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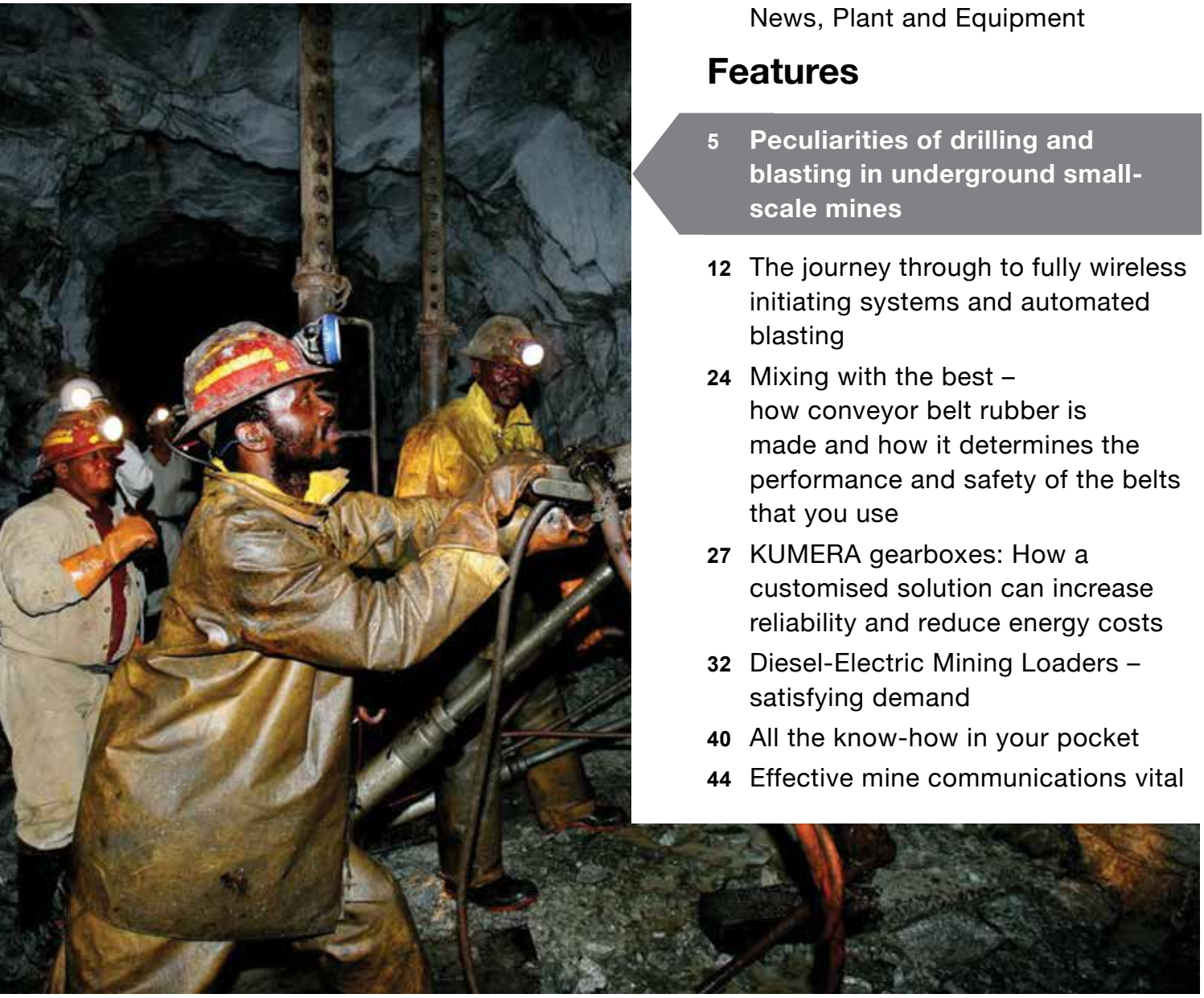

News, Plant and Equipment

Features

Orica

Orica is the world's largest provider of commercial explosives and innovative blasting systems to the mining, quarrying, oil and gas and construction markets, a leading supplier of sodium cyanide for gold extraction, and a specialist provider of ground support services in mining and tunnelling.

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New research from Global Palladium Fund reveals institutional investors predict an increase in industrial activity will drive precious metal prices higher

Adoption of green technologies and combating climate change are key factors in demand for precious metals

New research with institutional investors and wealth managers reveals a positive outlook for global industrial activity in 2021, and this should have a positive impact on demand for precious metals and their valuations.

The study, from Global Palladium Fund (GPF), which has recently listed four physically-backed metal Exchange Traded Commodities (ETCs) - including ones that track the spot price of palladium and platinum - shows that two thirds of investors (67%) predict industrial activity will increase this year. This will drive the price of metals such as silver, palladium and platinum higher according to 69% of professional investors surveyed. Almost a quarter (24%) predict that prices will increase dramatically.

Palladium

Palladium is a vital component of catalytic converters which turn the most harmful pollutants in car exhaust gas into environmentally friendly compounds like carbon dioxide and water. It also has a range of other applications, including ceramic capacitors, which regulate the flow of electricity in smartphones and laptops.

When considering the key factors influencing the price of palladium, 90% of investors said that growing electric car sales in China will play an important role in pushing the metal's valuation higher, 89% cited the weak US dollar as a driver of appreciation, and over three quarters (77%) said that continuing shortages of the metal would mean the price continues to rise.

Over two thirds (67%) of investors said that tighter emission standards would also push the price higher. For example, in 2019, China introduced new vehicle emission standards ('China VI'), which are among the strictest in the world. To comply, all new cars sold in China will have to be equipped with good-quality catalytic converters, and that means as much as 30% more palladium per vehicle.

Platinum

The study also highlights platinum's importance in the future hydrogen economy thanks to its unique hydrogen-absorbing properties, and as an essential metal for cleaning toxins from the environment. Given this, plus the United States re-joining the Paris climate accords under President Biden and the growing focus on combating climate change, the majority (95%) of investors agree that industrial demand for Platinum should increase over the coming months and years, and 85% predict that the price of platinum will rise in 2021.

Also, Platinum remains at a very inexpensive level compared to palladium and rhodium. The potential to substitute these metals for platinum could lead to growth in value of the metal – a view that 90% of professional investors interviewed agree with.

Alexander Stoyanov, Chief Executive Officer of GPF said: "Our research shows just how important precious metals are to making the green economy a reality. Their properties mean that they have a fundamental role to play in technologies such as hydrogen fuel cells and other green technologies crucial to changing the world we live in and, as a result, demand for metals such as palladium and platinum will increase."

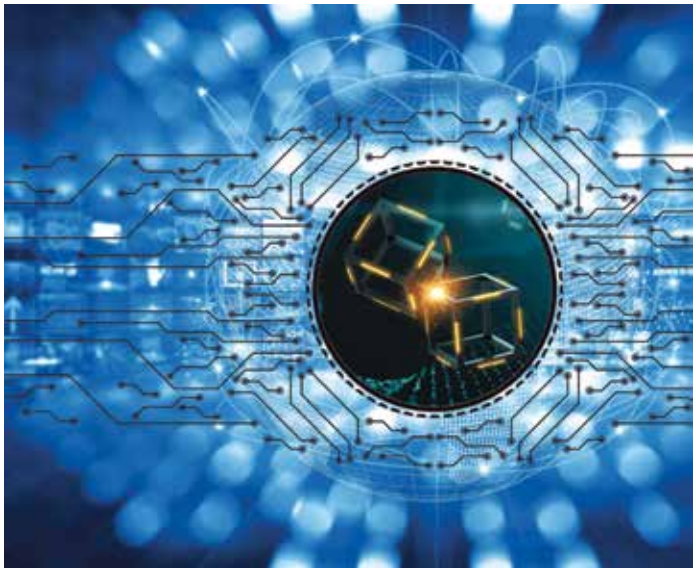
NTree International Ltd, a specialist in marketing, distribution and investor engagement, is leading the distribution and rollout of the products. NTree has set up a dedicated brand, Metal.Digital https://metal.digital as an education resource for professional investors with a focus on metals.

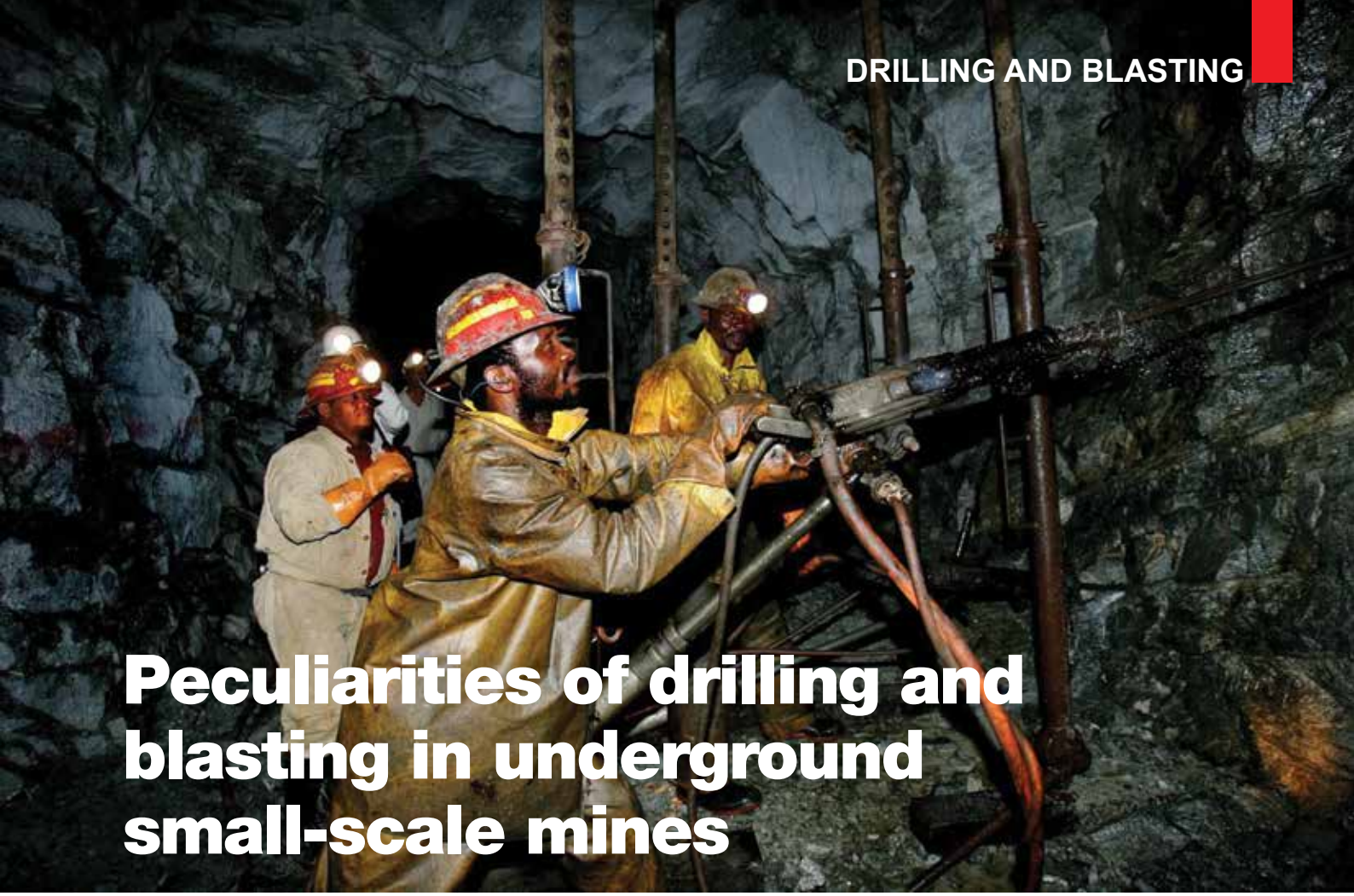
Timothy Harvey, Chief Executive Officer and Founder of NTree, said: "Investing in precious and industrial metals has never been timelier as global economies seek to address climate change. That's why we have launched new metal ETCs that have the lowest charges in the marketplace, enabling investors to access metals cost effectively."

Global Palladium Fund's (GPF) new ETCs are listed on the Deutsche Börse and London Stock Exchange and have the lowest charges with total expense ratios (TER) ranging from 0.145% to 0.20%. Targeting Family Offices, wealth managers, institutional and other professional investors, the new physically-backed gold, silver, platinum and palladium ETCs track the spot price of the respective metals they cover.

The ETCs have a strong focus on ESG. LBMA-approved metal will be sourced from producers and suppliers who support the Sustainable Development Goals of the UN 2030 Agenda and other global initiatives in sustainable development and responsible mining.

GPF is also the first to use Blockchain technology to record bar information into Distributed Ledger Technology, thereby providing an extra layer of security and proof of ownership to the Issuer. The use of Blockchain is in addition to the traditional recording processes used by the custodian.





Peculiarities of drilling and blasting in underground small-scale mines

A sector in need of support and training

Small-scale mining has positive and negative aspects. It is closely linked to economic development, particularly in the rural sector in many developing countries; it helps to stem rural-urban migration, maintaining the link between people and the land; it makes a major contribution to foreign exchange earnings; it enables the exploitation of what otherwise might be uneconomic resources; and it has been a precursor to large-scale mining.

Small scale mining can and should be encouraged by creating the operating environment that encourages the use of best practices for mining and occupational health and safety and environmental protection. Methods of drilling and blasting are one area that can definitely be improved with support and training to eliminate archaic and dangerous practises. In this issue we present an article relating to case studies carried out at two South American mines.

Artisanal and Small-scale Mining (ASM) is a prominent activity in the extractive industry: considering only gold, it produces about 20% of the world market supply. Despite this fact, ASM is generally associated with the negative aspects of its environmental impact, and operational research is generally neglected. This article emphasises the peculiarity of the drilling and blasting systems of small underground mines in selected South American Countries. Such Countries, while having large mineral deposits and well recognised large-scale mining activities, at the same time still present on their territory ASM activities that are archaic, highly inefficient, and dangerous for the safety of its operators. This article documents drilling and blasting activities from gold mining in Ecuador and Chile. First, described are the outdated and often non-rational techniques employed by miners, to provide a general framework of the current methods. Then, shown is what can be improved and how the current methods can be modified. Finally, some field applications and the comparisons of the results obtained are presented. One case shows how blast pull efficiency can be increased from 82% to 98% by changing non-rational applications of explosive products to rational, scientific-based employment. Another case shows how, by rationalizing blast designs, drilling and blasting costs can be reduced by 9% per month, the advance by blasting increased by 29% and the pull efficiency increased from 70% to 90%. Finally, it is concluded that examples of application show how operational improvements are easily applicable in the field, relying only on tools and resources of artisanal mining, but

combining solid engineering bases with confidence-gain and respect for the experience of the miners.

INTRODUCTION

Mining is one of the oldest and most important industrial activities in the world, providing raw materials for the development of countries and generating jobs for millions of people. However, there is a mining sector whose sustainable and responsible development has been neglected due to the wide publicity of its negative social and environmental impacts. That sector is Artisanal and Small-scale Mining (ASM), which is present in every mining country in the developing world, and in cases like gold, contributes about 20% to world production (Seccatore *et al*., 2014a), a figure that is quite important, as commented in articles, such as Hilson, 2002; Seccatore *et al*, 2012, Marin *et al*. 2016. The ASM sector, lacking resources and capital access, compared to the medium and large mines of the world has not been able to evolve towards the state-of-the-art methods and technologies that are applied to day (Andrew, 2003; Hentschel *et al*. 2003). The ASM way of working lacks an early exploration, feasibility studies and any kind of planning (Hruschka and Echavarría, 2011, Seccatore *et al*., 2013). Likewise, the methodologies, tools, and technological applications of ASMs are often very outdated, obsolete, inefficient, and unsafe most of the time because they are applied incorrectly (see Seccatore *et al*. 2014b). The line of work of underground ASM in the Andes region is basically based on drilling and blasting, and then, loading and transportation. Drilling and blasting are the most important activity, where miners suffer most of the problems, therefore where exists the most important opportunity to improve their work, achieving best practices, safety, and profitability (Hentschel *et al*, 2002, Hruschka and Echavarría, 2011). The study presented herein was developed during R&D projects in two mines in South America. The first, located in central Chile, is called Mina La Palmera and, the second, Golden Minera Comunitaria, in southern Ecuador. To conduct this study, we observed how each mine and its miners operate, understanding why they made certain decisions, eventually working with the miners to correct their mistakes and develop improvements.

THE CHILEAN CASE

The mine in Chile studied for this research is located in the 55th mining district of Chancón, near the city of Rancagua, in the VI region, central Chile. Details regarding the

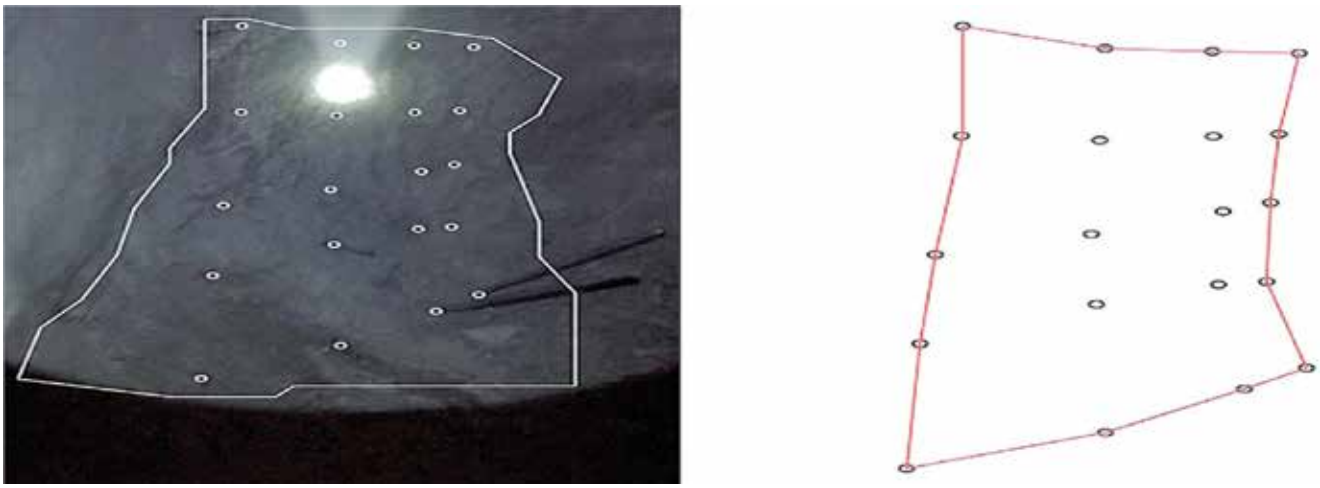


Figure 1: La Palmera Mine' firing diagram.

