increase production and relieve some of the burden on their system."

Keeping the belt centered and moving quickly is the key to high production, controlled operating cost and a safer



Different component designs for improving belt alignment.

Tracking idler.

A tracking idler tied off to limit its travel.

Multi-Pivot Trainer for the load-carrying run.

Multi-Pivot Trainer for the return run.

workplace. “Misalignment causes downtime and costs money,” Marshall concluded. “But nothing causes more downtime and expense than a destructive belt fire or other catastrophe as a result of inattention to mistracking problems.”

CASE STUDY

The Ash Grove Cement plant in Chanute, Kansas has received dozens of safety awards since the facility’s modernisation in 2001, and when operators experienced several frustrating involuntary shutdowns and rising costs from drifting belts, prevention-minded managers sought an effective solution.

“Although there was one belt that had a particular issue with tripping the emergency stop switch, mistracking was a problem on several belts from the limestone quarry all the way to the raw mill,” said Danny Wolken, Maintenance Planner at Ash Grove Chanute. “We have different materials converging into a single area, and disruption to the flow affects the productivity of the whole system.”

The belt carrying limestone was of particular concern. After passing through the crusher, 4 inch-minus (≤100 mm) aggregate would be loaded onto the conveyor. After leaving the settling zone, the belt had a tendency to crawl up on the side of the idlers. This would disrupt the centered distribution of the material on the belt, causing smaller aggregate to spill along the length of the system until the belt drifted far enough to activate the stop switch, which shut down the conveyor.

The shutdown would have a ripple effect throughout the plant. “Although the limestone conveyor had the worst problems, issues with tracking stretched across all eight conveyors. That adds up, since we run 10 hours a day, 7 days a week,” Wolken explained.

Ash Grove Cement plant in Chanute, KS (USA).

Along with excessive unscheduled downtime, the belt on the limestone conveyor began to fray from contact with the structural components of the system. Having only been replaced 6 months earlier, labor, downtime and equipment expense makes belting one of the costliest components of the system. Incidental contact drastically reduces the belt life and can degrade the splice. The belt damage likely contributed to further misalignment and spillage.

DIAGNOSIS

With a long-standing relationship of providing quality equipment and service, Martin Engineering was asked to inspect the systems and offer solutions. Technicians walked the belts individually and took detailed notes on the unique causes of mistracking for each system.

First, technicians found that when the belt drifted, cargo shifted downward to one side of the belt, causing it to mistrack further. The material lost surface area and spilled over the edge of the belt. The spillage dropped along the entire length of the system, causing product loss, creating potential workplace safety issues and requiring excessive cleanup.

Technicians also suspected some potential manufacturing flaws of the belt attached to the limestone conveyor. If the belt isn’t precisely engineered or properly stored, it can bow or camber, which may have contributed to the tracking and belt damage issues. In addition, the existing tracking systems were found to be inadequate. They delivered only minor corrections to discourage belt damage and quite often broke, requiring additional maintenance. Technicians realised that the belt’s return run also needed a solution for the whole system to remain in line.

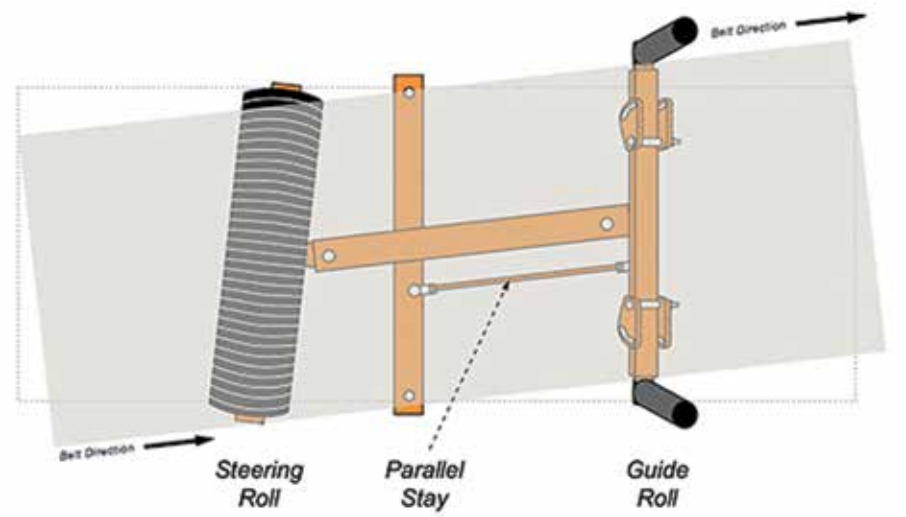
PREVENTIVE SOLUTIONS

Martin technicians pinpointed the problem areas on each of the conveyor belts and offered an economical solution that utilised modern belt tracking technology where it was needed. Across the eight conveyors, the technicians recommended installing 28 Martin® Trackers™. Many of the units control the belt return, but there are also upper trackers strategically placed in problem areas.

Utilising innovative multiple-pivot, torque-multiplying technology, the design has two sensing arms that extend out to either side of the conveyor with rollers at the tip, which smoothly ride the edges of the belt. The sensing arms detect slight variations in alignment and use the force of the belt to immediately pivot the position of the troughed idlers against the misalignment with equal force, thus returning the belt to its intended path.

With its sensitivity to misalignment, less opposing force is needed for the equipment to realign the belt. Early detection with a reduced range of drift before correction makes the belt run more efficiently, mitigates spillage and results in longer equipment life.

The installation was performed by two Martin technicians during scheduled downtime. Since edges of the belt on the limestone conveyor had serious damage caused by the mistracking, another team replaced the belt as well. The new belt was thoroughly inspected to ensure that it did not contribute to tracking issues.



The tracker pivots against the mistracking, using the force and weight of the belt to redirect it.

Trackers were installed with minimal impact on structural supports except for a few bolt holes. The idler angle of the upper trackers matched the trough angle of the system to ensure a smooth belt path, and the torsion arms were properly aligned with the belt edge.

Three critical areas on the conveyor required tracking: the exit of the settling zone, the entrance to the feed mill and along the return path. A lower tracker placed along the belt path and near the loading zone ensures the belt is aligned as it hits the tail pulley to promote centered loading. An upper troughed tracker at the settling zone exit reinforces a straight belt path as it travels the length of the system.