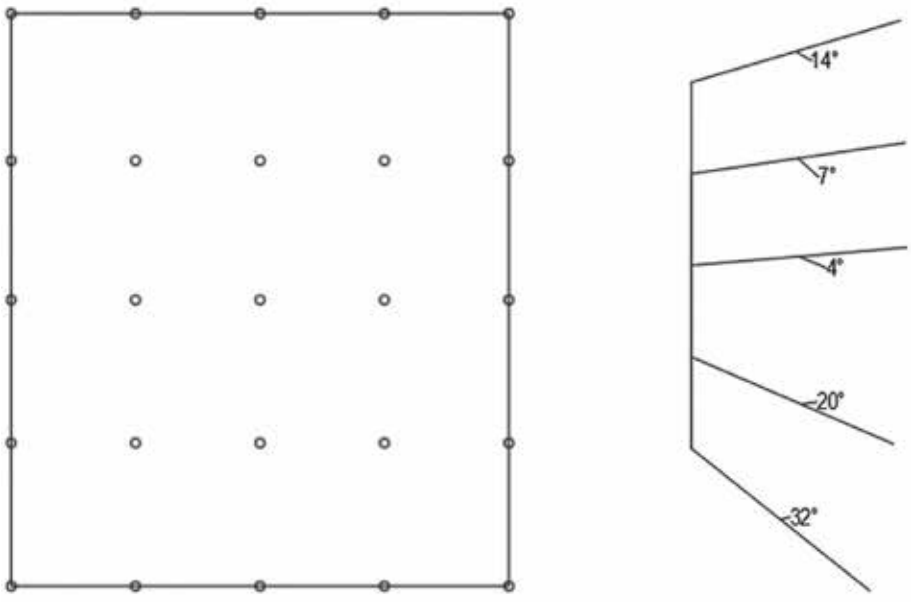


Figure 2: Restructured La Palmera Mine' firing diagram in front and side view.

Chancón district and its mining culture are described thoroughly in Espinoza *et al*., 2020. In Chancón, along the years, the miners developed a very peculiar drilling and blasting pattern. A quite unusual diagram was observed at the early stages of the project, and it can be seen in **Figure 1**. After thorough observation of the miners' operations, it was determined that all the patterns met in the miners' firing diagrams were adaptations of a general one, that is presented in **Figure 2**. Curiously enough, the diagram does not employ any kind of opening cut, neither parallel holes nor inclined ones.

All the holes are loaded (no relief holes are employed) and, in addition, as the side view shows that the holes are drilled in an outward fan fashion, the opposite of a traditional V-shaped or pyramid-shaped opening cut. This implies that the efficiency is extremely poor, and the range of overbreak per shot is very extended and forced into the rock mass. During the research, a baseline survey was carried out, for which the follow ing key performance indicators (KPIs) were considered: number of holes, drilling depth, average drilling time per hole, total drilling time, type of explosives, and total cost per blast. These data are reported in **Table 1**.

Table 1: Baseline drilling and blasting data, La Palmera Mine.

Parameter	Value	Unit
N. of holes	25	#
Drilling length (pull)	1.6	m
Drilling diameter	38.1	mm
Average drilling time per hole	0:03:03	h: min: s
Total drilling time	2:02:00	h: min: s
Emulsion cartridges 1"X8" (25.4mm X 203.2mm)	25	#
Cost of Emulsion	14.75	USD
Anfo	15	kg
Cost of Anfo	16.22	USD
Fire cap + safety fuse	25	#
Cost of cap + fuse	4.95	USD
Total Cost	35.92	USD

Table 1 shows that each hole is charged with one 1"x8" Emulsion cartridge (25.4mm X 203.2mm), 600 grams of ANFO and a detonator connected to 2.5 meters (2.8 ft) strand of safety fuse. Due to the employment of a safety fuse, the blast is manually lit using a hand-size gas blowtorch, and the initiation sequence is determined by the blaster in charge. This firing sequence does not follow a standard pattern, and is mainly based on the blaster's sensibility, experience, or mere custom. The authors of this study conducted burning tests of the fuse, in strands of 1m each, sampled along a fuse coil. The results showed no variation in the burning speed, indicating that it can be considered constant along the coil. Fuse from one single coil is used in a single blast. Therefore, the initiation sequence depends on the ignition sequence of the fuses per formed by the blaster with a blowtorch.

This randomness causes undesirable results, where the linear advance by blasting is approximately 1.12 meters

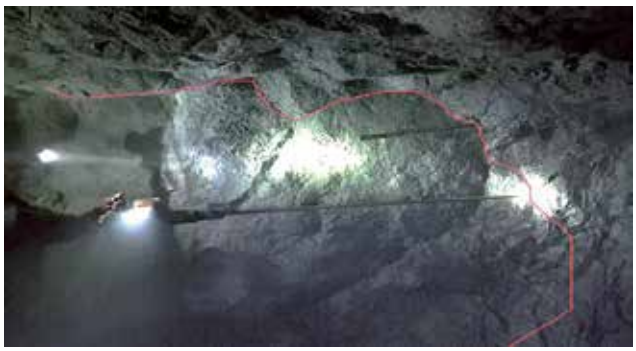


Figure 3: Result of blasting at the Mina La Palmera,showing the overbreak profile.

(3.67 ft, achieved pull or actual pull), which is equivalent to 70% of the total drilled length (drilled pull or theoretical pull). It also stands out that, as a result of the fanned shots, there is obtained a total breaking envelope that presents up to 600% of overbreak, more than what was expected due to lookout angles up to 32°. In addition, the resulting granulometry is normally coarse and very uneven, since the distance between shots is very uneven itself. In turn, the drilling diameter is too small for ANFO, taking into account the critical diameter of the ANFO (normally considered around 2" or 50.1 mm). The chance of the ANFO not properly detonating is severely high, and in fact the occurrence of misfires is quite common. In addition to that mentioned above, the mine has a heavy presence of water that runs through the tunnels, especially during the winter rainy season, generating critical conditions for the employment of ANFO. **Figure 3** shows the dramatically poor result of a typical shot considering all the above-mentioned criticalities.

To improve this situation, proper engineering methods for the design and realization of the blast were gradu ally applied. The drilling pattern was changed. Changing the drilling diameter was found to be an inconvenience by the miners, since the tools used could not be modified without capital investment unavailable to them. Therefore, the drilling diameter was kept at 1 "1/2 (38.1 mm) and the explosive agents were kept the same. This decision was made, besides the lack of resources, also to respect the fact that the miners distrust new practices, since they have always used a single work method all their life. To mitigate the rejection of the change, the miners were offered an integral solution, with engineering bases, but, above all, within the reach of what they could afford within the ASM framework. Each decision and calculation was studied considering Hustrulid and Bullock, 2001 and Hartman and Mutmansky, 2002. As for the changes that were made, it was proposed to prepare a shot diagram with standard dimensions being 2.3 meters (7.55 ft) high and 2 meters (6.56 ft) wide. Also, it was decided not to use the same amount of ANFO in each shot, but to separate the shots into functional sections (**Table 2**): Open cut in 3 rounds (Round 1, Round 2 and Round 3), Pro duction Hole (Bottom, Top), Contour holes divided into Side holes, Crown holes and Floor holes. This allows the proper dosage of the amount of explosive used in each section, focusing on strong charges for demanding areas such as the floor, and a low amount of charge in light areas such as the crown and side sections. Simultaneously, a design based on parallel and completely horizontal open cut holes was delivered (**Figure 4**), which allows the granulometry

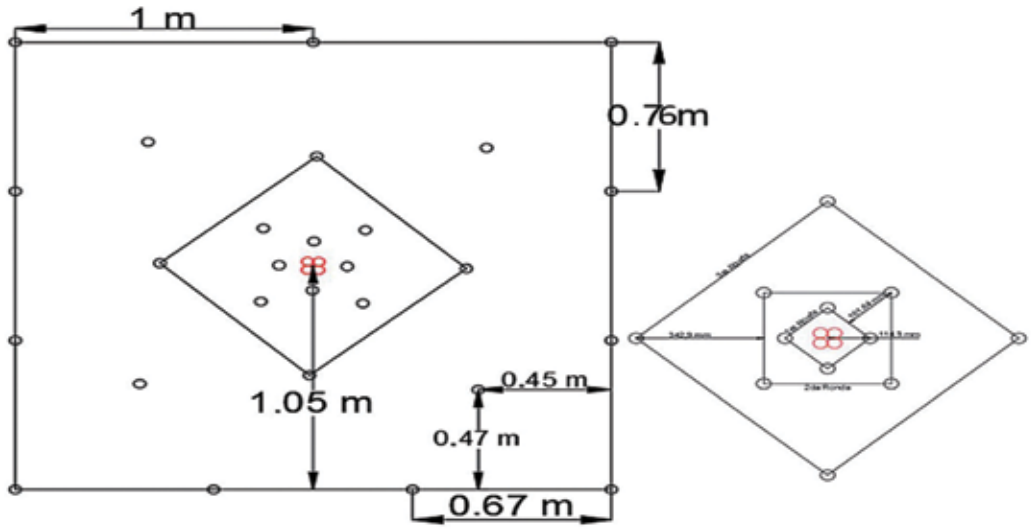


Figure 4: Proposed blast design.

Table 2 ANFO distribution according to section (kg-lb).

Section	Round 1		Round 2		Round 3		Prod. Top		Prod. bottom		Sides		Crown		Floor	
ANFO p/hole	0.28	0.62	0.2	0.4	0.52	1.15	0.93	2.05	0.93	2.05	1.4	3.09	0.57	1.26	1.48	3.26
ANFO Total	1.12	2.47	0.8	1.8	2.08	4.59	1.86	4.1	1.86	4.1	2.8	6.17	1.71	3.77	5.92	13.05

of the rock resulting from the blasting to be more uniform. Also, the holes of the Crown, Side and Ground sections are drilled with an outlook of maximum 5°. This allows to reduce the break envelope by 600%. The characteristics of the new proposed blast design are reported in **Table 3**.

Table 3: Proposed drilling and blasting data.

Parameter	Value	Unit
N. of holes	28	#
Drilling length (pull)	1.6	m
Drilling diameter	38.1	mm
Average drilling time per hole	0:03:03	h: min: s
Total drilling time	2:21:31	h: min: s
Emulsion cartridges 1"X8" (25.4mm X 203.2mm)	28	#
Cost of Emulsion	16.19	USD
Anfo	18.15	kg
Cost of Anfo	19.26	USD
Fire cap + safety fuse	28	#
Cost of cap + fuse	5.44	USD
Total Cost	40.89	USD

The results of the new proposed blast is shown in **Figure 5**.

- 90% of pull efficiency was obtained
- Overbreak reduced by 600%
- Clean contour
- Fine and uniform granulometry

THE ECUADORIAN CASE

The mine studied in Ecuador, Golden Minera Comunitaria,

Figure 5: Result of the new proposed blast.

is located in the Zaruma-Portovelo mining district, in the province of El Oro, southern Ecuador. Technical aspects of drilling and blasting in these mines have already been documented by Sec catore *et al*. 2014b. Other economic and strategic aspects of the mines of this area are described in detail in Sec catore *et al*., 2013 and Marin *et al*., 2016 and Sandoval, 2001. The R&D project developed in this mine was a training course on drilling and blasting techniques within the framework of a larger project of capacity-building for small-scale and artisanal miners in Ecuador. To understand the local miners' practices and evaluate possible improvements, it was decided to perform three different blasts, where practices by miners, a consulting company and a national explosives manufacturer could be compared.

- Blast n.1: in its entirety drilled, charged, and fired by local miners, according to their tradition and employing the tools and explosive agents typically used in the area. Shown in **Figure 6**.

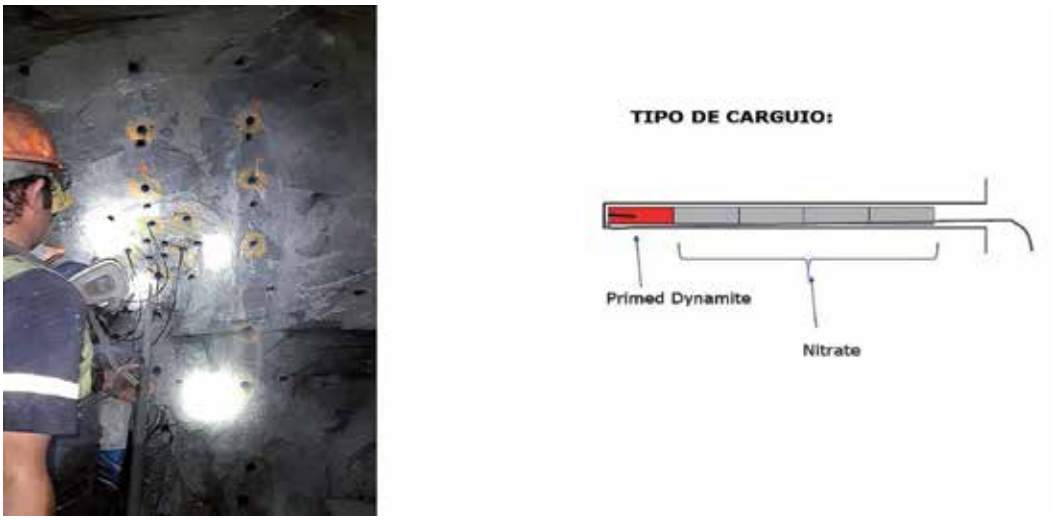


Figure 6: Blast 1: drilling and charging configuration.

- Blast n.2: drilling diagram based on rational methods studied by the contracted consulting firm, however, employing the same tools and explosive agents typically used in the areas in Blast 1. Shown in **Figure 7**.

Figure 7: Blast 2: drilling and charging configuration.

- Blast n.3: drilling pattern determined by the contracted consulting firm, on the basis of engineering design methods, employing modern explosives and initiation devices provided by the national explosive's manufacturer.

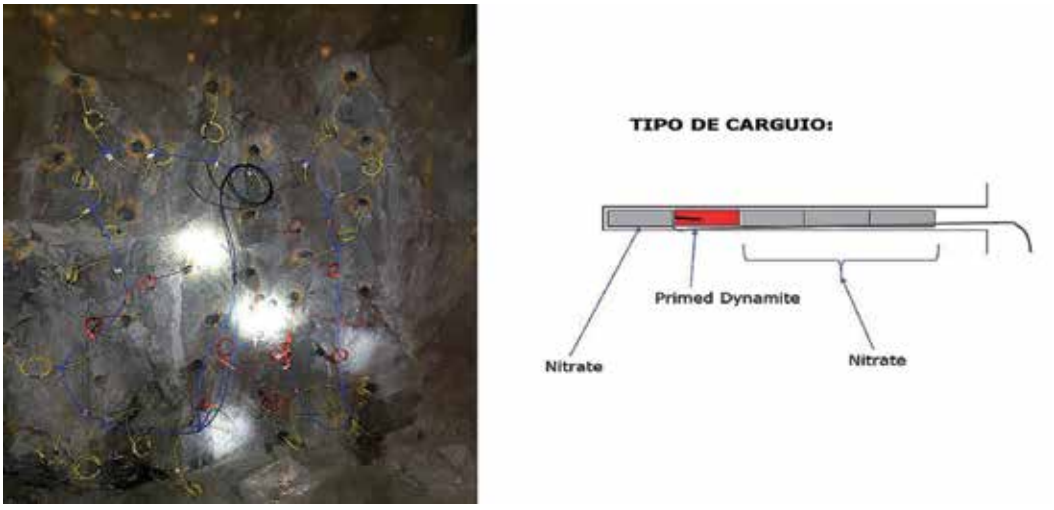


Figure 8: Blast 3: drilling and charging configuration.

Figure 9: Compared visual results of the 3 blasts.

Local miners typically employ a column charge of hand-made cartridges of Ammonium Nitrate (AN, without Fuel Oil, in drills: This is because the ventilation time decreases and, despite having a lower VOD, the shock wave manages to fracture the rock; detail in Seccatore *et al*. 2014b) rolled in newspaper foils, boosted by one cartridge of Dynamite 60% NGL as bottom charge, in its turned primed by a fire cap n.8. The good fragmentation obtained suggests that AN detonates when ignited by dynamite. Nevertheless, VOD recording proved unfeasible during this study.

One must note that the drilling and charging were always performed by local miners. As shown in **Figures 6, 7** and **8**:

- Blast 1 had the dynamite primer correctly located at the bottom of the hole, that breaks the toe by advantage of the high VOD of dynamite
- Blast 2 and 3 employed an irrational positioning of the dynamite primer, second in order after a cartridge of AN, that provides a very low detonation shockwave if any at the very toe, the hardest point to break.

The irrational charging method of blasts 2 and 3 had already been observed as commonly employed by the authors of this study during field research in 2012 and 2013. It is still unknown whether the irrational charging was employed in the blasts designed by the external contractor on purpose to discredit their work, or by mere chance of operational habit of the miners that prepared those blasts. Results of the 3 blasts are shown in **Figure 9** and numerical results reported in **Table 4**. The main conclusion drawn both by the miners and the R&D team for this project was that, with a good degree of sur prise, the blasting system developed over the years by the miners, with the shared experience of the local mining community and the empirical knowledge of the local geology, has allowed to reach 98% pull efficiency; on the other hand, the blasting system prepared by the contractor and the explosives manufacturer, based on scientific and rational methods, without prior knowledge of local geology and local rock-explosive interactions, has reached an average of 83% efficiency at the first attempt, despite the irrational charging method employed. Both the miners and the contractor concluded that shared experience and open-minded attitude, prone to accept changes and adapt, is the key for success in this kind of project.

Table 4 Compared results of the 3 blasts.

	Pull efficiency	Overbreak	Underbreak
Blast 1	98,16%	No	Yes
Blast 2	82,07%	No	Yes
Blast 3	85,36%	Yes	No

DISCUSSION ON SHORT TERM VISION OF ASM

In the Chilean study, it was found that the application of rational and engineering-based methods allowed to increase the blasting pull efficiency from 70% to 90%. Following this premise, an analysis was on 20 blasting, the equivalent of one month of work, using both methods. The results are shown in **Figures 10** and **11**. It is seen that the base blasting (with ASM method) has an advance of 22.4m (73.5 ft) over 20 rounds, and an associated cost of 718 USD compared to an advance of 28.8m (94.5 ft) at a cost of 818 USD in the proposed blasting (with engineering methods). For the short-sighted view of ASM operators, this seems cheaper, therefore the best option. Nevertheless, looking at a monthly term, tunnel advance is higher by 29% applying the proposed blast design, and, if an analysis of the true cost per meter is made, it can be observed that the proposed blasting has a monthly saving of 9% compared to base blasting.

CONCLUSIONS

This article deals with the application of engineering methods in a critical environ ment such as ASM. This is a very important opportunity for the development of this mining sector, which due to lack of resources and tools has not been able to evolve or grow as expected and deserved. Every great work starts from the smallest source, so the empirical knowledge that ASM miners have about the qualities and the behaviour of the rock mass is a wealth that many times the rigorous engineering methods would be unable to obtain without important capital investment. To

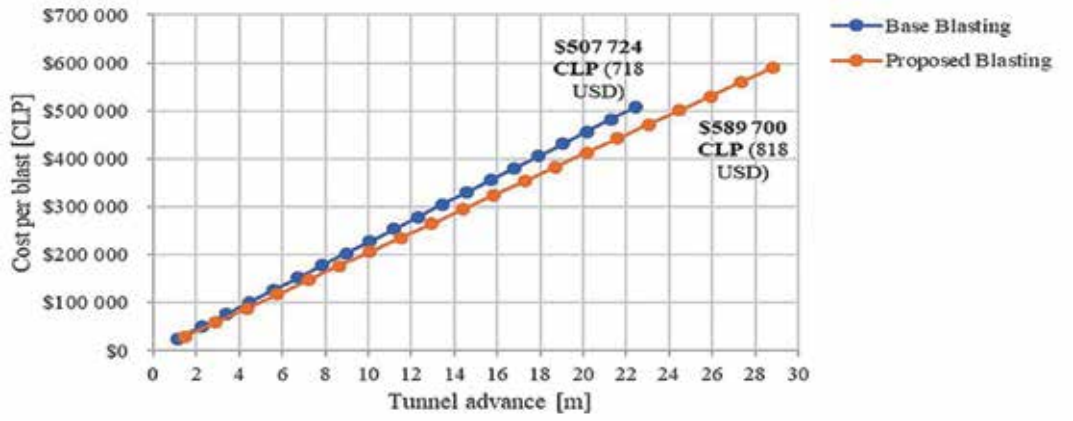


Figure 10: Cost per blast over 20 blasts.