One of the most difficult installations involved the trackers placed at the entrance to the feed mill. Raised off the ground in the weighing tower, the technicians required some extra safety equipment and time to install those units. This was an important step, because a centered belt entering the head pulley ensures that the belt cleaner blade adequately dislodges adhered material from the belt. Specifically positioned to clean the center of the belt where carryback resides, belt drift may cause some of the material to avoid the blade, dropping spillage and fouling rollers along the return path.

The return side Martin Tracker lifts the belt slightly for appropriate contact.

STAYING CENTERED

The installation of a new belt helped with testing the tracking system to ensure that the trackers are addressing cargo and transport issues and not belt flaws such as camber or cupping. Initial testing revealed positive results, with the belts remaining centered along the entire length of the system.

“Every time we replace a belt it costs approximately $35,000 in equipment and labor, not counting the loss of production,” Wolken said. “Replacing the belt is not a sustainable solution, so seeing the trackers keep the belt in line was a positive result.”

The belt remained centered from pulley to pulley, drastically reducing the amount of spillage. As with any bulk handling, cleanup is always a factor, but operators pointed out that the time and labor for cleanup were significantly reduced. This improved efficiency and lowered the cost of operation.

Observation over time revealed that the belt remained aligned through changes in weather, and none of the belts have come in contact with the emergency stop switches since the installation. This has resulted in a significant reduction in unscheduled downtime, improved efficiency and eliminated the need for maintenance staff to interrupt their work to get the system running again.

“We trusted that Martin Engineering would be able to offer an affordable solution that could solve our problem, and they really came through,” Wolken concluded. “We like the trackers so much that we’re looking into installing them on other systems. They have definitely paid for themselves.”

Cory Goldbeck
Territory Manager, Martin Engineering

Illustrations

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Driving sustainable change in the mining industry

Industrial water usage continues to be a hot topic, as people, countries and companies around the world seek to address the challenge facing global water security. It is predicted that by 2025, at least two thirds of the world's population will face 'water stress' ; defined as when the demand for water exceeds its availability or poor water quality limits its use. While the future of water security in this sense may seem bleak, it is not foregone and industrial companies are working toward a more sustainable future for the resource.

Water is of critical importance to mining in particular; most mining operations are located in water scare areas and without it, these operations would not be possible. Faced with the conundrum of the need to both use and conserve this precious resource, the responsible management of water by mining companies is more critical than ever. The mining industry is increasingly driving forward to achieve sustainable change and is helping to address the challenge of water shortages faced around the world. Collaboration and investment in innovative technology is key to making a real difference in conserving a source so vital to the world.

Anglo American has long been a leader in water sustainability and is a champion of making its mining operations as environmentally friendly as possible. Since 2012, the company has achieved water savings equivalent to 54,200 Olympic size swimming pools or the annual consumption of drinking water for around 148 million people. As demonstrated in previous reports and its recent 16th annual Sustainability Report, "Delivering Change, Building Resilience, Working in Partnership", Anglo American's strong sustainability strategy continues this year as the company embraces innovation to e nsure its operations are less water-dependent, as well as safer and more energy-efficient.

THE POWER OF COLLABORATION

As part of its ambitious sustainability strategy and its drive towards innovative mining, Anglo American is developing partnerships with a number of groups and is seeking to deliver real value and a positive impact to local communities and stakeholders through working together. With 75% of Anglo American's mining operations located

in high water-risk regions , the provision of water-related infrastructure that directly benefits communities is a priority at several of its operations where water scarcity is a prevalent challenge. This also presents Anglo American with an opportunity to play a leadership role in its water catchments, as demonstrated by its recent partnership with the International Council of Mining and Metals (ICMM).

In 2014, the ICMM developed a new water stewardship framework to create a new catchment-based strategy to mitigate shared water challenges. Collaboration and engagement with all relevant stakeholders was at the heart of this approach. President of the ICMM R Anthony Hodge has highlighted the power of working together: "Through collaborating or partnering with others to mitigate shared risks, address shared impacts and effect the responsible management of water resources, the industry has an opportunity to play a leadership role in local water catchments where operations are located."

In 2015, the ICMM selected Anglo American's Brazilian operation Minas Rio to collaborate with them in the first application of this guidance and the project was brought to life in 2016.

The pilot of this project has led Anglo American to develop a new water management standard and water management guidelines in alignment with global best practice and the ICMM water reporting guidelines. A cornerstone of the new standard is a more focused and structured approach to managing catchment-wide water risks in partnership with regional stakeholders. The standard requires that every site identify or appoint a water coordinator to oversee the implementation of the standards, leading each business to develop and implement its own water plan and in certain high-risk regions, draft regional water plans. The development of these regional water plans means the immediate priorities involve making sure that local needs are not compromised, whilst ensuring that mining operations have access to adequate supplies of water.

This collaboration with ICMM is just one example of how Anglo American is working to ensure its mining operations are sustainable. In fact, Anglo American participates in several important water-related fora, such as the Strategic Water Partners Network (SWPN) programme, which is aimed at addressing South Africa's water shortages. Also in South Africa, the company participated in a consortium that assesses acid mine drainage in the Olifants driver catchment in Mpumalanga, including the feasibility of applying mine-impacted water for irrigation purposes. It also recently participated in the Olifants River Catchment Management Forum, established with other mining companies. In Peru, the Quellaveco copper project engages local communities in monitoring its water management practices, and is examining options for providing water from its dams.

Anglo American is also working with local governments to build resilience in host communities through the provision of water and associated infrastructure linked to its mining activities, ensuring the mines leave a positive and lasting impact. Two examples of this are Kumba's Kolomela and Sishen operations, which pump groundwater, in excess of operational needs, to Sedibeng Water to supply neighboring communities. The business also provides potable water to communities in drought-stricken areas, including at Mogalakwena platinum mine in South Africa.

AMBITIOUS WATER SAVING TARGETS

As part of its commitment to mining sustainably, Anglo American has an ambition to eliminate fresh water from its mining processes where possible, especially in the separation and transportation of ore and waste (tailings). Water sent to a tailings disposal often represents the largest water loss at a mine as fine particle slurries are difficult and costly to dewater. Anglo American is examining whether it can reduce the cost of dewatering while looking at the physical and chemical properties of the fine ore particles to understand why they cling so resolutely to water. If successful, it has the potential to significantly limit how much fresh water its operations draw, while also

gaining access to ore bodies in water stressed areas that are critical to supplying the world's ongoing demand for metals and minerals.

As well as water conservation, water efficiency is rising as a key priority through onsite water recycling and reuse programmes. Anglo American's Los Bronces copper mine continues to mitigate water supply challenges by implementing technical solutions that promote water efficiency and water resilience. When water supply challenges in 2015 limited production at Los Bronces copper mine in Chile, this provided an extra impetus to reduce fresh water consumption. To overcome this issue, water is now transported to the operation via a 56-kilometre pipeline from the Las Tortolas tailings dam using a special water-recycling system. The site now currently recycles more than 66% of available water.

Anglo American continues to work towards more ambitious water savings targets for 2020. This involves reducing its absolute freshwater intake by 20% and recycling/re-using water for 75% of its water requirements. The company's 2016 sustainability report recognises the progress the company has made so far, with total new-water consumption decreasing by 14% in 2016 compared to 2015. This decrease was as a result of the divestment of water-intensive operations and efficiency measures. Of Anglo American's total operational water requirements, 66% was met by recycling/re-using water, an improvement on 64% achieved in 2015. Water saving projects, including more effective dust suppression, dewatering of tailings and more efficient ore separation, contributed to the water saving of approximately 23 million cubic meters in 2016.

FUTURE SMART MINING: AN INNOVATIVE APPROACH

Central to its drive to use innovative technologies to conserve water is FutureSmart MiningTM, Anglo American's wider response to the global drive for a more productive and sustainable approach to mining, where its operations have a reduced and sustainable environmental footprint for current and future generations. This is part of the company's wider vision of a world where its mines are integrated and automated, carbon-neutral and water-neutral. Collaboration is fundamental to this approach. Engagement with host governments, industry associations, local authorities, communities, NGOs, businesses, suppliers and other stakeholders on water related issues is an integral part of the company's water journey and sustainability strategy. Partnering with these groups is hugely important in helping Anglo American find solutions to mining's most critical challenges in the areas of safety, productivity, energy and water. One of the pillars of FutureSmart Mining™ is the aspiration of a waterless mine, which would eliminate all water usage in favour of dry separation and non-aqueous processing techniques. Another goal is a closed loop water system, which is already helping Anglo American to tackle its water challenges by drastically reducing its water consumption during mineral processing. By focusing on the two areas of evaporation and dry tailings disposal (dewatering), it minimises water losses and enables the same water to be used numerous times.

CONCLUSION

Collaboration and innovation are critical for the mining industry as it strives to address the challenge of water shortages and effective conservation. Through opening conversations with local governments and stakeholders beyond mining companies, real tangible benefits can be achieved, as demonstrated by Anglo American's partnership with the ICMM. Through working with a variety of organisations and local communities, Anglo American is able to deliver real value by creating a more holistic framework for managing regional water usage. At the same time, new and innovative solutions to water management are central to developing technologies which will make water usage as sustainable as possible. Water management is and will remain a critical issue for the mining industry, but through dedicated partnerships and collaborative approaches to innovative technologies, the future can be bright.

CASE STUDY: ANGLO AMERICAN AND ICMM PARTNERSHIP

The recent partnership with the ICMM presented an opportunity for Anglo American to assess and improve water security at Minas-Rio, as well as becoming conversant with the social implications created by the water catchment and the potential business risks associated with meeting legal, social and regulatory requirements. These challenges were being made more serious by the water crisis Brazil was experiencing, in which rainfall had been well below average since 2012 as a result of the weather phenomenon known as El Niño. The issues regarding a mine's water-basin management are complex and involve a vast range of aspects – technical, environmental, societal, and reputational. This initiative was an opportunity to run a robust analysis associated with those multi-disciplinary perspectives.

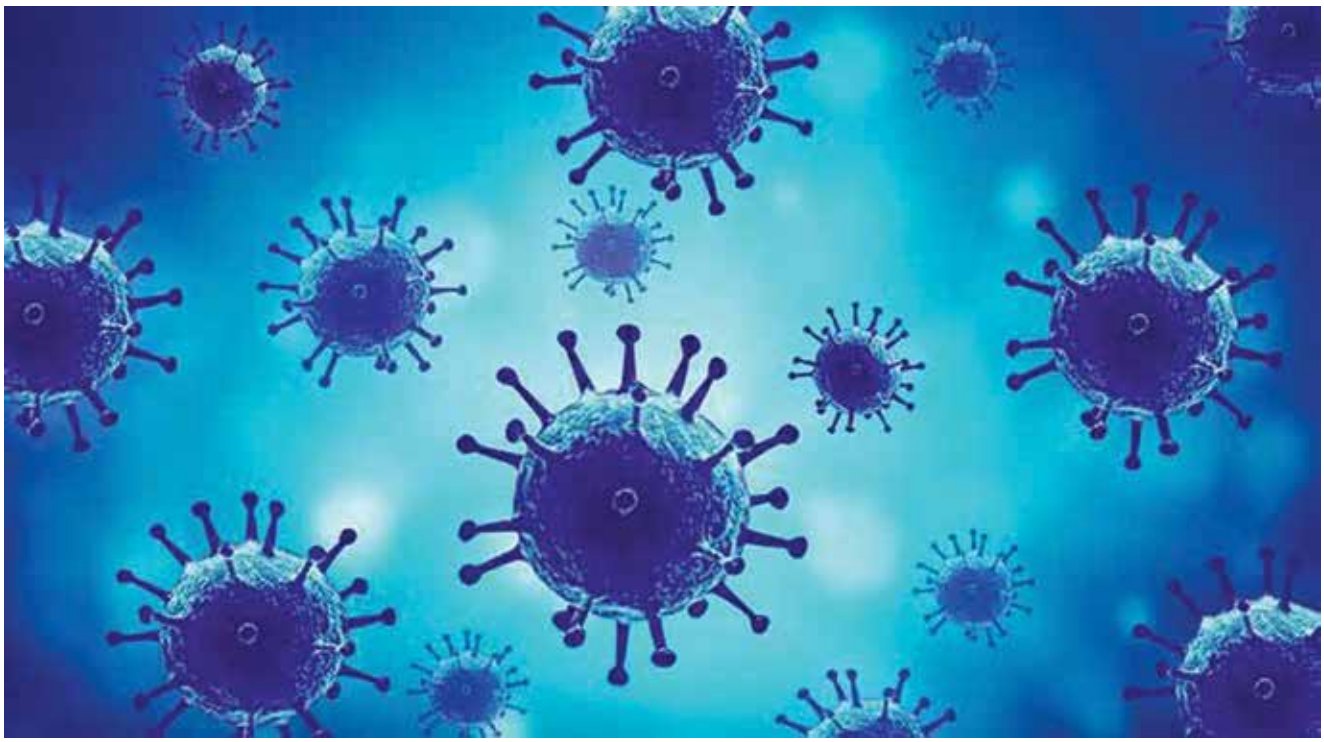
As a result of the inclusive nature of this initiative, Anglo American and the ICMM brought together members of the local communities, municipalities, water basin committees and civil society organisations to better understand and manage shared water risks in the San Antonio water catchment. This in turn enabled Anglo American to increase its understanding of stakeholder concerns and aspirations related to the use of water in Minas-Rio. It also allowed them to identify major water issues and risks in the catchment and across mine life cycle, and build a response strategy to address water risks. At the same time, the pilot gave the ICMM a real opportunity to road-test the approach at a water-intense operation and, based on the findings, ensure it was practicably applicable for other members of the joint industry organisation.