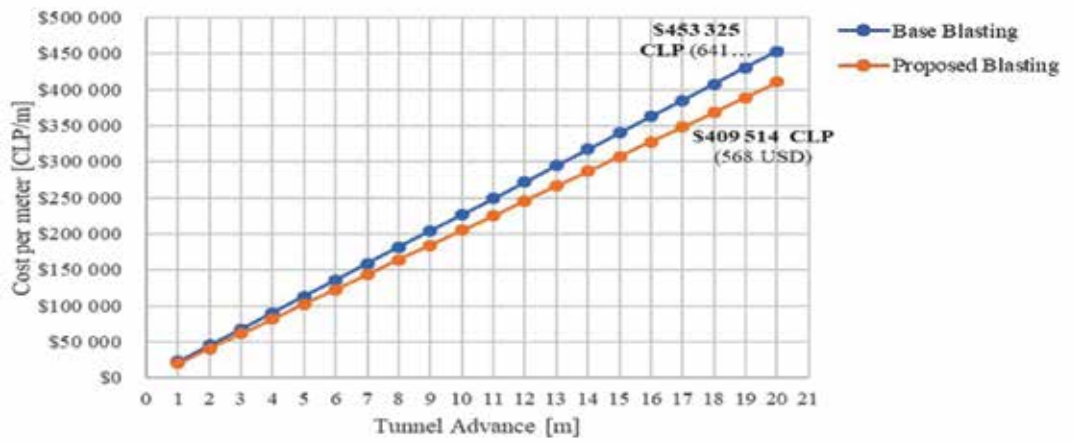


Figure 11: Cost per meter excavated, over 20 blasts.

achieve significant changes and success cases, both ends of the collabo ration chain, R&D developers on one side and artisanal miners on the other, must be able to keep a proactive, collaborative attitude and be ready to learn one from the other. As seen in the studies of Chile and Ecuador, understanding the very source of issues and collaboration to overcome them is the key to achieve a significant change in artisanal and small-scale mining and in the application of field engineering where perfect circumstances do not exist, but risk and uncertainty are constantly present.

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REFERENCES

ANDREW, J. S. Potential application of mediation to land use conflicts in small-scale mining. *J. Clean. Prod*. v. 11, n.2, p.**117-130**, 2003.

ESPINOZA, C.; SECCATORE, J.; HERRERA, M. (2020) Chilean artisanal mining: a gambling scenario. *REM: International Engineering Journal*, v. 73, n.2, p. **241-246**, Apr./June 2020.

HARTMAN, H. L.; MUTMANSKY, J. M. *Introductory mining engineering*. [S. l.]: John Wiley e Sons, 2002. p. **267-322**.

HENTSHEL, T; HRUSHKA, F; PRIESTER, M. *Global report on artisanal & small-scale mining*. London: IIED, WBCSD, January 2002. (Mining, Minerals and Sustainable Development, n.70).

HENTSCHEL, T.; HRUSCHKA, F.; PRIESTER, M. *Artisanal and small-scale mining*: challenges and opportunities. London: IIED, WBCSD, 2003. (Mining, Minerals and Sustainable Development).

HILSON, G. Small-scale mining and its socio-economic impact in developing countries. *Natural Resources Forum*, v. 26, n.1, p. **2-13**, 2002.

HRUSCHKA, F.; ECHAVARRÍA, C. *Rock solid chances for responsible artisanal mining*. Medellín: Alliance for Responsible Mining, ARM, 2011. (ARM Series on Responsible ASM, n. 3). ISBN 978-958-99798-0-8.

HUSTRULID, W. A.; BULLOCK, R. L. (ed.). *Underground mining methods*: engineering fundamentals and international case studies. [S. l.]: SME, 2001. p. **635-662**. ISBN 9780873351935.

MARIN, T.; SECCATORE, J.; DE TOMI, G.; VEIGA, M. Economic feasibility of responsible small-scale gold mining. *Journal of Cleaner Production*, v. 129, p. **531-536**, 15 aug. 2016.

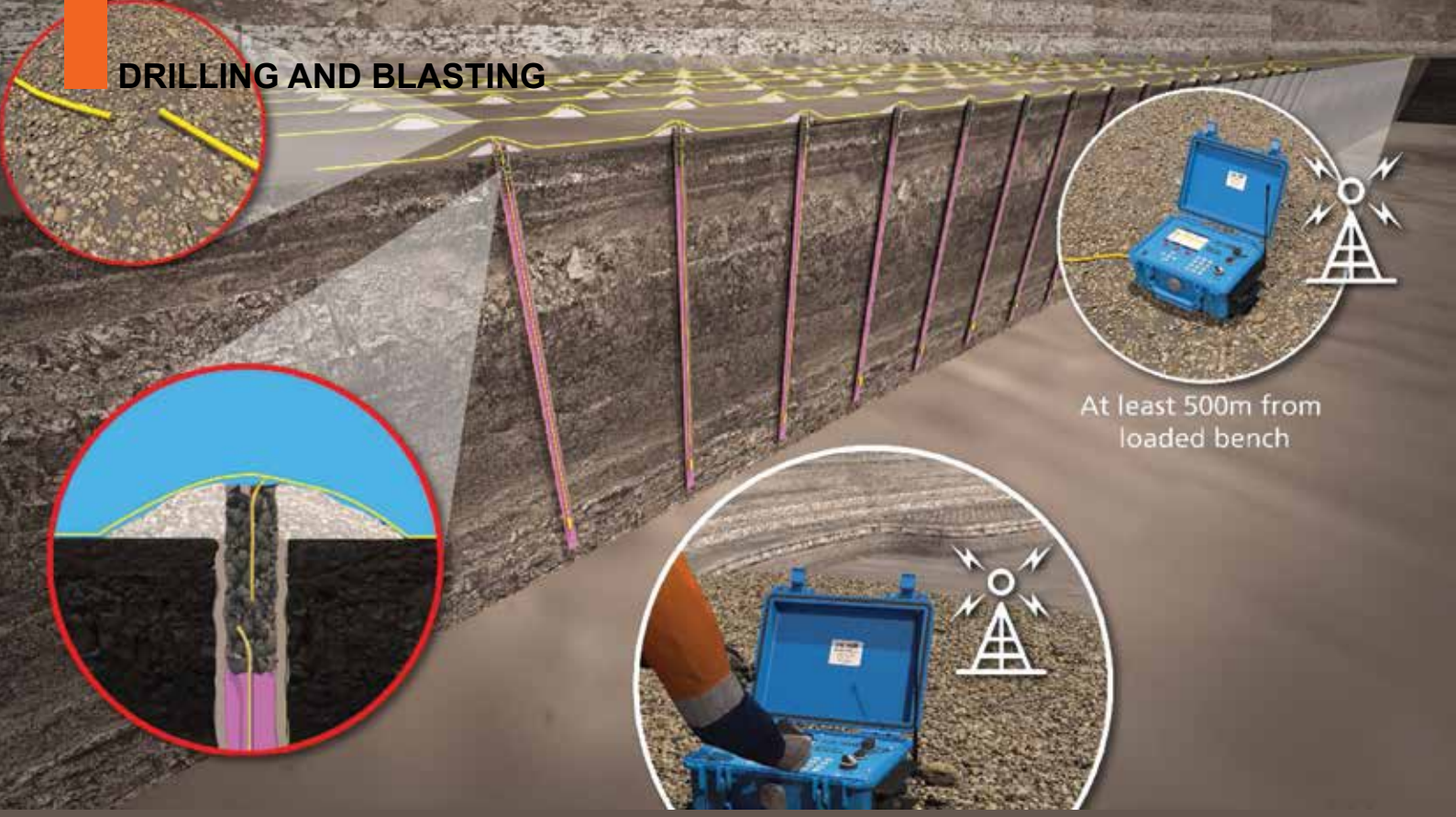
SANDOVAL, F. *La pequeña minería en el Ecuador*. London: IIED, WBCSD, 2001. (Mining, Minerals and Sustainable Development, n.75).

SECCATORE, J.; DE TOMI, G.; VEIGA, M. Efficiency as a road to sustainability in small-scale mining. In: INTERNATIONAL CONFERENCE ON INTELLIGENCE PROCESSING AND MANUFACTURING OF MATERIALS, 7th., September 2-3, 2012, Foz de Iguaçu, Brazil. *Proceedings* […]. Foz do Iguaçu: IPMM, 2012.

SECCATORE, J.; MARIN, T.; VEIGA, M.; DE TOMI, G. A practical approach for the management of resources and reserves in Small-Scale Mining. *Journal of Cleaner Production*, n. 84, p. **803-808**, 2013.

SECCATORE, J.; VEIGA, M.; ORIGLIASSO, C.; MARIN, T.; DE TOMI, G. An estimation of the artisanal small -scale production of gold in the world. *Science of the Total Environment*, v. 496, p. **662-667**, 2014a.

SECCATORE, J.; MAGNY, L.; DE TOMI, G. Technical and operational aspects of tunnel rounds in artisanal underground mining. *REM - Revista Escola de Minas*, v. 67, n. 3, p. **303-310**, 2014b.



The journey through to fully wireless initiating systems and automated blasting

Wireless to the blast area concept is still susceptible to wire damage.

In recent years, every part of the mining value chain has been transformed, none more so than drill and blast. Wireless initiating technologies in various forms have delivered significant gains to the industry since the early 2000s, but now with the first fully wireless solution available, the mining industry is realising a step change in safety and productivity.

Unlike conventional initiating systems, wireless communication can replace the hardwires between the blast box and individual detonators to varying degrees, and with each advancement, an increase in value is seen. Today, we explore the various options of wireless initiation in both surface and underground mining and how it is enabling the automation of blasting in the future.

WIRELESS TO THE BLAST AREA

Established in the early 2000s, centralised remote electronic blasting systems are used in underground and surface mining to fire a blast reliably from a safe and convenient remote distance. This technology eliminates the need for hardwiring the blast area to the safe point of firing, reducing overall inventory, and improving flexibility during firing time.

With this technology, the master blaster communicates wirelessly with one or more remote blasting boxes. Once

Blaster 3000, can fire up to seven blasts in parallel, totalling as many as 21,000 electronic detonators.

the master blaster is set to fire, it initiates an encrypted two-way communication with the remote blasting boxes. The remote blasting boxes then supplies the firing energy to the attached electronic loggers and detonators.

Orica's latest centralised remote electronic blasting system, the Blaster 3000, can fire up to seven blasts in parallel, totalling as many as 21,000 electronic detonators. Blaster 3000 suits a wide range of applications and is adaptable with various wireless communication protocols, including Radio Frequency, Fibre Optic, LAN, W-LAN and Leaky Feeder.

Wireless to the blasthole collar concept is still susceptible to wire damage.

The main limitation of the wireless to the blast area solution is that surface and down wires are still required to communicate with the detonator; only the wire connection between the blast area and the firing point is eliminated. This leaves a significant area of wire exposed to communications leakage and wire damage, resulting in lost communication with the detonator and an increased risk for misfires.

WIRELESS TO THE BLASTHOLE COLLAR

Orica first patented a wireless to blasthole collar system in 2006, however after prototyping the concept quickly decided to develop a through the rock, fully wireless initiating system to overcome the shortfalls of the wireless to blasthole collar solution.

In this concept, the surface harness wire connecting the electronic detonators to the logger is replaced with a wireless communication method. To achieve that, an additional electronic device with an antenna is placed at the collar of the blasthole. The electronic device is then connected physically to the electronic detonator down the blasthole with downline wire. The antenna communicates wirelessly using radio communications with the central remote blast box.

This concept eliminates the need for wiring the detonator to the logger, removing the need to tie up the blast on the surface and potentially improving on-bench productivity.

However, the addition of the collar antenna and retaining the downlines complicates the initiating system, potentially

WebGen™, the world's first fully wireless initiating system has no downlines and surface connections to the detonator.

WebGen™ uses ultra low-frequency magnetic induction signals to transmit firing commands.

impacting reliability and increasing the risk of misfires with no significant enhancement to overall safety.

Moreover, in underground applications wireless to the blasthole collar cannot deliver significant benefits such as pre-charging which allows for improved safety and new mining methods. In surface blasting applications, it does not reduce the risk of misfires caused by downline issues nor does it allow for the introduction of novel mining techniques such as driving over the loaded holes, multi-stratum blasting or reduce the risk of lightning disruptions.

Due to the limitations and lack of ability to deliver safety and reliability improvements, flexibility and enable new ways of mining and value to customers, Orica abandoned a wireless to the blasthole collar solution and instead focused on developing and commercialising a through the rock, fully wireless into the blasthole initiating system to deliver maximum value and eliminate the risks associated with wires.

THROUGH THE ROCK, FULLY WIRELESS INTO THE BLASTHOLE SOLUTION WITH WEBGEN™

Released in 2017, WebGen™ is the world's first fully wireless initiating system with no downlines and surface connections to the detonator. With this technology, the primer, consisting of a receiver, an electronic detonator, and a booster, can receive the firing command via an ultra low-frequency magnetic field.

Wireless communication at such low frequencies allows transmission through air, water and rock as far as 900m, meaning the firing equipment including the antenna can be located at a safe distance from the blast.

By eliminating the downlines and surface connections, WebGen™ enables improved on-bench safety and productivity above that of wireless to the blasthole collar solutions. It is however the unique ability of fully wireless, through the rock systems such as WebGen™ that enables customers to safely and effectively pre-charge entire blast areas in one loading pass while the blast can be separated into sections that can be individually fired on-demand, unlocking new and innovative mining techniques in both underground and surface blasting

The system includes the state-of-the-art i-kon™ III plugin detonator, a Pentex™ W booster and a DRX™, which is a digital receiver comprising a multi-directional antenna and a battery that serves as the in-hole power source. Additionally, the SIL3 rating of the Disposable Receiver, DRX™ component of WebGen™, means that it cannot be fired unless the correct firing command sequence is transmitted. This makes WebGen™ the only SIL 3 certified commercial explosives product in the world today.

To date, over 1,600 blasts have been successfully fired using WebGen™ around the world across both underground and surface applications, delivering reliability beyond that of any conventional initiating systems and significant value to those taking advantage of the revolutionary technology.

WebGen™ has demonstrated the benefits of its fully wireless blasting technology in many underground mines

The new WebGen™ 200 suite of fully wireless initiating systems set to release in late 2021.

Avatel™ at Epiroc's factory in Örebro, Sweden.

and has enabled the development of seven innovative mining techniques that would otherwise have been deemed impossible to execute.

The success of WebGen™ in underground mining has also led to the adoption of the technology in surface mining. To date, Orica has completed successful surface blasts using WebGen™ around the world. With its wireless capability, WebGen™ presents an opportunity to overcome one of the industry's most persistent limitations – a physical or wired connection to each primer in a blast.

THE NEXT-GENERATION WIRELESS INITIATING SYSTEM ENABLING AUTOMATION

The next generation of wireless initiation systems, WebGen™ 200, is set for commercial release in 2021. WebGen™ 200, harnesses digital technology to allow advanced reprogramming and digital inventory management, offering mine operations an integrated user interface with improved quality assurance. Built with encoding capabilities and enhanced security, the reliability of each blast is further improved with the new generation WebGen™ 200 system is designed to endure even greater shock resistance.

These significant product improvements and new features will support further innovative and more complex mining operations and will enable the first stages of automating underground development charging.

WORLD'S FIRST MECHANISED DEVELOPMENT CHARGING UNIT UNVEILED

Orica and Epiroc have successfully developed Avatel™, a first-of-its-kind, industry-driven semi-automated explosives delivery system, one year after announcing their collaboration in November 2019. The Avatel™ prototype which is undergoing trials is expected to be commercially ready by the end of 2021.

The innovative charging solution, enabled by Orica's WebGen™ wireless initiating system technology, addresses the final step in the underground development cycle yet to benefit substantially from mechanisation and automation. Today, physical wired connections remain a necessary part of underground development charging, introducing extended exposure times to workers in one of the highest risk work areas in an underground mine.

The highly anticipated introduction of Avatel™ will bring a step-change in safety by eliminating the need for wired connections and subsequent exposure to crews at the face. Instead, the entire charging cycle can be completed by a single operator from within the safety of an enclosed cabin, several metres from the face. Avatel™ will deliver significant efficiencies and improvements in productivity to customers in the underground mining segment by enabling continued, safe access in poor or seismic ground conditions to accelerate the development cycle while reducing costly and time-consuming temporary face support systems put in place to manage exposure under traditional charging methods.

As the entire industry moves rapidly towards an automated future, the introduction and adoption of the WebGen™ fully wireless initiating system will enable the mining industry to break new ground in safety and introduce new ways of mining, new thinking and supporting the industry's drive towards safer and more efficient mines of the future.

Dr Armineh Hassavand,
Wireless Blasting Engineer

Eurasian Resources Group CEO: Short supply ahead, as world's appetite for copper grows

2021 is shaping up to be a year of significant deficit in the copper market as tighter-than-expected supply struggles to keep up with a radically improved demand outlook, underpinned by unprecedented levels of 'green' stimulus.

We expect copper demand growth outside of China to be a key driving force this year. The global industrial recovery is picking up pace, with macro indicators across several key copper consuming nations showing strength. Recent manufacturing PMI readings in the US, Europe, Japan, South Korea and India have entered expansionary territory. The approval of the USD 1.9bn stimulus package in the US, as well as green stimulus measures across the EU countries, will also provide a boost to copper demand, effectively bringing forward the green energy boom by several years. Overall, we see the current period as the preamble to a prolonged phase of above-average copper consumption growth, especially in Europe and the US, where demand has been broadly stagnant over the past decade.

In China, the strong recovery from the coronavirus pandemic is set to continue this year. The world's largest consumer of copper has recently unveiled its 14th Five-Year Plan, which is highly supportive to copper demand. In particular, the Plan's focus on rural revitalisation, decarbonisation and pledges to advance infrastructure construction, transportation, power, green energy, digital development and technological innovation are set to underpin strong copper demand growth. Moreover, under China's 'dual circulation' strategy, copper-intensive investment-led growth will remain a priority, as Chinese manufacturers extend their supply chains upstream domestically.

Meanwhile, aside from its immediate disruption to mine production throughout 2020, COVID-19 will leave a lasting legacy on mine supply. As producers were forced to reduce CAPEX, push back maintenance and suspend project development, we estimate that the pool of potential production from mine projects has shrunk significantly during the past year. These developments prompted many mining companies to rethink their global supply networks, create alternate supply lines and re-evaluate their inventory strategies. At ERG, we were quick to safeguard our supply chains and implement an extensive business continuity plan, which allowed us to endure the coronavirus-induced downturn and ride a wave of recovery, unlike many of our peers. Our Metalkol RTR operation in the DRC – one of the largest copper reprocessing plants globally – will continue to supply customers in this fast-growing market in 2021 and beyond.

Evidence of constrained mine supply is most apparent in the copper concentrates market, where TC/RCs have slumped to near 10-year lows. Constrained mine supply has been compounded by shipping delays, especially from Chile, as well as China's unofficial ban on Australian concentrate imports. Overall, we expect the tightness in concentrate supply to prevail throughout 2021, which is likely to delay new smelting capacity construction in China, leaving the country more dependent on imports of copper cathodes, such as those produced at Metalkol RTR.

Moreover, we expect scrap supply to undershoot market expectations. While, historically, we have observed a strong positive relationship between copper prices and scrap supply, the recovery in scrap supply has thus far been very modest. In part, we attribute this to the continuing effects of coronavirus-related lockdown restrictions and logistical bottlenecks. Moreover, China's recent changes to scrap import regulations have disrupted global scrap flows, squeezing availability: we believe that it will be many more years before the market adjusts to these new realities. Perhaps most importantly, however, the entire scrap supply chain has become much more consolidated and lean over the past decade, with vastly diminished inventories of 'old' scrap: scrap copper obtained from products that have ended their useful life.