The process followed the steps outlined in the ICMM guidance, which involved reviewing the importance of water in a mining context and then establishing why water is important for the Minas-Rio operation specifically. The next step was then to evaluate stakeholder perceptions, draft a baseline report and hold a multi-stakeholder workshop to discuss the findings, from which future actions were agreed.

Applying the ICMM guidance demonstrated that water-related risks are often seen from very diverse perspectives across Minas-Rio, and that management of such risks can fall under separate systems and processes. The approach has helped Anglo American consolidate these risks so that they can be managed using a holistic framework, addressing the concerns of all stakeholders.

MINE WASTEWATER TREATMENT RESEARCH

Tiny organisms – or microbes – are being explored for mine water treatment at Evolution Mining's Mt Rawdon gold operation, where the company plans to adopt a wetland-like system to remove contaminants.



BIO-REMEDIATION OF MINE WASTEWATER

CSIRO scientists are using microbes and other methods to remove valuable metals and other contaminants from mine wastewater – making remediation pay. These technologies can process the water so that it's pure enough to be safely returned to the environment. The water can also be recycled and reused in mine production.

CSIRO's Anna Kaksonen is an environmental scientist in Perth and leads the research group working in biotechnology for water quality.

"Certain microbes can help to either oxidise or reduce metals or other compounds, like sulphate, nitrate or selenate, so we can remove them from water," Dr Kaksonen says.

"Microbes can also be used to clean up organic impurities and reduce acidity or alkalinity.

"For example, wastewater from the alumina industry has a lot of organic impurities that can accumulate in the water used in ore processing."

COMBINING BIOLOGICAL APPROACHES WITH OTHER WASTEWATER TREATMENT

Biological treatment can be combined with other processes like hydrotalcite precipitation, delivering a more effective clean-up than either process can do alone.

The hydrotalcite (an anionic clay) precipitation process invented by CSIRO's Grant Douglas and licensed to Virtual Curtain Ltd, involves adding patented mixture into the wastewater which then binds to metals and other contaminants as it forms hydrotalcite.

Then contaminants are easily removed from the wastewater as a well-settling sludge containing valuable metals in highly concentrated compounds. Adding biological processes after the hydrotalcite precipitation can remove other contaminants remaining in the water, such as sulphate and nitrate.

MIMICKING NATURE

Dr Kaksonen says that the biological technology often uses bacteria and archaea, which is another type of prokaryotic microbe. Some treatment processes use plant materials or even wetland plants to provide a continuous carbon and energy source for the microbes. These biotechnologies mimic natural systems, but they are designed to provide optimum conditions to clean up wastewater.

"Most of our work has two dimensions," CSIRO senior research scientist, Dr Ka Yu Cheng, says.

"First, we aim to understand how the biology works in the environment now.

"Second, we try to engineer the process so that microbes can work better to achieve what we want them to do – such as finding the right mix of plants, the right temperature or the right pH to increase the activity of the microbial community."

MICROBE CLEANERS

The CSIRO team uses DNA analysis to identify the type of microbes that exist in mine water. Then they search through large databases to identify more information about these tiny helpers.

Sometimes the team conducts research using micro-organisms from commercial culture collections, which have micro-organisms gathered by scientists globally.

The team also do their own “bio prospecting” – exploring various places in both natural environments and in contaminated sites, to find microbes that thrive in harsh environments.

"We take samples from mine sites, existing wastewater treatment processes or sediments," Dr Kaksonen says. Team members also look for suitable organic solid or liquid waste streams, such as the glycerol waste from biodiesel production that could be used to drive biotechnical mine water treatment.

INDUSTRIAL SYMBIOSIS – WASTE BECOMES FEED STOCK

"There could be some synergies for using waste from one industrial sector as a feed stock for another sector," Dr Kaksonen says.

"For example, industrial symbiosis could happen between biodiesel and mining industries, moving both industries toward a more circular economy."

The CSIRO team recently tested their biotechnology processes in the laboratory on mine water. They are now working with Evolution Mining to develop better treatment solutions for the wastewater at the company's Mt Rawdon gold mining operation in Queensland.

"The company is planning to use a wetland system to treat mine wastewater. CSIRO's team will compare the effectiveness of sawdust, plant material, ethanol and lactate to find the best material that can support the microbial treatment in a wetland-like system," Dr Cheng says.