All in all, we believe that a return to five-digit (integral) copper prices is not only justified, but also a likely near-term reality.

Greenland minerals

Greenland Minerals moved to calm shareholder concerns around the future of the company's Kvanefjeld rare earths project.

The miner suspended share trading after leader of the newly elected Inuit Ataqatigiit party told state broadcaster DR that the development of the Kvanefjeld project would be halted.

In the lead up to the election, the Inuit Ataqatigiit party expressed an anti-uranium position, which has been reaffirmed since the election win.

While Kvanefjeld's development strategy is focused on the production of rare earths, it also incorporates the by-production of zinc, uranium and fluorspar, with the uranium occurring at relatively low grades compared to most primary uranium mines.

Greenland Minerals noted that while the uranium was not of great economic significance to the Kvanefjeld project, the revenues generated by the uranium and other by-products would serve to reduce the rare earth production costs.

Greenland Minerals pointed out that the company had been operating in the region since 2007, under all successive Greenland governments, and that the environmental impact assessment and the social impact assessment for the proposed Kvanefjeld project had been accepted by the Greenland government as meeting the requirements for public consultation, which is expected to run until 1 June.

Furthermore, the company noted that it has at all times operated within Greenland's Minerals Act, and that its application for an exploitation license for the Kvanefjeld project followed a development strategy which was shaped by extensive stakeholder engagement and both community and government level.

The ASX-listed company said that it was hoping to work with the newly elected government to progress the development of the Kvanefjeld project.

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Some smaller or one large pump?

Whether two small pumps are better than a single large one: In this consideration of many users, it depends on the application. And a special component that in many cases even makes the purchase of new pumps completely unnecessary.

Tsurumi, the market leader in dewatering pumps in the construction industry, points out that various aspects speak in favour of two or more small pumps in applications with dirty water. In some cases, one large pump is too much of a good thing.

If the distances are short, only one adequate pump is needed. If the distance to be covered exceeds its capacity limit, a second pump can be connected via an adapter. This is called booster operation: the second pump increases the possible total length of the water pipe.

Many pump operators do not know that this option exists at all. Moreover, it is relatively easy to realise.

Theoretically, the number of pumps that can be operated in series is unlimited. Significant capacity losses are not to be expected. With two identical pumps, the achievable distance performance is roughly doubled. However, the flow rate remains the same. If one wanted to increase this, parallel operation of the pumps is necessary or the use of larger models.

Key factor flexibility

Small pumps connected in series offer the advantage that the individual pumps can be moved more quickly due to their relatively low weight, they are easier to replace and can be better maintained or repaired. There are practical advantages in terms of spare parts logistics and capital requirements, too.

Two pumps can be connected directly one after the other. Alternatively, they can be spaced so that, for example, one pump is positioned every 30 metres. Whether the piping is fixed or with flexible hoses is functionally irrelevant. There are also advantages during dismantling.

Dewatering with large pumps is particularly interesting because the entire system consists of only a few components.

This is attractive, considering the potential problems of an extensive small unit configuration. That comes with the core risk of all complex systems: (Too) many components are involved, they may not be in the best condition, they may not be set up optimally or they simply should not have been combined in the first place.

Space requirements as a bottleneck

However, a solution with a powerful unit like the multi-stage high-pressure pump LH4110W, the manufacturer's top model

with a delivery head of 216 m, has to be realised first: such a pump weighs about 1.3 tonnes when dry. Also, the use of these big guys only makes sense if their performance is needed from the very beginning.

The reliability of the system must also be taken into account: if the only large pump fails, the entire dewatering system stops. However, this also applies to the chain solution if a link fails – no matter how small. But getting a large pump going is likely to take longer.

In some cases, however, the question does not even arise. If sheer performance with high throughput is required, for example in open-cast mining, there are hardly any alternatives to large-scale equipment.

On the other hand, the space available underground or in tunnelling is often so limited that there is simply no room for a large pump: After all, vehicles, mining machines and people still have to be able to move accident-free in the narrow veins. Often there are not even intermediate basins for pumping in the roadway sections, so that only a slim solution is available for dewatering. A similar problem arises with deep bore holes or in the waste water sector of industry and municipalities.

The booster adapters are available from Tsurumi Europe in Düsseldorf, Germany, as a standard component at a comparatively low price. Operators of dewatering pumps should therefore first consider connecting them in series if necessary. As a rule, different pump types may be combined. The adapters can thus continue to be used if other, larger pumps are purchased later.

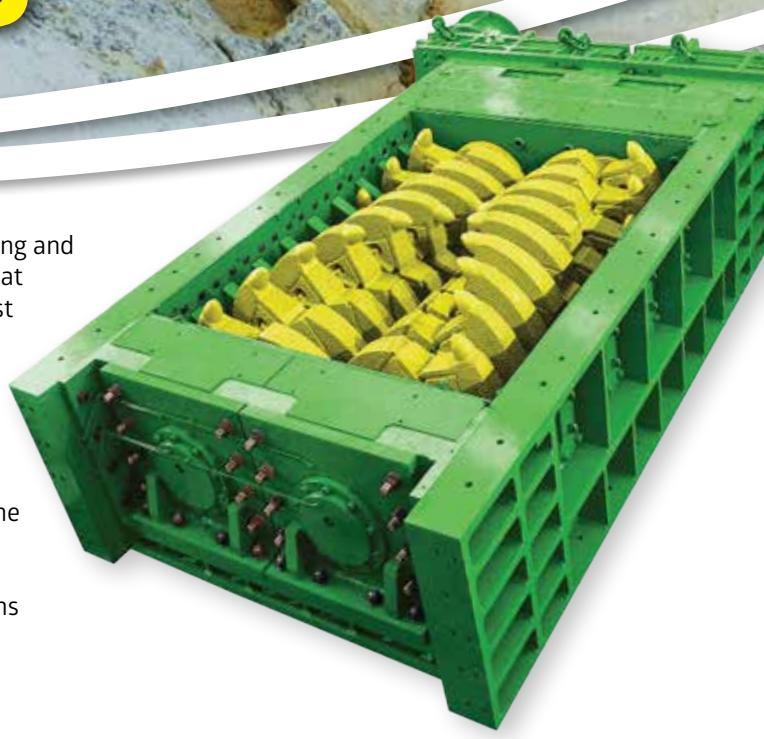
Info box: Pump performance

What a pump is actually capable of is stated in the data sheet. Every pump unit has an optimum operating point. Two essential factors determine the performance of a pump: the maximum flow rate indicates the highest possible throughput under ideal conditions. Usually 15 degrees Celsius outside temperature, a homogeneous medium and horizontal pumping are defined. Which already describes the second factor, the maximum delivery head: the greater the slope or distance, the higher the power required. If pumping is to be vertical, the pump must not only bear the weight of the water column, but also generate flow velocity so that the pump sump empties. The specific weight of the pumped medium and its viscosity also play a role.

Info box: Booster adapter

The booster adapter is a passive component that is quickly mounted: unscrew the swash plate at the bottom of the first pump, replace the series screws with new double bolts, put on the adapter, screw it tight, and connect the second pump or hose there. A video on Tsurumi's Youtube channel shows how easy the assembly is.

DEPENDABLE SIZING SOLUTIONS



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Rusal has allocated over usd1bn to environmental projects over the last 10 years

Thanks to the environmental measures and initiatives implemented by RUSAL over the last decade, the volume of emissions from the Company's enterprises has decreased by almost 20%, industrial wastewater discharges have decreased by more than twice, and the consumption of fresh water has decreased by a third.

Such results were achieved thanks to the introduction of modern production and environmental technologies as part of the modernization and development of existing production. In 2020, the Company prioritised its work towards achieving its strategic environmental goals. Thus, last year the EcoSoderberg technology was introduced across the Krasnoyarsk aluminium plant and work continues to implement this at the enterprises in Bratsk (BrAZ), Shelekhov (IrkAZ) and Novokuznetsk (NkAZ). The implementation of electrolyzers operating at baked anodes at the experimental section of the Novokuznetsk aluminium plant has started. In addition, NkAZ, BrAZ and IrkAZ are modernizing their existing gas cleaning units with the introduction of modern and more efficient dry gas cleaning units developed by RUSAL's engineers. The Company continues to pivot towards more environmentally friendly raw materials together with partners for the production of pitches, which not only allowed to partially replace imports, but also to reduce emissions of harmful polyaromatic substances.

"The results that RUSAL has achieved in improving the environmental profile of its enterprises over the past 10 years are noteworthy and I am pleased with the progress we have made. Such results are thanks to the comprehensive program that the Company is implementing to reduce the environmental impact of its production facilities, including developing and implementing its own initiatives. This approach is an integral part of the Company's strategy, and, naturally, we will continue to develop in the chosen direction," said Ivan Rebrik, Director of the Department for Environment, Labor Protection and Industrial Safety of RUSAL.

September start for inquiry into the West Cumbria coal mine

The date has been set for a final showdown over Copeland's most divisive issue.

West Cumbria Mining's Woodhouse Colliery will be the subject of a public inquiry carried out by the planning inspectorate.

The inquiry will run from Tuesday, September 7 and is anticipated to last for 16 days.

Copeland MP Trudy Harrison, a vocal supporter of the mine, called for any physical venue of the inquiry to be in the local area.

Mrs Harrison also confirmed she would be speaking in favour of the mine at the inquiry.She said: "Clearly the people who will benefit the most and who will be most affected by the Woodhouse Colliery development are my constituents in Copeland. That is why, if there is a physical venue, it must be in Whitehaven.

"I will be speaking in support, arguing the present and future societal need for steel, especially as we transition from fossil fuel dependency to low carbon alternatives and green jobs.

"I will explain the current and long-term coking coal requirements for the UK and European steel plants, whilst also making the case for a net zero compliant steel industry.

"Ultimately, I'll set out the pragmatic and positive impact West Cumbria Mining would bring to both our area's economy and the wider environment."

The deadline for any submissions is Thursday, May 6. Copeland residents have all been encouraged to submit their responses on the planning inspectorate's website.

The inquiry comes after sustained pressure from campaigners, coupled with a change in government policy, saw Cumbria County Council "reconsider" the application, having previously given it the green light.

While some residents are keen to see the coal mine built due to the employment prospects it would bring to the area, campaigners are concerned over the impact the mine would have on the environment.

The South Lakes Action on Climate Change group is among those against the mine, and will be presenting evidence against it at the inquiry.

Dr Henry Adams, a consultant ecologist and group member, argued that the main argument for the mine – that the coal is needed for the production of steel – is incorrect.

He said: "All this about the UK steel industry needing the coal is absolutely, totally incorrect. It's absurd.

"There's plenty of coking coal on the market. The two blast furnaces in the UK can get all the coal they need from overseas.

"They would anyway, because they use a mixture of different grades and types of coking coal to form a blend.

"They can only use a small amount of West Cumbria's, because it's not the high quality that they make out. It's too high sulphur for the furnace in Scunthorpe to use at all."

Epiroc to acquire mining electrification solutions provider

Epiroc, a leading productivity and sustainability partner for the mining and infrastructure industries, has agreed to acquire Meglab, a Canadian company with expertise in providing electrification infrastructure solutions to mines. The solutions support mining customers in their transition to battery-electric vehicles.

Epiroc is committed to providing its full range of mining equipment in battery-electric versions by 2030. The acquisition of Meglab will be an important part of providing the infrastructure needed for mining electrification.

Meglab, based in Val-D'Or, Quebec, Canada, is a technology integrator that designs, manufactures, installs and supports practical and cost-effective electrification and telecommunications infrastructure solutions to customers in several countries. Its products and solutions include system design, substations, switchgears and automation system solutions, enabling the infrastructure needed for mine electrification and equipment charging solutions, as well as for digitalization and automation of operations. Meglab has more than 240 employees and had revenues in 2020 of about MCAD 49 (MSEK 335).

"Epiroc is proud to be the leader in providing battery-electric vehicles for the mining industry, improving customers' work environment and lowering their emissions while increasing their productivity," says Helena Hedblom, Epiroc's President and CEO. "The acquisition of Meglab will strengthen our capacity to provide the infrastructure required as mines transition to battery-electric vehicles."

The acquisition is expected to be completed in Q2 2021. The purchase price is not material relative to Epiroc's market capitalization and is not disclosed. The business will become part of Epiroc's Parts & Services division and will continue to be based in Canada.

Revolutionizing Supervisor Training

Immersive Technologies provides learning systems with high levels of learning retention and skills transfer, engineered to solve mining challenges around safety, productivity and equipment availability. “Over the past 18 months we have been collaborating with some of the largest mining companies in the world to improve the supervision and coaching of heavy equipment operators via improvement of supervisor proficiency. Gone are the days where it takes a full year for a supervisor to be exposed to all types of weather, traffic, loading and digging conditions. This exposure and skills development can now be accomplished by immersing the learner into a replicated 3D mining environment through VR and touchscreen technology” says Cian Dobson – Visual Database Manager, Immersive Technologies.

Introducing our newest training system: Mine Standards Training (MST).

Imagine being able to simulate a scenario from surface or underground operations, put it on a virtual table and walk around it. Now add the capability to view the process from the cabin of any machine, or teleport to the pit floor itself. Then, take this scene and insert visual cues a supervisor should be able to identify, assess and correct. Sometimes these cues are subtle and sometimes obvious. Some are visible immediately, some are only clear at various times of the day or from a certain vantage point.

Visualise every conceivable operator behavior, inappropriate action or best practice from in-field, in-cab or birds-eye view, in any weather condition or time of the day. From recruitment and selection to compliance and workforce optimization, Mine Standards Training will help users on their capability to identify these issues.

Mine Standards Training – Virtual Reality

The **Mine Standards Training** tool is dynamic, offering users the option to operate in Virtual Reality via our existing Worksite VR Quest platform, or on an interactive classroom touchscreen. These two options leverage current simulation assets to create engaging content such as drilling and blasting, ground engagement tools, supervisor training, pit priority rules, and many more related situations.

“We are excited about the real value our customers are already realizing with the improvement of Supervisor skills. We help them create realistic simulations in Mine Standards Training of both perfect and flawed operator behavior requiring the user to identify the deviations from best practices. This capability is helping transform existing flat content training programs to ones that are engaging and have higher levels of learner engagement and knowledge retention. The content is highly realistic and will improve the learning experience for both experienced and inexperienced users.” says Cian Dobson.

Metro Mining brings Bauxite Hills back online

Metro Mining will recommence operations at the Bauxite Hills mine in Queensland following an early shutdown for the wet season in September 2020.

Operations are planned to resume on April 19, with the company aiming to mine and ship four million wet metric tonnes of bauxite between April and December 2021.

Prior to the shutdown, the mine’s four million wet metric tonnes target was also affected by COVID-19 despite record mining and shipping rates and lower operational costs.

Metro employs more than 120 people at Bauxite Hills, with an additional 130 people to be employed by contractors who provide services to the mine.

Metro Mining managing director and chief executive Simon Finnis welcomed the resumption of operations at Bauxite Hills.

“The Metro team and our contracting partners are keen to get back to work and we are in the fortunate position of being able to welcome back many people who have experience working at Bauxite Hills before,” he said.

“We have implemented several operational changes that will improve efficiencies, and will continue to focus on mining and shipping rates and lowering operational costs, as we are always looking for improvements in our systems and processes.

Some of Metro Mining’s Bauxite Hill employees. Image: Metro Mining.

“From what we’re seeing in the market and from our ongoing negotiations, the demand for Metro bauxite is returning, and confidence is returning to the market more widely.”

The initial 2.3 wet metric tonnes of bauxite will be provided to Xinfa, while additional sales are yet to be finalised.

Metro Mining has remained committed to its Metro stage two expansion, a six million wet metric tonne strategy as part of Bauxite Hills’ long-term development.

The Metro stage two expansion will also see the construction and commissioning of a floating terminal to allow for faster loading for vessels.

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Mixing with the best – *how conveyor belt rubber is made and how it determines the performance and safety of the belts that you use*

In the simplest terms, rubber multi-ply and steelcord belts consist of two constituent parts – an inner carcass protected by outer layers of rubber known as the covers. Although both parts play a central role in enabling a conveyor belt to fulfil its purpose, it is the rubber itself that ultimately has the biggest influence on the actual operational performance of the belt. The different types of rubber covers needed for specific materials and working environments are common knowledge amongst conveyor operators. However, much less is understood about how the rubber is actually made and how that process determines the qualities, characteristics and ultimately the cost-effectiveness of the conveyor belts that you buy.

A SCIENCE IN ITSELF

Because of the its adaptability, the vast majority of the rubber used to make modern-day conveyor belts is actually synthetic or, at most, contains only a relatively small element of natural rubber. In basic scientific terms, the creation of rubber compounds (rubber compounding) is the process where a range of 'specific task' chemicals, reinforcements and anti-degradants are mixed together with rubber polymers.

Creating rubber compounds is a highly complex process.

The most common polymers used in conveyor belts are Styrene-Butadiene rubber (SBR) and Nitrile rubber (NBR). The chemical agents form chains of polymers to form rubber compounds that will ultimately be vulcanised to create the finished product. Vulcanisation is the process in which the compounds are chemically converted into a more durable final product by using heat and what are termed as 'cross-linking agents' such as sulphur or other accelerants. In short, it is a highly scientific process and even more complex when you begin to consider the multitude of physical properties and characteristics that the rubber covers of conveyor belts need to possess.

MEETING EVERY NEED

Every type of rubber used on conveyor belts has to meet a considerable list of basic requirements so each has to be made according to a very specific recipe. These always include the basic ability to resist abrasive wear, otherwise the surfaces will wear down too rapidly. The rubber will also need to meet specific minimum requirements in terms of tensile strength, elongation (stretch), hardness (Shore), and resistance against tearing (tear strength). The list does not end there because every type of rubber cover also has to be able to endure potentially sub-zero temperatures (usually at least minus 20 or 30 °C) and, at the other end of the scale, withstand maximum continuous material temperatures as high as 80 °C. Then of course, there is the

ability of the rubber to resist the seriously damaging effects of ground level ozone and ultra violet light (both sunlight and fluorescent light). Both of these last two properties require special additives being part of the rubber compound 'recipe'.

As I said, those are just the basic requirements. When you begin to include 'specialist' rubber covers such as resistance against the effects of oil, chemicals, fire, extreme heat (up to 400 °C), extreme cold (as low as minus 60 °C), high impact, ripping & tearing and the numerous combinations of those qualities for multi-purpose belts such as oil and fire resistant for example, then the permutations become mind blowing. Finally yet very importantly, the rubber needs to be able to form strong, reliable splice joints. Being able to consistently achieve all of these requirements so that every individual batch of rubber compound is exactly the same as the previous batch is unbelievably challenging. And all of this has to be achieved during the mixing process.

THE MIXING PROCESS

There are literally hundreds of different chemicals and ingredients used to make the huge variety of different rubber compounds that different conveyor applications demand. Perhaps the best analogy to use is that it is like making cakes that have to taste precisely the same every time. The mixing process is where all of the polymers, chemical additives, carbon black and zinc oxide are mixed together according to the specific recipe for the required rubber type. For accuracy and consistency, at Dunlop we use a highly advanced computerised, automated mixing carousel that places very precise measurements of each ingredient into biodegradable bags. These ingredients will be used to ultimately create a batch of compound weighing between 200-250kg.

The ingredients are then placed into a 'coarse mixer' as the first step towards blending everything into one. The total mix is then transferred into a mill, which blends the rubber until it reaches an evenly distributed consistency. Different ingredients react differently and many are extremely sensitive to permanent damage if the machine settings and particularly the temperatures during mixing, are not exactly right for them. For example, additives used to create the all-important self-extinguishing properties in fire resistant belts can become almost totally ineffective if not mixed in precisely the right conditions.

TWO BECOME ONE

For this reason, some compounds need to start the mixing process as separate batches of ingredients. For example, Batch A may contain 90% of all the ingredients and Batch B may contain the remaining 10% that need to be mixed under slightly different conditions. When cooking a meal a chef would not throw all the ingredients into one pot and cook them for the same length of time at the same temperature and that same principle applies to making a complex rubber compound. After the initial mixing, the two batches are then mixed together to form the final batch. In all cases, regardless of rubber type, not only does the rubber compound have to possess all of the requisite physical properties and characteristics, it must also be able to undergo the further processes involved in making a conveyor belt, such as calendering for example.

The calendering process is where the rubber compound material, which has been pre-softened by heat, is placed into the center of counter-rotating rollers. The rollers compact the rubber into a sheet as it passes through them. The thickness of the resulting product is determined by the gap between the cylinders, called the nip region. The rubber sheet can then be joined with a carcass fabric layer. After the sheet passes over cooling rollers it is then spooled into a roll with special anti-stick fabric placed in between to stop the surfaces sticking prematurely to one another. These huge rolls of unvulcanised rubber are then ready to be made into conveyor belts.

The Dunlop mixing carousel.

Precise measurements of each ingredient in biodegradable bags are mixed and blended together.

The calendering process.

SAFE TO HANDLE

As I have already mentioned, there are literally hundreds of different components that are used to create the various rubber compounds, such as anti-degradants, anti-ozonants and also as accelerators (essential for the vulcanisation process for example). These components include primary amine–based sulfenamides, such as N-cyclohexyl-2-benzothiazole sulfenamide, and thiazoles, such as 2-mercaptobenzothiazole. It is an inescapable fact of life that to make some rubber compounds it is necessary to use chemicals that are extremely dangerous in their own right. Fortunately for us all, at least as far as Europe is concerned, there are very strong regulations in place to protect humans and the environment in the form of **REACH** (**R**egistration, **E**valuation and **A**uthorisation of **Ch**emical substances) regulation EC 1907/2006, which came into force in June 2007. Unlike virtually anywhere else in the world, the EU's REACH regulatory system puts the burden on industry to prove that chemicals are not harmful to human health and the environment before they can be put on the market.

REACH regulations stipulate that all European manufacturers (not just those who make conveyor belts) are legally obliged to comply with the regulations relating to chemicals, preparations (mixtures) and substances used to create finished products. Although not commonly known by consumers, the use of "substances of very high concern" listed within the regulations must be registered with ECHA (European Chemical Agency) headquarters in Helsinki.

Perhaps not surprisingly, some European manufacturers have chosen to ignore this legal requirement, either completely or at least partially because of the impact on production costs. Manufacturers located outside of EU member states and the UK are not, of course, subject to the regulations. Neither are they subject to EU regulation concerning Persistent Organic Pollutants (POPs). This means that they are free to use unregulated raw materials even though those same materials may be entirely prohibited or at least have strict usage limitations within the European community.

SOMETHING SMELLS WRONG

One of the biggest concerns involves short-chain chlorinated paraffin's (SCCP's). These are commonly used to accelerate the vulcanizing process. **REACH** regulations clearly stipulate that SCCP's should either not be used at all or at least only used on a very restricted basis because of their category 2 carcinogenic classifications. Their presence can usually be identified by the unpleasant smell of the rubber whereas good quality rubber usually has very little smell at all. It is not for me to point the finger at others so all I will say on this subject is that at Dunlop Conveyor Belting we are very proud that, to the very best of my knowledge, we were the very first conveyor belt manufacturer to achieve full compliance.

HOME MADE

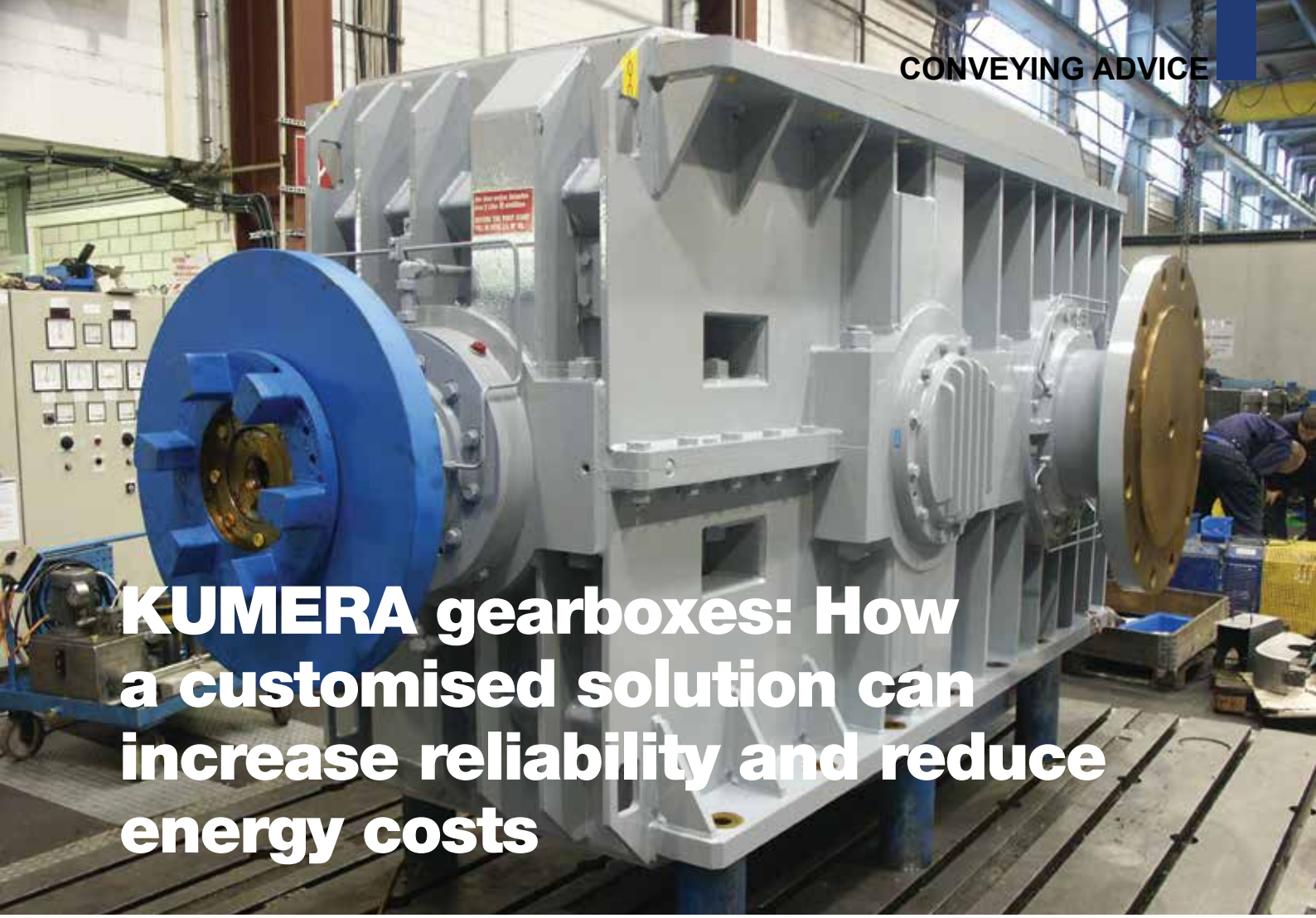
In real terms, only a limited number of actual conveyor belt manufacturers exist, certainly in Europe anyway. Apart from ourselves, virtually every other European manufacturer imports belting from outside of Europe to some degree. This is done to supplement their own production. What is certainly a growing trend is for manufacturers to outsource the manufacturing of their rubber compounds rather than produce them in-house. The advantage is that specialist rubber compound manufacturers are able to minimise production costs by mass-producing rubber compounds in extremely large quantities. The downside, however, is that it makes it much more difficult to ensure the consistency of properties throughout each production run and, indeed, between batches of rubber produced at different times. It is also almost impossible to apply quality control disciplines to an outsourced provider. Another downside is that some compounds have a 'best before' shelf life so they need to be used before some important characteristics start to diminish.

Controlling the quality and the consistency –all Dunlop rubber is 'home made'.

Other cost cutting practices include the use of bulking agents such as chalk and/or increasingly larger proportions of recycled scrap rubber of highly questionable origin. For me, the key word is 'control' because another thing we are immensely proud of in Dunlop is that we manufacture all of our conveyor belts ourselves, including the rubber, using our own facilities and our own people. We develop our own rubber compounds and we have an ongoing R & D program to further improve existing compounds and create new ones such as our BV GT, which is simultaneously resistant to oil, fire, heat, abrasion, ozone & ultra violet light. In short, every batch of rubber used on our conveyor belts is home made. Pure and simple. To our mind, it is the only way to be absolutely sure that every belt of every type will have identical properties and achieve exactly the same standards of quality and performance every time.

ABOUT THE AUTHOR

Rob van Oijen is Manager Application Engineering for Dunlop Conveyor Belting in The Netherlands is one of the most highly respected application engineers in the industry. He has specialised in conveyors for over 14 years, supporting businesses throughout Europe, Africa, the Middle East and South America.



KUMERA gearboxes: How a customised solution can increase reliability and reduce energy costs

Highly efficient KUMERA 2,500 kW conveyor belt drive.

Powerful conveyors and their drive systems have a key role in surface mining. In ore mines, conveyor belts up to several kilometers long transport ore for further processing or transportation and reduce labor burden. The operational safety and reliability of the systems are of great importance since delays or shutdowns due to damage can cause immense downtime costs.

Environmental hazards such as extreme weather conditions and fluctuations, dust, and dirt pollution, and falling rocks must also be considered for operational safety. Systems are often installed in impassable locations so low-maintenance concepts are required. In the event of service or damage, the downtime should be as short as possible.

Three-phase AC motors with the following gear variants are typically used as drive concepts for the conveyor belt systems:

Standard gear with or without fan

Advantage:	Fast availability
	Inexpensive
Disadvantage:	Small outputs up to 1,000 kW
	For gear ratios greater than 16:1 in 3-stage design, which results in high power losses.
	Less possibility of variation in terms of installation and environmental conditions.
	Additional lubrication and cooling units are usually required for heat dissipation

KUMERA customised gears

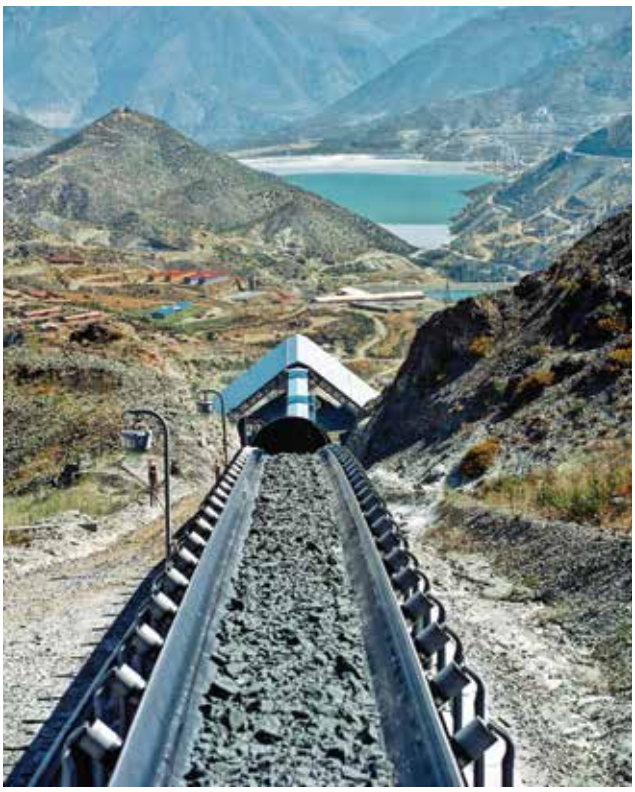
Advantage:	Optimised drive design for the respective application and the specified environmental conditions.
	Outputs over 2,500 kW are possible.
	In the 2-stage design, ratios greater than 20:1 are possible, which reduces the power losses by up to 30% compared to 3-stage gearboxes.
	Large variety of options, including universal installation options thanks to the double foot design.
	Compact design through the flange output shaft.
	No additional lubrication and cooling system.
	Higher operational safety thanks to a significantly lower number of components at risk of failure.
Disadvantage:	Higher design effort and more complicated gear housing design due to the internal oil routing. This means higher costs, which, however, are partially offset by saving the oil supply system.

KUMERA conveyor belt drive solution – right position.

The gearboxes are mounted on a base frame as a drive unit together with all additional components (e.g., brakes, torque support, etc.) and flanged on the belt drums. Depending on the power requirement, a conveyor belt is equipped with one or two driven belt drums, whereby each drive drum can be equipped with a drive on one or both sides. A conveyor belt is thus equipped with up to four drive units. A great advantage of having several drives per conveyor belt is that if one drive fails, the system can continue to operate, albeit with a reduced delivery rate, until the defective drive is repaired or replaced. Another advantage in connection with the universal gearbox design is that in the event of a defect with a replacement gearbox any damage, regardless of the gearbox position in the system, can be repaired at significantly lower costs than if the conveyor belt were driven by just one large drive.

KUMERA conveyor belt drives are designed as a two-stage design when possible. Compared to a three-stage version with standard gear units, this has the advantage of 1% better efficiency (approx. 98% instead of 97%). What does not sound like much at first glance, however, turns out to be an ecologically and commercially significant advantage.

For example, a KUMERA conveyor belt with 10 MW drive power (4 drives at 2,500 kW each), currently in use in a copper mine in Chile, has a savings of approximately 100 kW/h in motor operation by an efficiency increase of 1%. For a conveyor system consisting of three conveyor belts, with a system utilization of 80% on average and an operating time of 16 hours/day and 250 days/year, this means an energy savings of approximately 960 MW per year. If still considering a system utilization of 80% but 24/7 operation time and 14 days downtime for maintenance per year the savings ending up to 2,016 MW.



Conveyor belt slope downwards – generator mode.

In many applications the systems convey the material downhill, which means the operation is in generator mode. The higher efficiency means the systems will generate approximately 100 kW/hour of power more than a three-stage version with standard gear units.

KUMERA endeavors to support plant manufacturers in the implementation of their drive concepts with the best possible gear design. KUMERA also offers support to system operators and tailor-made drive concepts for the renewal and improvement of operational safety and increased performance of conveyor belt drives. The KUMERA belt drives are subject to continuous improvement. At present, new concepts are nearing production, through which both greater power density and an increase in operational reliability under thermal performance limits will be achieved.

KUMERA powered overland conveyor in operation in Chile.

AUTHOR
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Managing Director
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Anglo American hires Mastermyne as Aquila production nears

Anglo American has extended its services contract with Mastermyne at the Aquila metallurgical coal project in Queensland for a further 12 months.

The $60 million contract involves development and outbye services by Mastermyne since August 2019.

In view of establishing a new longwall operation at Aquila, Mastermyne is tasked to undertake roadway development in the mains and gate roads of the mine.

The extension goes until March 2022 and includes the operation of an additional roadway development unit.

It requires the employment of a further 60 full-time personnel, adding to the 178 personnel already engaged from the original contract.

Up to half of the additional personnel required will be relocated from Anglo American's Moranbah North coal project in Queensland by the end of March.

Mastermyne will continue to supply development equipment from its fleet, including a continuous miner and ancillary development equipment.

Mastermyne chief executive Tony Caruso said the company had been working to deliver major underground infrastructure and roadways safely and efficiently, and it looked forward to continuing its work with Anglo American to deliver the new longwall project.

"The company is very pleased to have extended this contract and undertake roadway development works. … It is pleasing to see projects progressing and building on Mastermyne's already very strong order book," he said.

Anglo American last year announced its plan to increase Aquila's mine life by six years.

It is investing $240 million in the development, $200 million of which would be awarded to longwall suppliers and more than $20 million to civil works. The remaining will be invested in an overland conveyor system.

The company aims to deliver first hard coking coal from the longwall operation early next year.

Bonfiglioli acquires Sampingranaggl

Bonfiglioli S.p.A. won the auction at the Court of Bologna, 12 March 2021, for the acquisition of Sampingranaggi from Bentivoglio (BO), for € 7,158,000.

This acquisition confirms the interest Bonfiglioli S.p.A. had already expressed in Sampingranaggi, generated by the total synergy of Sampingranaggi's know-how with the Group's design and production strategies . The move preserves and consolidates the Sampingranaggi strategic supply chain, strengthening their role as a technological pivot for the Bologna regional and metropolitan area.

The acquisition includes the assets of the Italian and Chinese Sampingranaggi companies (Bentivoglio – BO, Funo di Argelato-BO and Shanghai-China), their respective warehouses, the Sampingranaggi brand, patents, designs and products for robotics, as well as all their staff. Sampingranaggi's 2020 turnover was €21 million, of which €15 million in Italy and €6 million in China.

Precisely with this in mind, on 3 March 2021 Bonfiglioli S.P.A. had signed a "Bonfiglioli/Sampingranaggi integration agreement" with the Emilia-Romagna Region, Metropolitan City of Bologna and FIOM-CGIL Emilia Romagna. FIOM-CGIL Bologna and the Sampingranaggi joint trade union representatives (RSU), a pact that the Group has declared complementary and functional to its own bid, with a view to safeguarding the production continuity of Sampingranaggi and the people who work there, currently about 80 employees.

A priority will in fact be the appropriate enhancement of the workforce, also through the provision of the Bonfiglioli Academy's continuous training programs, now available also to the Sampingranaggi staff, with a view to a synergic and transversal use of their respective skills.

With this acquisition, Bonfiglioli S.p.A. will be able to increase its production verticalization both in Italy and China, accessing the robotics market also through the development of other extremely precise and efficient products.

The Chairwoman Sonia Bonfiglioli commented: "I like to think that, if Sampingranaggi had not already been there in the post-war period, today Bonfiglioli would not exist. Because it all began there, in 1948, when a young technical graduate started out on a valuable journey of work and experience that, three years later, led him to set up his first business.

So beyond this "sentimental" reunion, which makes me very happy, and the full complementarity of Sampingranaggi and Bonfiglioli products, my first thought, however, goes to the women and men of this company who now become an important part of Bonfiglioli.

Many times we could have bought plants to produce bevel gears (that are the heart of gearboxes), but without the human hand, machines are merely stationary atoms. Their skills, knowledge and experience are the great heritage of Sampingranaggi, and today become part of the great Bonfiglioli family. My warmest welcome goes to them."

"For Bonfiglioli, SAMP represents a great opportunity," underlined Fausto Carboni, CEO of the Group, "in many aspects. From an industrial point of view, it offers us the possibility to integrate some strategic component productions, including bevel gears, while in terms of business development it allows us to enter the robotic gearbox market, where there is ample room for growth in future, both in Italy and in China through their local company, which that is part of the acquisition."

Rio Tinto hires CSI for Brockman 2 development

Rio Tinto has awarded a contract to CSI Mining Services for the development of the Lens A/B pit at the Brockman 2 iron ore mine in Western Australia.

The Mineral Resources (MinRes) subsidiary will engage a team of 150 people to assist in load and haul, drill and blast and short-term mine planning activities at Brockman 2.

This will involve scheduling, drilling and blasting and excavating 27 million tonnes of waste rock and iron ore for a period of nine months.

A new fleet of Komatsu 830E electric-drive dump trucks and Komatsu PC4000-11 have been mobilised to site.

The contract is the latest awarded by Rio Tinto since first engaging the mining services company at the Nammuldi iron ore mine in Western Australia 16 years ago.