"The mine wastewater from Evolution’s mine will contain sulphate and metals, so we are working with the company to combine hydrotalcite precipitation and biological sulphate reduction," Dr Kaksonen says.

COST-EFFECTIVE BIOTECHNICAL TREATMENT

"While some mining companies have used wetland systems and have trialled various biotechnical processes, most mine sites still use chemical treatments to clean up mine water."

A constructed wetland could potentially be a cost-effective process to treat water to a stage where it is safe to release back into the environment. The wetland could be constructed while the mine is operating, and form a part of the mine closure plan.

"Biotechnical processes have many advantages when compared to traditional chemical treatments," Dr Kaksonen says.

One example is that sulphate-reduction based bioprocesses can form metal sulphides – instead of the hydroxides that form in traditional treatments – making it much easier to remove cleaner water from the mix.

"Because metals can be more easily recovered from sulphides, and bioprocesses can use organic waste streams, these techniques also reduce operating costs."

The processes that the CSIRO team is developing could herald a revolution in mining remediation – making effective mine wastewater treatment an economic imperative, as well as an environmental one.

AN ALTERNATIVE TO WATER COVERED MINE TAILINGS

When a tailings pond dam at the Mount Polley copper and gold mine in British Columbia failed recently, over 10 million cubic metres of alkaline water and 4.5 million cubic metres of liquefied tailings were released into local watercourses.

Although the toxicity of the released material has proven to be much less than many feared, the event may have serious ramifications for the mining industry. It may further call into question the use of water-covered tailings management areas (TMAs) retained by dams.

An evapotranspiration cover/engineered bioreactor system provides an economic alternative to water-covered TMAs. It involves:

- Draining tailings ponds after mine closure.
- Covering the resulting dry surface with local vegetation such as trees.
- Converting the tailings dams into permeable dikes holding back only relatively dry materials.
- Installing a stormwater management system.
- Treating released leachates with an advanced engineered bioreactor located down-gradient of the new lowered dikes.

Most mines impound tailings behind large dams in TMAs to contain and manage residues. These areas allow solids in the tailings slurry pumped from the mine’s mill to settle out. Decanted water is recycled back to the mill. After a mine is closed, these areas are often used for the long-term storage of tailings.

The tailings ponds then become water covers. These are especially appropriate where the ore that was mined contained sulphidic material. A one-to-two-metre deep layer of water maintained over the tailings will greatly limit the influx of oxygen. This mitigates the generation of acid rock drainage, which adversely impacts the health of aquatic animals, insects, and plants.

Tailings dam failures are rare. However, there have been a number of highly publicised ones such as those at Stava in Italy in 1985, the Sullivan Mine in Canada in 1991, the OMAI mine in Guyana in 1994 and the Los Frailes mine in Spain in 1998. Rates of tailings dam failure have, however, increased in recent years.

It has been concluded that of the roughly 3,500 tailings dams worldwide, there are between two to five “major” failures each year. Furthermore, these statistics are for physical failures only and do not include “environmental” failures where the structures of dams were maintained, but leakages of polluted mine drainage water occurred.

Most jurisdictions now require mining firms to have a closure plan before opening new mines. It must detail how the maintenance of tailings dams will be carried out after closure.

One alternative to storing tailings long term in water-covered, dammed tailings areas is to place them under water in lakes, rivers or seas. However, submerged disposal of tailings is controversial. Other options such as placing the tailings in mined-out open pits or dewatering them and placing them back in mineshafts are only possible in some cases.

DRY COVER SYSTEMS

There are two main kinds of dry covers. Barrier covers seek to totally and permanently isolate the underlying tailings under covers of impermeable plastic, clay, or earthen layers. Evapotranspiration (ET) covers involve phytoremediation technology.

The kinds of vegetation that are planted on barrier-type dry covers usually have roots that will not penetrate cover material. In effect, this limits cover vegetation to various grasses and necessitates long-term maintenance programs to prevent deeper rooting vegetation such as trees and bushes from growing. This is a difficult problem for mines in forested areas, where trees are the natural vegetation.

With ET covers, the penetration of roots through the cover material or into the underlying tailings is not a problem. Any infiltrating water will be treated in down-gradient wastewater treatment systems, such as constructed wetlands. With ET covers, woody plants native to the area of a mine can be used.

CONSTRUCTED WETLANDS

Constructed wetlands are passive natural wastewater treatment systems, consisting of multiple, in-ground cells arranged in one or more parallel flow paths. There are various types, including free water surface wetlands and sub-surface flow wetlands. Here, the water being treated flows beneath the surfaces of permeable beds. Wastewater may flow either horizontally or vertically in a sub-surface wetland.

Wetlands are already used at many mine sites for treating mining and sanitary wastewater. These treatment systems are attractive because they are economic to build and operate and require relatively little attention long after mine decommissioning. However, they have limitations, including:

- Requiring relatively large surface areas.
- Limited overall contaminants removal, only up to 40 to 60% for many pollutants.
- Sometimes-erratic treatment capabilities.
- Inability to handle some mining wastewater contaminants such as dissolved metals
- Poor or non-operability during winter.