"Our relationship with Rio Tinto dates back 16 years. Since then, we have been able to establish a track record of consistent project delivery for Rio Tinto, which we are very proud of," MinRes chief executive mining services Mike Grey said.

"CSI is the world's largest crushing contractor so it is immensely satisfying that this latest Rio Tinto contract includes other mining activities, such as load and haul and drill and blast, to demonstrate CSI's diverse skills set.

"We are confident this Brockman 2 scope of work will become the latest chapter of our ongoing association with Rio Tinto."

The contract is preceded by CSI's completion of a 30-million-tonne load and haul contract at Rio Tinto's Tom Price mine in Western Australia.

The company is also working at a fellow Rio Tinto iron ore operation in Western Australia, Paraburdoo, where it is carrying out 13 million tonnes of load and haul operations.

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Innovation out of tradition - It pays to talk to a specialist!

ABB, Hitachi to collaborate on electric mining technology

ABB and Hitachi Construction Machinery have agreed to work together to develop electric, automated and digital solutions for mining trucks and excavators.

Under the memorandum of understanding (MoU), Hitachi Construction Machinery will use its trucks and excavators for the collaboration, while ABB will aim to implement its electrification, automation and digital solutions.

The goal of the MoU is to lessen the impact of greenhouse gas emissions produced by heavy mining machinery.

Hitachi will also use its innovations in driverless operations under the MoU, with the combined solutions also striving to improve customer efficiencies and flexibilities.

ABB division president, process industries Joachim Braun said the company was pushing for OEMs to accelerate emissions-reducing technology development.

"ABB is calling for more collaboration between OEMs and technology companies to fast-track the development of new emissions-reducing systems with electrification and automation of the whole mining operation the goal," he said.

"We are ready to work more with OEMs to establish a common approach for the market, and through strategic collaboration provide solutions that can help enable a low-carbon society and make mining operations more responsible.

"New emissions-reducing technologies can transform the energy-intensive mining industry to achieve an even more productive, but also sustainable future."

ABB's digital, automated and electric solutions can be delivered to all stages of a mining operation.

The company believes collaboration with OEMs and mining companies is the only way for the industry to integrate electrification.

Hitachi president of mining group, senior vice president and executive officer Sonosuke Ishii welcomed the collaboration.

"This collaboration will enable the two companies to more effectively work towards our shared vision for mining," he said.

"We are delighted to be collaborating with ABB as we continue to invest our efforts in introducing eco-friendly technologies and systems for the mining industry."

The MoU was signed by Braun and Ishii on 22 March.

Diesel-Electric Mining Loaders – satisfying demand

A wheel loader is without doubt the most versatile piece of equipment used in many industries but the task of fully automating the machines despite the implementation of modern technology has still eluded many experts mainly due to the complexity of bucket-environment interactions, even three decades of research efforts towards automation of the bucket loading operation have not yet resulted in any fully autonomous system. Automation of the bucket-filling step in the loading cycle of a wheel-loader has been an open problem for many years

Despite numerous trials. there still remains key challenges in automation and tele-remote operation of earth-moving machines and research seems to be lagging behind. Real-time video transmission over wireless is difficult, but may present a way towards improving the remote operator's quality of experience.

Tele-remote operation of mobile earth-moving equipment is needed along the development of fully autonomous machines. Some underground mines have already deployed tele-operated load-haul-dump machine where loading is done on tele-remote while hauling and dumping is autonomous. However, many industries including quarrying will benefit if more general solutions for tele-operated heavy equipment are available.

Tele-operation requires good quality audio-video links along with control data, monitoring data and feedback data. Since even the most advanced wireless network can get overloaded, it is important to use the network's bandwidth efficiently by choosing the most suitable protocol suite for tele-remote operations. In tele-remote operations, since several cameras are needed to give sufficient visual feedback, the video streams account for almost all the network bandwidth used. Although wireless transmission is plagued by path losses, multipath propagation, and interference causing throughput and delay variation, wireless networks are still essential for tele-remote operations.

Previous short-loading-cycle experiments with three operators, comparing productivity between tele-remote operation and manual operation. A productivity loss of 42% with tele-remote operation motivated the case for more automation. To date no one has successfully proposed a method to fully automate the bucket-filling process, which is one of the key operations performed by a wheel-loader.

This said using innovative hydraulic and drive train technology and rock-solid quality, modern loaders are more than satisfying the toughest quarry and mining production demand. Mining and Quarry World presents in this study an overview of the evolvement of diesel electric power train drive systems and there use in Turkish mines and quarries.

Diesel-Electric Mining Loaders -A Case Study

In this paper, Diesel-electric (DE) drive train systems' evolution and their application to mining loaders among other applications to earth moving equipment are investigated. Furthermore, the mines where DE mining loaders are utilised, the application type, the range of bucket capacities and the range truck capacities of DE mining loaders can load are given. The evolution of DE power train have been the development of DC, AC and SR motorised wheels in sequence. Diesel-electric drive has a number of applications in surface mining equipment,

as DE loaders, DE trucks, DE bulldozers. The DE mining loaders explained are compared to DM mechanical loaders and hydraulic excavators (HE) in terms of advantages and disadvantages. The high-tech production and maintenance monitoring systems that DE mining loaders are equipped with are mentioned. Based on the data gathered from the monitor outputs, performance and production facts and figures are depicted for a specific period of operation for illustration purposes. There exist (2) two units of 21 m^3 bucket high lift DE rock loaders and (20) twenty units of 150 tonnes capacity DE rock trucks, and (9) nine units of 220 tonnes capacity rock trucks operating at open pit mines in Turkey.

INTRODUCTION

Electrical power-train had to be developed because of the fact that the 1950s' technology was not good enough in manufacturing reliable gear-boxes and transmissions for larger off highway trucks and loaders. Another reason was the intention of reducing the number of moving parts such as gearboxes, differentials, and other mechanical drive components to reduce repair and maintenance costs and increase the maintainability (MTTR) and reliability (MTBF) of the drive systems. The principle has been that prime mover (diesel engine) drives the electric generator (DC), generated electricity is transferred to motorised wheels via electric cables to drive the planetary transmissions which are an integral part of motorised wheels. Diesel-electric power train system was developed by Mr. R.G. LeTourneau between the years 1953 to 1970 in USA and applied to off-highway trucks, wheel loaders, wheel bulldozers and other mining equipment; thus, diesel electric drive system has had a wide range of application in mining machinery (Orlemann 2009, LeTourneau 1972). Mining machinery with an electric powertrain has got a diesel engine as a prime mover which runs in its' nominal ratings; therefore, the life expectancy is longer and fuel consumption is comparatively lower (Fleet 2012)

EVOLVEMENT OF DIESEL ELECTRIC POWER TRAIN DRIVE SYSTEM.

DC Drive Systems

In the early days of the evolution of electric drive train in surface mining machinery, the mechanical drive trains of on highway vehicles were not very reliable, either. Therefore, it was a smart idea to have electric drive on rear tyres of vehicles operating under severe applications like construction, quarrying, and mining. Dart company, USA, manufactured the first diesel-electric drive coal hauler in year 1939. Mr. RG LeTourneau built the first prototype of electric drive rock trucks in late 1950s. LeTourneau's design was probably the most revolutionised one; therefore, it was not accepted by the mining customers immediately (Lovejoy 2013).

After a short while, Unit Rig company, USA, built M-64 Electra-Haul prototype and Mr. Ralph Kress designed a series of mining trucks in early 1960s; thus diesel-electric drive concept flourished again. Mr. RG LeTourneau manufactured a number of electric drive mining equipment like rock trucks, wheel loaders and wheel bulldozers and attracted the attention of many mining customers. Especially, LeTourneau company continued designing and manufacturing large DC drive electric mining loaders for the industry (Lovejoy 2013). DC electric drive systems had been applied to large mining loaders and large rock trucks for about seven decades. Electric drivetrain generates a greater torque on the ground via tyre at slower speeds. Diesel engine runs under a steadier load in electric drive system, so, the period between engine overhauls is comparatively longer. Diesel electric drive mining equipment has a smaller number of moving components compared to that of mechanical drive versions. Traditionally, electric drive mining vehicles have DC motors in their motorised wheels. However, in the last decade and a half as result of the technological advancements AC motors, SR motors are being used in addition to conventional DC motors, which require less maintenance and of lighter weights. According to the literature, fuel saving is 60 percent in diesel-electric SR drive mining loaders, and it is 20% in AC drive electric mining trucks (Wood 2014).

AC Drive Systems

AC drive system has been possible by the technological developments achieved in the recent decades. AC drive system is comparatively smaller in physical dimensions and lighter in weight than conventional DC drive system (Anon b 2014). Prime mover diesel engine runs in its nominal ratings; this results a better performance and fuel efficiency. Electric drivetrain generates extremely high torque (traction) at tyre-ground interaction (engagement) with respect to mechanical drive train. AC electric-drive system is getting more and more popular as a drive system in surface mining equipment.

SR (Switched-Reluctance) Hybrid Drive Systems

The system consists of a brushless switched reluctance motor combined with high-power semiconductor switches and digital controls. The SR motor includes a rotor with no magnets or windings and a stator whose poles contain a winding, similar to a field of a DC motor. The SR system employs the principle of magnetic attraction to move the motor's rotor from pole to pole creating rotation (Fleet 2012).

SR motor achieves rotation by the sequential energizing of stator poles. When the stator pole winding is energised, the nearest rotor pole is attracted into alignment with that stator pole. The rotor will follow this sequence, attempting to align rotor poles with energised stator poles. However, as the rotor and stator poles align, the stator poles switch off and the next group of stator poles switch on, continuing the rotation of the rotor (Fleet 2012).

The switched reluctance motor generates continuous movement by consecutively switching the currents on and off, thus ensuring the poles on the rotor are continually chasing the stator current. The movement achieved is a function of the current flowing through the winding and the characteristics of the iron in the rotor (Fleet 2012).

DRIVE SYSTEMS AND LOADERS.

Loaders are generally used as secondary vehicles in open pit mines in load haul-dump operations; handling and loading ore and spoil heaps. On the other hand, diesel-electric mining loaders are designed and developed to be used as primary digging and haul truck loading equipment. Gold, coal, diamond, iron, copper, zinc are among the mines that electric mining loaders are used as primary vehicles in digging both ore and rock. The electric mining loaders are used at copper, iron and coal, mines of USA and Canada in North America; Brazil, Chili, Peru, Venezuela, Colombia in South America; and

countries like Russia, Mongolia, China and India in Asia (Anon c 2011).

In Turkey, there are two 21 m^3 high lift diesel-electric mining loaders operating at Kisladag open pit gold mine since year 2013. The loaders operate in digging rock and ore and load 150 tonnes rock trucks in five passes whereas loading 220 tonnes trucks in 7 passes. Average bucket payload is about 30 tonnes; and cycle time is in the range of 50 seconds. The rock material is of volcanic origin with a loose density of 1,30 tonnes/ m^3 and it is very abrasive.

Electric mining loaders can be utilised as rock digging tools in addition to being used as mere loaders on conditions that bench is blasted properly. Mining loaders have higher cycle times due to their design with respect to hydraulic excavators with rotating upper frames. According to the mining literature, to compensate this drawback it is proposed to have an additional 5 m^3 extra capacity in the bucket so that it can compete with the hydraulic excavator and reach the same production volume (Wood 2013). Assuming, a 20 m^3 hydraulic shovel excavator is selected to do the job, a 25 m^3 mining loader would be replacing it. The mining loaders have high lift or low lift options depending on the size of the trucks that they will match up.

Diesel-electric mining loaders are mainly favoured instead of equivalent mechanical drive loaders because of the fuel economy which is 45 to 60 % less than the mechanical one depending on the application (Norris 2013).

Lubricant consumption amount is smaller since it has not got any gearboxes and conventional transmissions. Furthermore, a smaller number of components means less parts consumption. Because of its simple structure, repair and maintenance expenditures are less. Even though the first capital investment is a little bit higher with respect to equivalent mechanical drive ones, this difference is compensated in a short while with the lower cost of operation (Anon a. 2012).

Diesel-electric mining loaders

Electric mining loaders operate with diesel-electric drive train. Every tyre is a motorised one with SR motor and integrated planetary transmission; electric loaders are suitable for loading and/or excavating. The motorised wheels have got up-to-date, efficient, and reliable, low maintenance SR motors. Erection and commissioning take 10 to 15 days at a mine site, (**Figure 1**).

DE mining loaders are specially developed for open-pit mining applications. Bucket capacities vary from 14 m^3 to 56 m^3 whereas payloads vary from 25 tonnes to 72 tonnes (Anon. a 2014). Matching mining truck capacities vary from 68 to 120 tonnes, and 290 to 363 tonnes. Working weights of DE loaders vary from 107 tonnes to 267 tonnes (Anon. a 2014). DE mining loaders require less capital investment than electric mining shovels (rope shovels) and hydraulic shovels but slightly higher investment than conventional mechanical drive (MD) loaders, which is compensated by higher performance, lower operational and maintenance costs.

Figure 1: Erection of a 21 m^3 mining loader in workshop yard (Özdoğan 2013).

Table 1: CT components of a DE mining loader with a (21 m^3) bucket.

Days	Travel to Dig (TDG), s	Dig (D), s	Travel to Dump (TDMP), s	Dump (DMP), s	Total Cycle Time (TCT), s
1	7.61	5.14	24.62	12.95	50.51
2	8.13	5.31	25.10	12.29	50.86
3	7.29	5.49	24.95	12.58	50.34
4	7.46	5.45	23.36	12.27	48.29
5	7.33	5.70	25.38	11.38	49.76
Average	**7.56±0.34**	**5.42±0.21**	**24.68±0.79**	**12.29±0.58**	**49.95±1.01**

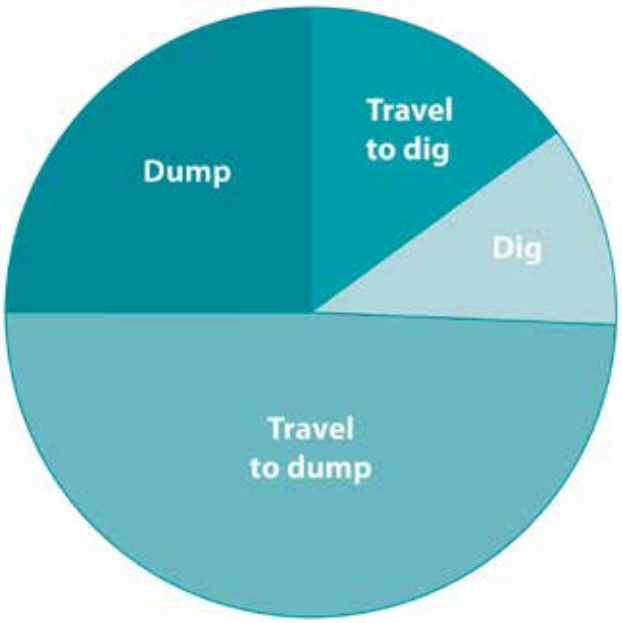

Figure 2: CT component percentages of a DE mining loader (21 m^3).

Cycle time of a mining loader consists of the following phases: Travel to Dig (TDG), Dig (DG), Travel to Dump (TDMP) and Dump (DMP), (**Table 1**). In the case studied, the total cycle time comprises of 15 % of CT is travelling to dig, 11 % of CT is digging, 49 % of CT is travelling to dump and 25 % of CT is dumping into truck tray, (**Figure 2**).

Among the constituent phases of the cycle times, the longest time consumed is travel to dump, and the second highest time consumed is the dumping phase. This is something expected because travelling to dump is made by full bucket. The other difficult phase is raising full bucket up to reach higher than the tray level by overcoming the gravity. Spotting position of the truck may have a secondary effect on travelling to dump phase. Dumping period may be effected by unconformity of the height of the truck body and lifting height of the mining loader (**Figure 4**).

In (**Table 2**) the loading details of a DE mining loader is given. In this specific application, the mining loader's average payload was about 30 tonnes. Average bucket payload fluctuations of a five days operation is illustrated in (**Figure 3**). The below cited factors may influence the payloads realised; degree of blasting, fragmentation, size and distribution of fragments, density, abrasiveness, stickiness, flow properties, swell factor, fill factor of rock material; furthermore, experience and skills of the operators have an impact on the payloads reached.

Diesel-electric mining loaders and diesel-mechanical loaders

DE mining loaders' advantages over MD loaders may be cited as follows: Operational costs are lower. Fuel consumption is lower and the periods between diesel engine overhauls are longer. Due to the lower fuel consumption exhaust fume emission is lower. More favourable HP/Weight ratio. Equipment life and tyre life expectancies are higher. It requires less maintenance, for instance less brake abrasion and replacement. Equipment operation is easier for the operator. It has got no transmissions, no torque converters, no hydraulic brakes and related cooling systems. Its' center of gravity is closer to the ground thus the equipment's balance is better (Norris 2013).

Reliability of DE Loader, (R) (MTBF) : Mean Time Between Failures is longer as expected due to the fact that it does not have transmission, torque converter, axels, differentials, universal joints and hydraulic brakes and related cooling systems. As mentioned earlier, the number of moving parts on it is 60 % less than mechanical drive loader. Therefore, the expectation of reliability is higher.

Table 2: Loading details of a diesel-electric SR drive (21 m^3) mining loader.

Days	Travel to Dig (TDG), s	Dig (D), s	Travel to Dump (TDMP), s	Dump (DMP), s	Total Cycle Time (TCT), s
1	5.14	28	5	4.72	50.51
2	5.31	29	5	4.28	50.86
3	5.49	31	5	4.57	50.34
4	5.45	32	6	5.2	48.29
5	5.70	29	6	5.65	49.76
Average	**5.42±0.21**	**29.80±1.64**	**5.4±0.55**	**4.88±0.54**	**49.95±1.01**

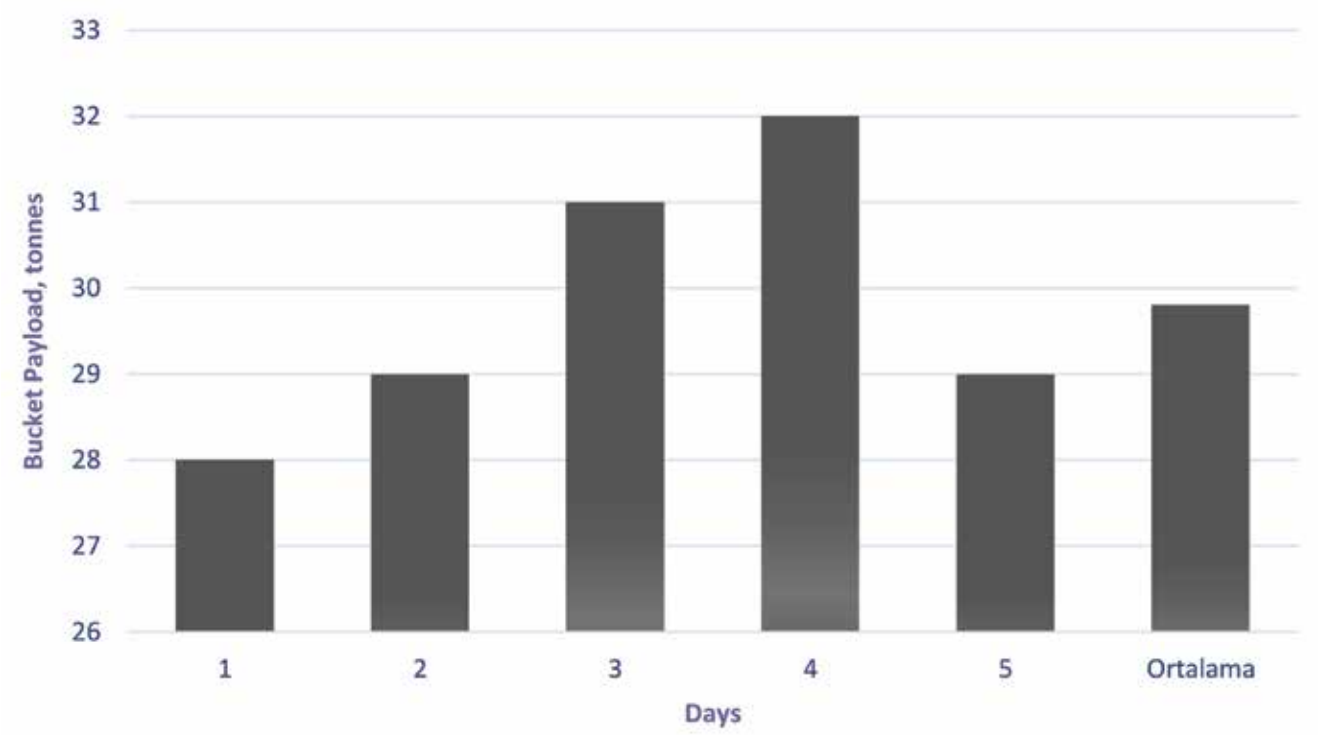

Figure 3: Payload variation of a 21 m^3 a DE loader in a five days of operation.

However, the SR hybrid drive system's major components include power electronics, motor/generator, control system and gear train. Therefore, maintenance and repair team should have electric electronic and computer bacground as well as mechanical background and trained properly, for the reliability expected.

Maintainability of DE Loader (M) (MTTR) : As expected less components to maintain and repair, no transmissions and reservoirs to drain and fill, less oil usage. Longer diesel engine overhauling intervals (Fleet 2012). Easy Access maintenance multiple friendly Access points all around the machine and modular components save the valuable time and contribute to increased productivity. These features reduces the mean time to repair the failures (Anon a, 2014). Health and operation of components are monitored thru the computer system at the operator's cab and failures are diagnosed.

Figure 4: The DE loader filling an AC truck at a rock bench (Özdoğan 2013).

Table 3: The loading details of a 150 tonnes off-highway trucks.

Days	Bucket payload, tonnes	# of Passes	Truck filling time, min.	Truck payload, tonnes	Production, tonnes per day
1	30	6	5.25	157	23.336
2	31	5	4.57	160	24.250
3	30	5	4.02	136	18.450
4	31	5	4.28	158	19.579
5	29	5	4.40	143	26.387
6	31	5	4.57	141	26.137
Average	**30.33±0.82**	**5.17±0.41**	**4.52±0.42**	**149±10**	**23,023±3328**

Productivity of DE Loader, (P) : Having higher mean time between failures and shorter mean time to repair and ease of maintenance imply a better productivity expectation of the equipment and the result is lowest cost-per-ton material handling. Production and production parameters such as bucket and tray loads, number of passes, cycle times etc. are monitored at the screen of the computer system in the cab.

How Fuel Saving is Achieved by Hybrid SR Drive DE Mining Loader?

A typical DE mining loader loading cycle is ideal for capitilasing on capturing regeneration power with multiple braking. Utilising switched reluctance system allows power generation to be fully regenerative, resulting in a very efficient wheel loader operation. During braking or retarding electrical motors become generators and feed power back into the generator which is connected to the diesel engine. Ultimately, this causes the generator to operate as a motor and turns the diesel engine (Anon a, 2014).

The DE Mining Loader (21m^3) Loading 150 Tonnes Rock Trucks

As it is seen in **Table 3**. the 21 m^3 DE loader filled 150 tonnes rock trucks 4,5 minutes and in 5 passes as an average of 6 days operation. The average weight of a bucketfull of rock is 30 tonnes. The loose weight of the rock is 1.30 t/m^3 . The bucket truck match is good. The average weight of truck truck tray is 149±10 tons. The average amount of rock daily hauled is 23,023+3328 tonnes per day.

The DE Mining Loader (21m^3) Loading 220 Tonnes Rock Trucks

The DE loader filled the 220 tonnes rock trucks in 7 passes as an average of a week. 220 tonnes rock trucks do not match the DE loader. According to the mining literature a loading equipment is better to load the haul truck in 3 to 4 passes. In the case observed, the loader filled the truck as an average of 6 minutes in 7 passes. The average payload of the loader was 29.43 tonnes. The average tray-load of the truck was 203±17 tonnes. The daily average number trucks filled up was 131±8 each. The average

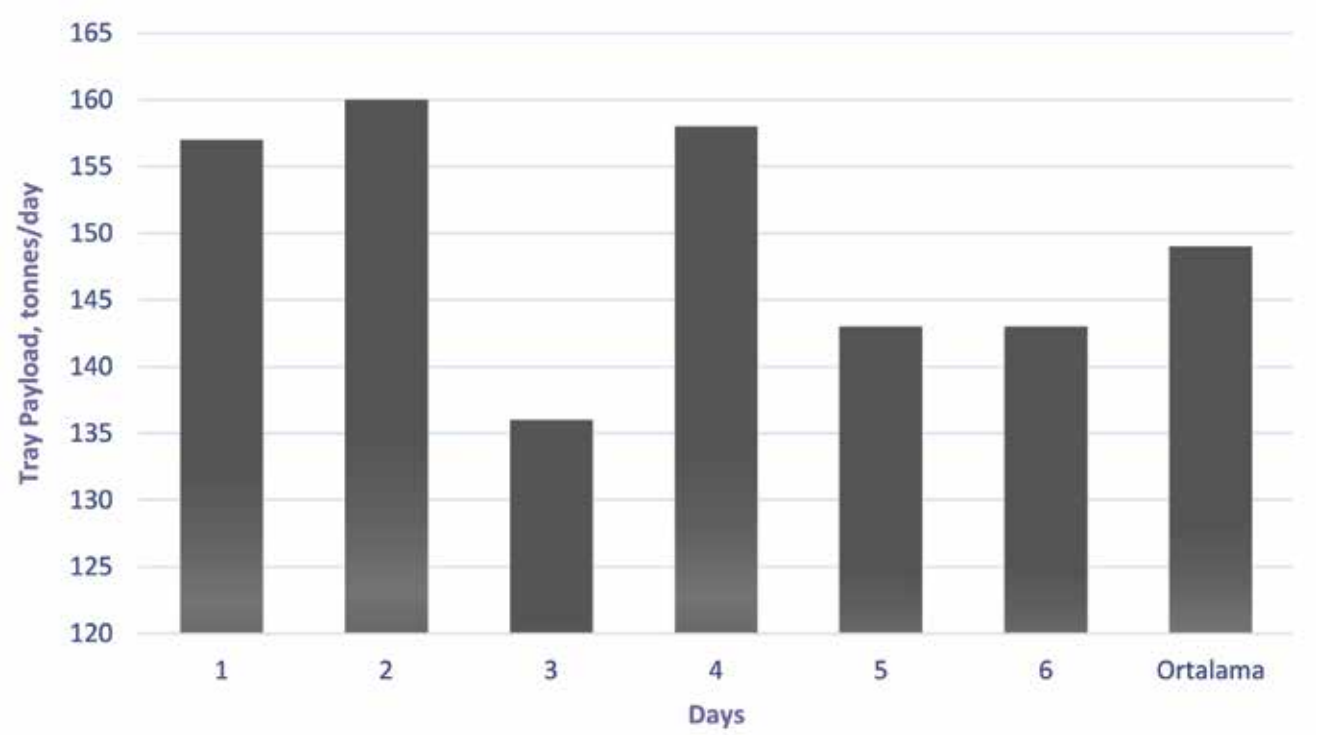

Figure 5: Daily tray payload of 150 tonnes trucks loaded by a 21 m^3 loader.

Table 4: Daily 220 tonnes truck tray loading details by a 21 m^3 loader.

Days	Bucket payload, tonnes	# of Passes	Truck tray fill time, min.	Avg. tray payload, tonnes	Total # of trucks, each	Daily production, tonnes
1	31	7	6.1	222	136	30.152
2	29	6	5.65	183	142	26.051
3	32	5	5.20	193	133	25.684
4	27	7	6.72	185	119	22.029
5	30	7	5.93	213	128	27.220
6	28	7	6.22	201	134	26.988
7	29	8	6.30	225	127	28.635
Average	**29.43±1.72**	**6.71±0.95**	**6.02±0.49**	**203±17**	**131±8**	**26,680±2559**

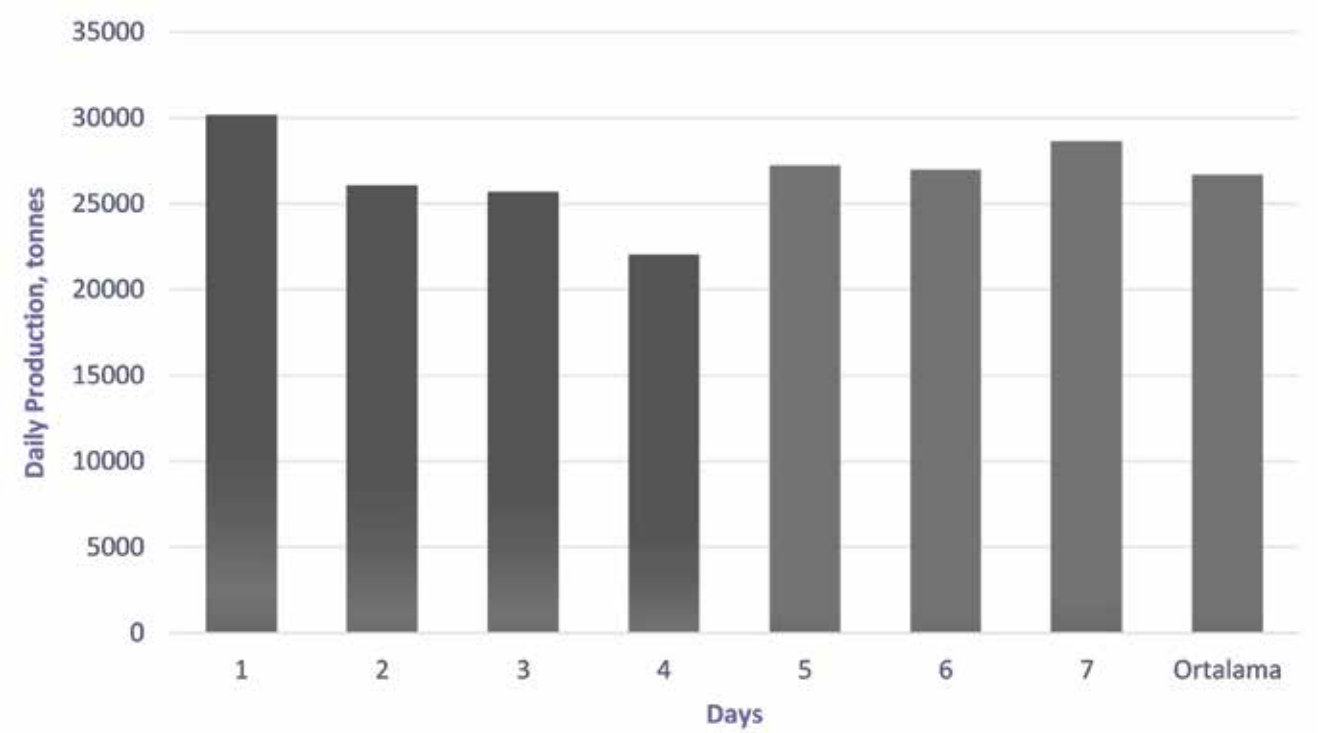

Figure 6: The 220 tonnes trucks' average daily production in a week's time.

daily production was 26,680±2559 tonnes, (**Table 4**). (**Figure 6**) depicts the change of daily average tray-load in a week. The records reflects the operations after a short while after the commissioning of DE loaders; the operators were used to operating MD loaders; After having enough experience and proper operating training for DE loaders, the operators presumably having better cycle times, better payloads, and better truck filling times, now.

CONCLUSION

In the monitored case, DE mining loaders operated in digging blasted hard rock benches of a gold mine. Loading details and cycle time statistics may not be compatible with the applications elsewhere; the reason why being the site-specific blasting practices and the inexperience of operators in electric drive loaders. The monitoring was done shortly after the commissioning of the equipment, and hands-on training of the operators. Presumably, they are performing much better, now. Electric drive train delivers excellent low-speed torque and more power to the ground than conventional transmissions (Anon a 2014). There is a heavy tax burden on fuel in Turkey; even though, the oil prices plunge in the world, it ascends in the country. Therefore, it is extremely important to introduce fuel friendly diesel-electric SR Hybrid electric drive mining loaders to Turkish open-pit mines. It regenerates power in breaking or retarding during the phases of cycle time; as motors behave as generators and pump the power back to the generator; generator acts as motor and drive the prime mover diesel engine. That is how the major fuel saving is achieved.

AUTHORS

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REFERENCES

Anon. a, 2014; Joy Global P&H, Generation 2 Wheel Loader Product Overview, *P&H Mining Equipment Inc., Milwaukee, USA*.

Anon. b, 2014; Development of a mining truck with an electrical drive system, *Available on http://www.hitachi-c.m.com/global/company/csr/environment/research*

Anon. c, 2011; Reference list LeTourneau, *Longview, Texas, USA*.

LeTourneau, R.G., 1972; Mover of Men and Mountains, *The Autobiography of R.G. LeTourneau, Moody Publishers, Chicago, USA*.

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All the know-how in your pocket

The founder receives extensive support from the Berlin-based, autonomous company builder Beam, a spin-off of BEUMER Group.

Start-up Elara Digital GmbH develops a new virtual assistant for the manufacturing facilities

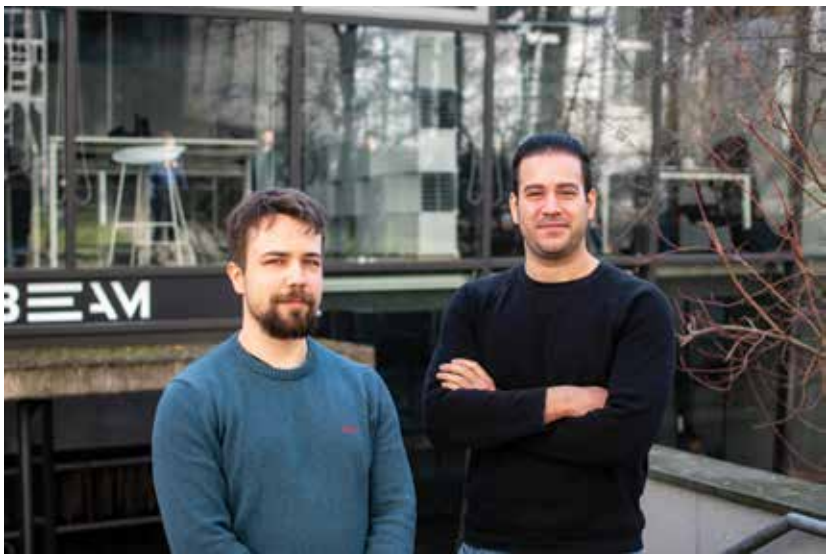
Unplanned machine breakdowns cost time and money. Elara Digital GmbH now offers the right solutions for reduced downtimes and increased machine availability. Relevant information such as work orders, checklists, machine documentation or guides for trouble shooting can be created in an easy and intuitive way and can be accessed at any time: a knowledge data base for maintenance teams. BEUMER Group supported the project of the founders and managing directors Akram Alraai and Dominik Adamowski with start-up financing.

"Numerous discussions with customers from the manufacturing sector have shown that unplanned machine breakdowns always represent a big problem and can last up to three hours on average," says Akram Alraai who, in collaboration with Dominik Adamowski, founded the Elara Digital GmbH in Berlin. Adamowski mentions a typical example with a well-known German sports manufacturer: "Because a Profibus component failed, the systems stood still for two hours. The calculated loss amounted to approx. 40,000 Euro." In order to support the companies in reducing these costs considerably and in increasing the machine availability, the two company founders developed a new solution - a cloud-based software application, which starts with the improvement of the trouble shooting process: getting an overview, orchestrating communication and, in cases of emergency, local access to relevant information. Elara Digital closes the gap between the maintenance director and the workshop employees. The founders emphasise that their application reduces complexity and provides transparency by equipping the employees in the workshop with a simple mobile application: the factory know-how in your pocket.

A STRONG PARTNER AT YOUR SIDE

The two founders received extensive support also from the Berlin-based, autonomous company builder Beam, a spin-off of BEUMER Group. "We try to solve unique problems in logistics together with the start-up teams," explains Managing Director Robert Bach. "My task is to find young entrepreneurs with business ideas that are relevant to us. We want to create three start-ups per year and transform them each into a separate company under the umbrella of Beam - like the Elara Digital GmbH." The aim of BEUMER Group is to open new business areas in logistics together with these companies.

Akram Alraai reports of the beginnings: "BEUMER Group brought us together with more than 30 companies, allowing us to interview them on machine breakdowns and maintenance subjects." His co-founder Dominik Adamowski and he were surprised how painful trouble shooting processes can often be. But what happens exactly? Presuming, the user is operating the BEUMER stretch hood® high-capacity packaging system. Suddenly the system stops during the shift. An indicator light starts flashing and the error code xfDE45 appears



The target of Akram Alraai (right) and Dominik Adamowski with their start-up: service technicians should have all the important information at their fingertips via smartphone in case of a machine failure and thus be able to minimise downtimes.

on the display." The operator either takes care of the problem or calls a service technician. But no matter who of the two carries out the task, both of them will have to face questions: "Where is the manual for this machine? Where are the checklists and the spare parts lists? Who has carried out the last inspection? What does xfDE45 actually mean? Is there a trouble shooting guide for the current problem?"

PEN AND PAPER SLOW DOWN DIGITALISATION

It can sometimes take a long time for the employee to have all the information ready. In their discussions with the companies, Akram Alraai and Dominik Adamowski were able to identify some of the main causes of these time wasters: "Often predictive maintenance is missing," says Adamowski. This means: The technicians repair defective components and replace the bad ones only if really necessary or at fixed intervals, but not at intervals based on empirical values." This usually requires auxiliary means such as Internet of Things or big-data analysis. The implementation is too complex and time-consuming for many companies. Often, work orders, trouble shooting guides or checklists are handwritten and filled in laboriously.

There is not only the risk of mistakes due to unreadable handwriting, but these documents also have to be scanned in order to be filed digitally. "Companies would like to have a system for easy order processing in maintenance," describes Alraai. "Electronic maintenance schedules or checklists should not be put on paper first, but directly into the system."

During the discussions, the two founders also learned how the maintenance topic has changed especially in the Covid pandemic. In order to adhere to the distance rules, many companies switched to shift operation. The result: the personnel cover is thinner in each shift and therefore less employees are available for quick repairs.

MOVING TOWARDS MORE EFFICIENCY

"We have started here," says Akram Alraai. „Our software allows to create digital work and maintenance orders in easy and fast way and to directly assign them to the right employee." He can start working directly with his

The team of the two company founders.

Start-ups enable BEUMER Group to successfully pursue its goal of bringing digital solutions into the corporate group.

smartphone: He scans the QR code at the machine or system and can immediately access all relevant data required for example for inspection or trouble shooting. "In order to find the required document even faster, he can call it up via voice command," says Adamowski. In case of unexpected problems in production, employees often refer to trouble shooting guides and if these are not available, it is possible to upload pictures and videos. This makes it easier to diagnose the problem and then solve it. The software records all possible malfunctions and communicates them," describes Adamowski. "Thus the employee has the entire know-how on his smartphone."

The web application permits the maintenance director to have an overview on all machines and employees in operation. On the display, he can also call up all important figures to determine the activities in the workshop. Reports and protocols can be generated and exported in different languages via the app with the help of artificial intelligence. Thus they can be easily transferred to existing systems.