ENGINEERED BIOREACTORS/WETLANDS

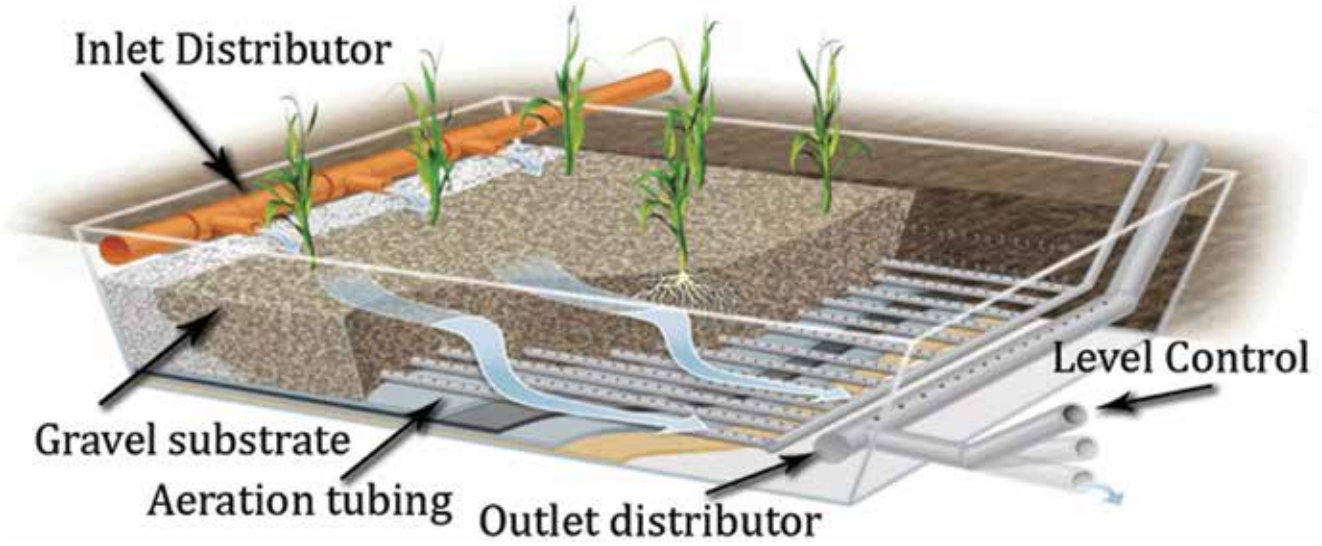
Engineered bioreactors, also called engineered wetlands, are types of in-ground wastewater treatment systems that evolved from sub-surface constructed wetlands. With engineered bioreactors, design, morphology, operatingmethods, substrates, flows, and/or other process conditions in wetlands, are manipulated and controlled to perform whatever the ambient conditions.

There are several types of engineered bioreactors, including aerated and non-aerated aerobic and anaerobic.

The aerated bioreactor engineered wetland (BREW Bioreactor) injects air from a nearby blower via aeration tubing under its aggregate substrate.

Many types of anaerobic bioreactors can be used as engineered bioreactor cells for treating wastewaters. These include denitrification bioreactors; successive alkalinity-producing systems for neutralising acid rock drainage without generating ochre; and biochemical reactors for removing many dissolved metals and metalloids.

The substrates of most anaerobic bioreactors contain high molecular weight active media that can be degraded microbially in the bioreactors. These generate lower molecular weight breakdown products that are metabolised by characterising bacteria. These are different for the various anaerobic bioreactors.



A horizontal sub-surface flow bioreactor engineered wetland cell.

Aerobic and anaerobic in-ground engineered bioreactors have much higher treatment efficiencies and can handle higher wastewater flow rates than constructed wetlands. In addition, they are modular and can operate successfully at higher contaminant loading rates. The capital expenditure for engineered bioreactors is often roughly half of conventional mechanical wastewater treatment plants. Operating expenditures and life cycle costs are also much lower, and they can operate in frigid conditions.

INTEGRATED DRY COVER SYSTEMS FOR CLOSED MINES

ET covers and engineered bioreactors can be combined with other technologies to create an integrated system that is a viable and economic long-term alternative to water covers and tailings dams.

During construction and operational phases of a mine, stripped overburden and cleared brush are stored for use at closure. Prior to closure, an appropriate engineered bioreactor system is constructed down gradient of the tailings management area. It is relatively small in area and designed to treat any leachate, drainage and meteoric water under worse case possible contaminant concentrations and extreme environmental conditions.

Lined stormwater ditching is constructed around the tailings management area to isolate it, diverting away water that might otherwise enter from the surrounding watershed. These stormwater ditches will direct un-contaminated water into a down-gradient stormwater wetland, which will remove any suspended solids before discharging it to local watercourses. Effluent from the new engineered bioreactor system will also be directed into the stormwater wetland.

On closure, a section of the TMA's dam will either be breached or replaced with a permeable section, depending on design and local morphology. This allows the tailings pond to be drained into the engineered bioreactor system, where its water is treated. Any future percolation through the tailings is also treated. The resulting dry tailings surface is then contoured to improve surface drainage. Following this, it is covered with previously stored or acquired organic material, to allow vegetative growth.

The former tailings dam will become a dike, holding back largely dry materials. As appropriate, this dike can then be lowered, contoured and vegetated in the same manner as the area above it. The consequences of any future break in the dike would be minimal, compared to a breach in a dam holding back water and tailings.

Once the surface of the now hydraulically-isolated tailings is vegetated, the amount of water that can infiltrated into it and percolate through it, will be limited. The amount of water that can infiltrate will be further reduced by evapotranspiration from the cover's vegetation, and surface contouring.

CONCLUSION

Regulators, the public and other stakeholders can be expected to be even more skeptical or resistant to water covered tailings management areas. Engineered bioreactors and evapotranspiration systems can provide viable alternatives for mine closure.

Jim Higgins
Ph.D., P.Eng. is with Environmental Technologies Development Corporation.

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Komatsu announces development of new Modular Mining open-technology platform

Advancing toward its smart mining vision for customers where mining environments are connected, interoperable ecosystems that bring together the customer's chosen equipment and technologies to accelerate value delivery and empower innovation, Komatsu recently announced further alignment of its mining business segments to best serve the needs of its global customer base.

Komatsu's new Mining Technology Solutions team brings together experts from across its businesses to focus on rapid technology advancement. This new business unit includes the Modular Mining brand; a Komatsu technology brand focused on real-time digital offerings that are compatible with all makes of equipment. As part of this evolution, the MineWare brand is being discontinued and its Argus and Pegasys solutions will now be part of the Modular Mining brand portfolio. All MineWare and Modular Mining employees have been integrated into the new Mining Technology Solutions team.

Aligned around common goals of being more agile and collaborative, increasing efficiencies and leveraging the full capacity of Komatsu's mining experience, the Mining Technology Solutions team has been developing the new Intellimine Synergy open-technology platform as part of the Modular Mining technology portfolio to debut at MINExpo International on Sept. 13 in Las Vegas. Designed to collect, integrate and process data in real time, Intellimine Synergy is on track to be an industry first for offering customers a single source of actionable insights through an open-technology platform that brings together data from all relevant Komatsu, Modular Mining and third-party machines, mining processes, systems and technology applications.

"The number of data sources available to our customers now can be overwhelming," said Jeffrey Dawes, President and CEO of Komatsu Mining. "So, we set out to provide a solution that seeks to cut through the noise; to provide a single source of real-time information that can assist, automate and help optimise the important decisions customers make every day."

To find out more about how the Komatsu Mining Technology Solutions team is leveraging next-generation optimisation algorithms and open-technology solutions, join them in person at MINExpo Sept. 13-15 at the Modular Mining booth, #7671, and the Komatsu booth, #7027. Further details will be available during the show both in-person and online.

'Green steel': Swedish company ships first batch made without using coal

Hybrit sends steel made with hydrogen production process to Volvo, which plans to use it in prototype vehicles and components

A piece of iron produced as part of the green steelmaking process.

The world's first customer delivery of "green steel" produced without using coal is taking place in Sweden, according to its manufacturer.

The Swedish venture Hybrit said it was delivering the steel to truck-maker Volvo AB as a trial run before full commercial production in 2026. Volvo has said it will start production in 2021 of prototype vehicles and components from the green steel.

Steel production using coal accounts for around 8% of global greenhouse gas emissions. Hybrit started test operations at its pilot plant for green free steel in Lulea, northern Sweden, a year ago. It aims to replace coking coal, traditionally needed for ore-based steel making, with renewable electricity and hydrogen. Hydrogen is a key part of the EU's plan to reach net zero greenhouse gas emissions by 2050.

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Mining of the future

This is what the future of mining looks like. A mining automation concept vehicle from Sandvik gives a unique and real hands-on preview of how the latest technologies can make the mining industry more safe, efficient, and sustainable.

Cabinless, electrified, and automated. Without human interaction, a concept vehicle from Sandvik with an Automine® mining automation solution can navigate through the rough and changing conditions of underground mining tunnels. It can read the environment in 3D, create a model of the environment, and plan its own missions – while the miners monitor the machine operations from the comfort and safety of a control room that can be located hundreds of miles away.

“Automation, digitalisation and electrification will form the future of mining,” predicts Jarkko Ruokojärvi, Director of Automation Global Business Development and Marketing at Sandvik Mining and Rock Solutions. “New technologies provide new opportunities to increase safety and productivity and make the operations more sustainable.”

Removing people from hazardous environments is really one of the main drivers for automation. “Add to that the fact that many easier deposit locations have already been mined,” says Ruokojärvi. “The companies need to search for valuable minerals in locations that are more and more challenging and remote.”

Generally speaking, the deeper into the ground the more challenging the rock mechanical conditions and the more challenging and costly it becomes to establish a mining area. Safety hazards increase and building infrastructure can become problematic.

GREAT SECRECY

Sandvik has been developing autonomous and remotely operated equipment for 20 years and its Automine automation system has been delivered in hundreds of mining machines to customers around the world. Many of the ground-breaking mining innovations have come to life in its test mine and test lab in Tampere, Finland. To continue this journey, it is here that also the concept vehicle is being developed under great secrecy.

“With this vehicle we wanted to take automation a step further, disrupt the mindset of how things are conventionally done and show what we think the future will hold,” says Ruokojärvi.

The current concept loader operating its way through the test mine in Tampere is not for sale. It is even doubtful that there ever will be a loader that looks exactly like it available on the market. This is a teaser, to show what to expect. The concept loader showcases the Sandvik vision for future robotic mining technologies, and the plan is to gradually commercialise and deploy the technologies across different types of equipment.

BENEFICIAL ELECTRIFICATION

Developments in the automotive industry have been valuable in this endeavour. The advances in sensor technology development for self-driving cars have led to new components becoming available for sensing the environment, for route planning and for avoiding obstacles. The electrification is greatly beneficial in mining too, as battery-driven equipment reduces CO2 emissions both above and underground. If powered with renewable energy the value chain increases further.

The new concept vehicle has been designed from the ground up for autonomous use. All factors necessary to accommodate people onboard have been eliminated, such as the operator cabin. Optimising the design for autonomous use allows higher payloads in existing tunnels. It also enables the design of smaller machines that can work in narrow passages, a valuable aspect as smaller tunnels mean less mining waste.

“Focusing on machine design for only autonomous use allows for improved motion control and higher reliability,” says Ruokojärvi. “The higher intelligence provided by the new technologies allows for increased operational flexibility, higher adaptivity and higher productivity, due to the machine’s self-awareness and self-planning, as well as simpler preparations required by people.”

Mining operations are widely varied in terms of mine design, minerals and geology. Different levels of automation are already in use in mining operations.

GENERIC AUTOMATION

“Our goal is to make the automation more generic so that more types of mining methods can get the same benefits of safety, production efficiency and sustainability, regardless of how complicated the mining process is,” Ruokojärvi says.

He predicts that in five to ten years mining operations in most parts of the world will be far more technically advanced than they are today. The concept vehicle has already shown what it can look like.

“It’s very exciting that we can show that these technologies work in the toughest conditions and what is possible to achieve,” says Ruokojärvi. “In our next steps it is necessary to evaluate how to incrementally commercialise these technologies to make sure they meet the needs of our customers.”

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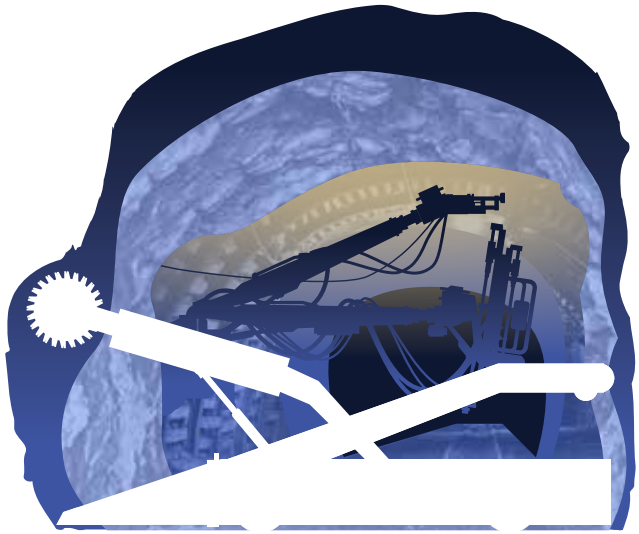

Big 3 launch challenge

BHP, Rio Tinto, and Vale, three of the world's biggest resource companies, have launched the Charge On Innovation Challenge, a global competition for technology innovators to develop new concepts for large-scale haul truck electrification systems to help significantly cut emissions from surface mine operations and unlock safety, productivity, and operational improvements.

BHP, Rio Tinto, and Vale are the Founding Patrons of the Challenge, in partnership with Australia's Mining Equipment, Technology and Services (METS) industry body Austmine. The Challenge is expected to attract additional interest from resource companies that maintain substantial haul truck fleets and are looking for innovative concepts to deliver electricity to large battery-electric haul trucks.

Current stationary charging systems require substantial time to charge large trucks, which would result in significant lost productivity. The mining industry needs multi-megawatt scale fast charging concepts capable of delivering around 400kWh to charge (and propel) a truck within the truck's haul cycle (load, travel, dump, return, queue).

"METS and mining companies are united on the Challenge to reduce emissions across the supply chain," said Austmine CEO Christine Gibbs Stewart.

"With 80% of METS companies supplying products and services outside mining, the Challenge leverages the experience and innovation of industries in the automotive, battery makers, aerospace, defence and other sectors."

"We are confident that we will find a solution to the delivery of electricity to trucks in the complex operating environment of a large surface mine. We expect the Challenge will attract companies from a broad range of sectors including mining, automotive, aerospace, agriculture, and defence to deliver selected charging concepts to create a standard product that can interface with all trucks," Ms Gibbs Stewart said.

President of BHP Minerals Australia Edgar Basto said: "We expect the Challenge will stimulate innovative ideas, some of which could be immediately applied to existing diesel-electric equipment and help fast-track implementation of longer-term solutions. We understand that these challenges will not be solved overnight, but together we can find the best concepts that can be applied across the industry."

Rio Tinto Group Executive Safety, Technical and Projects Mark Davies said: "This is a global call-out to innovators to change the way haul truck systems operate in the mining sector. Innovation is the key to decarbonisation, and we expect the Challenge will deliver exciting new concepts that could drive huge long-term benefits for our industry and the environment.

"Partnerships and collaborations across a diverse range of sectors can drive significant technological change. This is an important, industry-wide approach that has potential to create new jobs and opportunities for suppliers, both globally and locally."

Carlos Mello, Ferrous Engineering Director of Vale said: "Mine electrification requires considerable integration between mine planning and operations. We need to develop new charging solutions that can be incorporated into our operations in parallel to the development of battery trucks, to ensure we create a truly sustainable electric haulage system in all aspects – clean, competitive and flexible."

The mining industry needs to be at the forefront of tackling the climate challenge. The Charge On Innovation Challenge is a great example of the current collaborative work being done by the mining industry and mobile equipment manufacturers to decarbonise mining fleets. In addition to providing a zero-carbon energy source, the conversion of mobile mining equipment to battery electric can potentially unlock value, as electric motors have fewer moving parts when compared to standard equipment.

Several non-traditional mining sector vendors are actively developing technologies that can be applied to mine electrification. The Challenge is expected to demonstrate an emerging market for charging solutions in mining, accelerate commercialisation of solutions, and integrate innovations from other industries into the mining sector.

The Challenge Expression of Interest process opened on Tuesday, 18 May, and candidates who made the short list are expected to pitch their concepts later during this calendar year.

Komatsu announces theme and featured products for MINExpo 2021

At MINExpo 2021, Komatsu's booth will showcase and demonstrate the company's commitment to its new brand promise: Creating value together. That promise will serve as the company's show theme, highlighting the importance Komatsu places on partnering with customers to deliver scalable, sustainable solutions that prioritise safety and optimise mining operations at every level.

Through digitalisation, electrification, automation and interoperability, Komatsu is already finding new ways to extract the minerals needed to advance the future of energy and help create renewable resources for the long term. The products, technologies and solutions that will be featured are designed to help mining companies advance their journey toward this future vision. Visitors will have the opportunity to learn about the company's existing offerings, as well as concepts for a bright future that support society's growing needs in an environmentally responsible way. Within the coming decades, Komatsu envisions a connected mining ecosystem where mining activities are conducted in harmony with surrounding communities, with focus on a zero-harm mentality, zero emissions and zero waste.

Visitors to Komatsu's MINExpo booth will have the opportunity to learn more about:

- **Room and pillar automation.** Komatsu automation provides customers with scalable options to match their needs by driving consistency, enabling tele-remote operations and helping to moving operators out of harm's way.

- **Longwall solutions.** Komatsu supports and serves the global longwall market by providing Joy-engineered PRS solutions and designing and manufacturing its Joy armoured face conveyors, shearers and longwall controls, including the Joy RS20N, a faster, more powerful and reliable electronic control system that enables real-time decisions to be made from a remote location to remove people from the mine face.

- **Lithium-ion battery power.** By moving from lead acid battery technology to lithium, mine operators have the potential to reduce maintenance requirements and increase productivity. This longer-life battery can also help mine operators lower the total cost of ownership for battery haulers.

The Joy 12HM46 with Titan Cutter head is the largest and most powerful Joy drum-style continuous miner for mining industrial minerals such as trona, gypsum, potash and salt.

- **12HM46 with Titan Cutter head**. The 12HM46 is the largest and most powerful Joy drum-style continuous miner for mining industrial minerals such as trona, gypsum, potash and salt. Designed to be very maneuverable, Joy continuous miners provide an option that's more flexible than traditional borer miners.

Komatsu's MINExpo experience will demonstrate how the company partners with its customers and others to deliver the equipment, technologies and solutions needed to help mining operators reach their goals and help position the mining industry to meet the world's need for minerals in increasingly sustainable ways.

Komatsu can be found in **booth 7027 in Central Hall at MINExpo 2021**, 13-15 September, in Las Vegas, Nev., U.S. For more information on Komatsu's mining products and solutions, visit www.mining.komatsu.

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