SHARED KNOWLEDGE IS MORE KNOWLEDGE

Headword Knowledge Sharing Economy: "On our platform we want to make the manufactuer's digital information, such as manuals or tutorials, accessible to our customers," says Adamowski. "At this regard, we offer an interface through which their documents can be uploaded. Machine operators can also upload and share their reports on faults and how to fix them." This way, the knowledge database is continuously filled with practically applicable know-how. Data security plays a very important role: the data are anonymised, protected and stored on servers in Germany. Thus, every user can access checklists, manuals or guides and benefit from a large pool of knowledge and expertise.

With the start-up, BEUMER Group can successfully pursue its goal of bringing digital solutions into the corporate group. The system provider can now provide its customers with even better support, strengthening its position as partner on the market. The two company founders Akram Alraai and Dominik Adamowski have calculated that users need up to 1.5 hours less for trouble shooting than without virtual assistant. This can save them up to 30,000 euros on average. And Elara Digital? "We benefit from the cooperation with BEUMER Group in the form of generous start-up financing, an extensive network of experts and customers, and a great deal of know-how," Akram Alraai says happily. "We are now part of the BEUMER family."

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Managing Director Robert Bach. "My job is to find young entrepreneurs with business ideas that are relevant to us".

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Effective mine communications vital

The rapid development of industrial and communications technology in recent years increasingly benefits mining activities around the globe and has affected nearly every facet of the mining process. Companies are rapidly deploying these new tools and applications to gain the associated productivity and financial benefits. However, they face a key challenge in that they require the appropriate infrastructure to support data communications technology in the mining environment, particularly in underground mines.

Reliable and effective communication is a vital part of creating a safe, efficient, and productive mine. While the historical timeline of materials extraction technology goes back many centuries, the mining communication systems era stretches back to the last century or so.

The invention of the telephone precipitated the communication revolution in mining, just as it did above ground. Before phones, mine shaft communication consisted primarily of bells or whistle signaling systems. By the early 20th century, mines began to use ruggedized telephones connected by cable strung throughout the mines. The phones themselves were essentially the same as those being used above ground, but enclosed in cast-iron housings to protect them against the varying humidity levels, wide temperature ranges, and dust or corrosive atmospheres that inhabit a typical mine. The most common phone systems developed were based on a paging-type format or a magneto (crank ringer) system. Still in wide use today, both of these systems use a party-line format, with a telephone for each working section, with additional phones at other key locations above and below ground. The hard-wired format of these systems makes them simple to install and maintain, but the fixed location of the devices means that miners usually have to stop work in order to communicate.

Some mines still use traditional hard-wired, wall mounted telephones plus a paging system. The time lapse between a page and a response is typically fifty minutes, resulting in inefficiency causing considerable energy waste. The most effective product that later came onto the market to be offered for wireless communication in transmission-limited environments was the now over 40 years old so-called “leaky feeder” system.

The challenges of maintaining safe workplaces and improving operations and services in underground mines are unique Just as mineral extraction technology has come a long way in the past century, so too has mining communications technology.

The rapid shift from traditional, legacy analog systems (e.g., leaky feeder) to high-speed digital networks has created a lag in the knowledge and experience that is required to properly plan, design, deploy, and maintain such systems.

The following factors should be considered during the development of industrial communication systems. An underground communication network must exhibit redundancy under rugged working conditions. In addition to the rigorous requirements of hardware design and quality, a two-way communication architecture should be developed to provide high reliability. A reliable and robust communication system – usually composed of two parts: transceivers and a communication network –

is necessary for transmitting audio and data information and tracking assets. For stationary units or worksites, cable-based (wired) communication systems are normally adequate; wireless systems should be used for mobile units. There is a tendency for underground mines to use a single communication network for both voice and data. Older, single-function technologies required separate networks for each mode of communication; this is no longer necessary in modern mines. Standardizing communications and running multiple services along a single fibre backbone simplifies deployment and operations and can help reduce costs. When there is a fault in the network, redundancy such as ring-type architecture allows continued communication by looping the signals at the location of the fault. Even if the communication system focuses on the targets set during short-term planning, it should include instruments that could satisfy requirements for optimal or near-optimal solutions for the long term.

NETWORK SELECTION AND DESIGN

The type of network that will be suitable for a specific underground mine is dependent on several factors, including:

- The stage of operation of the mine (e.g., development, commercial production, or near end of life)
- The purpose of the network: Emergency response, tracking, ventilation on demand (VOD), environmental monitoring, and collision avoidance, or a combination of applications
- The mine's budget for the network

The type of application(s) required will dictate which communication infrastructure is necessary: wired, optical, radio, or a hybrid system. The more complex an application is (e.g., collision avoidance), the more complex the design and implementation will be. Additionally, any applications that might be desired in the future must be considered in advance so that, if funds allow, the selected communications infrastructure can support the expansion. Once the applications and communication infrastructure have been selected, the characteristics of the various technologies must be considered to design the network.

LEAKY FEEDER SYSTEM

A leaky feeder system consists of a number of different components: head end, base station, power coupler, leaky feeder cable, line amplifiers, barriers, splitters, mobile radios, auxiliary antennas, and terminators. First developed in the 1970s. It employs both wired and wireless communication features to provide robust and flexible communication in challenging mine environments. The leaky feeder cable, which is the backbone of the system, is a coaxial cable that has sections of the outer shielding shaved away during manufacturing to allow the RF signals to "leak" out (or leak in), thus allowing it to function as an antenna, providing a communications path for radio transmissions in the mine. The most basic leaky feeder system will use a repeater connected to some leaky feeder cable, which is then extended into the mine, with strategically placed line amplifiers and repeaters to compensate for the signal loss. Current communication options via leaky feeder include: underground radio communications, RFID tracking of personnel and equipment, gas monitoring, I/O, and the list goes on.

Cutaway view of a leaky feeder cable.

This system requires an extensive installation of a bulky, hard-to-install, 5/8" diameter cable in all the paths, tunnels and rooms where communication is needed. The general response at the time was that this was the best system available, but the system suffered from many shortcomings that rendered it unsatisfactory. The user must be in line-of-sight of the cable and within 30 to 80 feet from it; there is interference between channels; there are many "dead" spots; and there are too frequent unplanned downtimes that render the system unreliable. As for wireless communication between the surface and the mine interior, there was available a one-way communications system that sent messages from the surface into the mine. The message appears as an LCD display. No voice communication was possible. No response, and therefore no "message received" acknowledgement from inside the mine to the surface was possible to ensure that communication was successful.

It is important to note that it is difficult to provide complete mine-wide communications coverage with leaky feeder systems. However, with proper coverage extension schemes and redundant or alternative communications approaches, most areas where miners work and travel can have high-quality communications signals, with a good chance of survivability in the event of a mine emergency.

These systems one would say have now given way and have largely been mitigated by the implementation of the new technology of wireless sensor networks (WSNs) in the last few years. Establishment and development of a reliable monitoring and communication network through such hostile environments are still major concerns. The rapid shift from traditional, legacy analog systems such as leaky feeders to high-speed digital networks has created a lag in the knowledge and experience that is required to properly plan, design, deploy, and maintain such systems.

PLANNING

The safety of miners is paramount when planning a mines communication network .and as we all know it is a rarity for any two mines to have the same characteristics, so selecting the right system is of great importance whether it be a surface or underground operation where the latter may have an environment where for example the installation of wires for power and communications is problematic, in which case battery-powered wireless networking technology could provide a reliable and cost-effective alternative solution. Until now, no single communication system exists which can solve all of the problems and difficulties encountered in underground communications. However, combining research with previous experiences might help existing systems improve, if not completely solve all of the problems and as the industry continues to move in the right direction.

CONSIDERATIONS.

The discussion of *wireless communications* systems begins by considering the general characteristics of the systems and addressing the following questions:

- What is necessary to establish communications between two radios?
- What *frequency* or frequencies are appropriate for use in a mine?
- What frequency or frequencies must not be used to avoid potential interference?
- How much *radio frequency (RF)* power is allowable for use in underground mines?
- How much bandwidth is needed?
- What is *bit error rate (BER)* and how is it related to reliability?
- How are communications components interconnected to form a network?
- Why is a network necessary?
- How does a network configuration or topology affect the ability of the network to survive an accident?
- On what basis are different systems or technologies compared?
- What are the appropriate metrics for measuring performance?

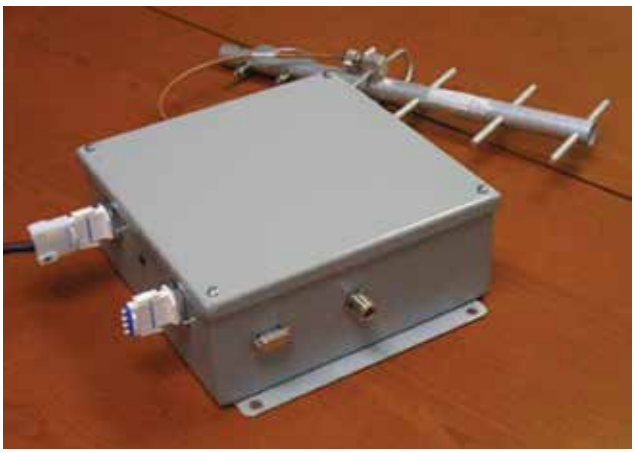
Another important consideration is the basic type of wireless communications system, i.e., primary, or secondary.

Primary communications systems are those used by miners for providing daily underground and surface communications throughout their shift. These systems are typically hand-held devices operating in the conventional radio bands (e.g., very *high frequency (VHF), ultrahigh frequency (UHF)*, 2.4 GHz, 5.8 GHz). Leaky feeder and node-based systems are examples of such primary systems.

Secondary communications systems are those which operate in nonconventional frequency bands (100 Hz to 1 MHz) and are not readily portable, but they may be more likely to remain operational following a mine accident or disaster. *Medium frequency (MF)* and *through-the-earth (TTE)* systems are examples of secondary systems that may provide survivable alternative paths to primary communication systems

WIFI OR ZIGBEE?

Wi-Fi and ZigBee both have their positive qualities, but they obviously come with negatives. What you gain in bandwidth with WiFi is lost in battery power and range, and what you gain with ZigBee's battery life you lose in range and bandwidth with ZigBee. So, like any decision based around link budgets, trade-offs are crucial to understand.



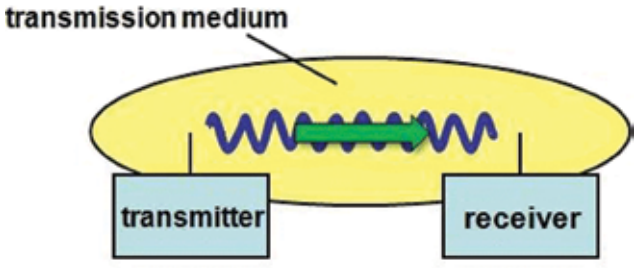
Components of a simple wireless communications link.

When speaking specifically about power consumption, ZigBee-based networks generally consume 25% of the power of WiFi networks. ZigBee's battery life is a major plus over WiFi, and needs to be strongly considered if a mines endpoints will run on batteries.

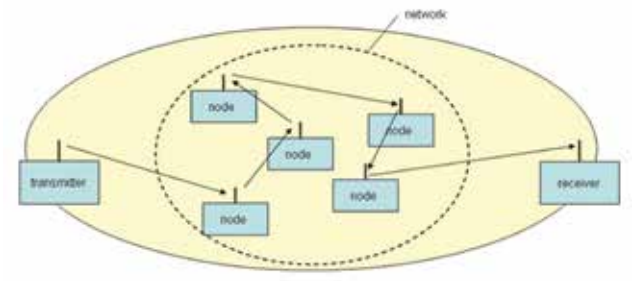
NETWORKS AND NODES

The primary component in a node-based network is, of course, the nodes deployed throughout the mine to provide wireless coverage. The nodes send and receive radio signals to extend the communications range between hand-held devices, which are another component of the system. The mesh network uses a variety of mobile devices such as hand-held voice-over-Internet-Protocol (VoIP) phones, laptop computers, tracking tags, and text communicators. The nodes link with other nodes to form a wireless or wired network throughout the mine. Nodes may be called by other names such as mesh points (MPs), access points (APs), or wireless access points (WAPs). Under normal operation, the nodes require power from an external supply. Thus, they must be located near electrical power wiring. In an emergency, when main power is unavailable, the nodes can operate from a backup battery.

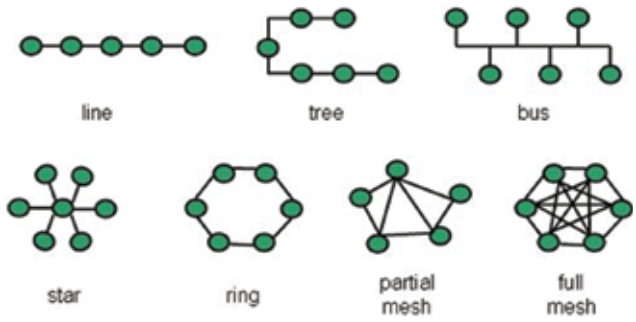
A *network* is the interconnection of multiple communications components designed to extend the area of coverage and the number of users able to access the services provided. Due to the limited range of a single wireless communications link and the large geographical



Components of a simple wireless communications link.



Communications via a network.



Examples of standard network topologies.

extent of modern underground mines, any of the wireless communications or electronic tracking systems installed in a mine will require a network of some sort, except possibly in a very small mine, i.e., < 600 m (2,000 ft) in length.

Topology is the configuration of the network components. The choice of topology plays a major role in the performance of the network and its likelihood to survive accidents (i.e., its *survivability*). The figure below shows several basic types of network topologies. The green circles represent nodes, and the lines represent connections between the nodes. The connections may be hard-wired metallic conductors, fibre-optic cables, or wireless links.

There are advantages and disadvantages to each topology pictured. The line topology is simple, and failures are easy to isolate. However, if the leftmost node is on the surface and there is a failure at one of the connections or other nodes, the nodes to the right (inby the *working face*) of the failure have their communications cut off. Thus, the network is vulnerable to a single-point failure.

The tree topology is an improvement over the line topology simply because a failure on one of the branches does not affect the other branches, but each branch has the same single-point failure-mode potential as the linear structure. In the full-mesh topology, each node connects to every other node. Thus, a miner accesses one of the nodes with his radio link, but the signal could take multiple paths to reach the intended receiver. In addition, if one node fails, there are multiple paths around the failed node. However, it is unlikely that the full-mesh topology would ever be implemented in an underground room-and-pillar coal mine. With the many thousands of feet of mine entries to cover, it would be impractical or impossible to interconnect each node to every other node. A *partial mesh* offers many of the advantages of the *full mesh* and is much more practical in the mine environment.

OPTIMUM PERFORMANCE

Irrespective of what system is chosen for a mine and without delving into any of the technical merits that manufactures portray there is no doubt that mine communications and tracking systems require periodic maintenance for optimum performance. Although these are rugged systems, the mine environment is very harsh. The RF system manufacturers should specify periodic maintenance checks. For example, when the power shuts down during emergencies, most systems will have battery backups. These batteries need to be checked periodically to ensure they are operational. Even rechargeable batteries in hand-held devices have a terminable lifetime associated with them, requiring periodic replacement. To verify that the coverage is fully functional, periodic testing of the communication system should be a necessary routine in the mine. Testing can be quantitative or qualitative. Quantitative testing requires specialised equipment to measure radio signal strength as a function of location throughout an area. Qualitative testing will likely involve spot checks of communications links using a series of "Can you hear me now?" interchanges between underground and surface users. *Performance metrics* and performance goals for communication systems in underground mines is a controversial topic. When it comes to specific metrics, there are diverse opinions as to what those metrics should be in relation to the achievable performance goals.

CONCLUSION

Generally, it is relatively easy to obtain agreement on qualitative performance goals. Most mining companies would agree that a pre-requisite for any communication systems should be:

- Able to provide two-way communications.
- Able to determine a miner's location.
- Easy to use.
- Easy to install and maintain.
- Safely operable in both pre- and post-accident scenarios.
- Reliable in both normal and emergency situations.
- Survivable in being able to remain operational post-accident.

Quantitative performance metrics and goals, however, cause opinions to rapidly diverge. For example, the following questions arise for a CT system:

- What mechanical and explosive forces and extent of damage must the system survive?
- How often should the system be tested, and how is it verified to be properly functioning?
- How long does a system have to remain operational post-accident?
- What percentage *reliability* or *availability* is required of a system?
- What is the maximum acceptable time for routine maintenance and repairs?
- What is the maximum acceptable delay for a miner's message to reach the surface (during normal operations and/or post-accident)?
- What constitutes sufficiently safe operation of battery-powered devices in a potentially explosive (methane and/or coal dust) environment?
- How accurately does a miner's location need to be determined?
- How is a system tested once *survivability* goals are established?

There are several reasons why it is very difficult to answer these questions and to establish quantitative performance metrics that will have consensus agreement.

A good communication system can save lives.
It is good to talk!

Maxam mining group

As a major global specialty tire manufacturer and distributor, MAXAM has a strong reputation for market-leading quality, reliability, and delivered value. MAXAM MINING GROUP (MMG), a dedicated global group under MAXAM Tire, specifically focuses on the mining segment. The MMG's core value is to provide superior support on all MAXAM products through partnerships with high-level dealers in conjunction with the support from MAXAM MINING GROUP. Their goal is to ensure the best product performance and the highest level of overall customer satisfaction while reducing the end-user's operating costs. Gaining a strong reputation in the industry, MAXAM Mining Group continues to innovate and engineer products with the best performance and value.

Most recently, MMG has ramped up its investment in the ultra-large OTR tire segment following the recent introduction of its first-ever 63-inch tire, the MS453. To meet the toughest requirements for haul trucks that require 63" large mining tires, the newly developed MS453 utilises an enhanced casing construction with advanced compounding technology. The MS453 is the result of advanced engineering, extensive research, and global testing. MAXAM designed the MS453 with the goal to provide the best-delivered value, greatest productivity, and the lowest cost-per-ton value for global mining operations.

Featuring a rugged and aggressive tread design that allows maximum tire life for the most demanding mining applications, the MS453 is built to withstand even the most severe challenges on haul roads. Taking feedback from customers and mine sites globally, MAXAM has reinforced the sidewall of the MS453 by enhancing the tread belts and bead construction to provide maximum protection and performance. Similar to the products within the large mining series, the MS453 features a deep tread depth to deliver longer tire life. It also contains a heat-resistant undertread for reduced heat built up, increasing the tire's TKPH/TMPH.

As mining applications continue to evolve, MAXAM's engineering team continuously develops new products utilizing leading technology that focuses on performance, safety standards, reliability, and quality. In today's competitive market, mining customers are looking for other viable large haulage tire options. The recently launched MS412 27.00R49 is a perfect reflection of MAXAM Tire's innovative vision on providing performance, technology, and value. Designed to tackle demanding conditions in mine sites globally, the MS412 is the result of cutting-edge engineering and groundbreaking compounding technology.

The MS412 features a high net-to-gross tread pattern that provides extremely low wear rates that drastically increase tire life. MAXAM's engineers have also strategically placed stone ejectors to provide maximum protection from stone drilling, which leads to the cause of premature tire removal and out of service conditions. Engineered with tread grooves that allow for exceptional traction and heat dissipation, the MS412 delivers excellent traction in a variety of haul road conditions. To enable high-speed operation with minimum heat build-up, MAXAM has optimised the MS412's base compound to help maximise productivity for mining operations globally.

Featuring a strong all-steel casing to reduce cuts and punctures, the all-new MS412 is engineered with increased casing durability to dominate severe hauling conditions. As an innovative group, with years of expertise in the mining industry, MAXAM's engineering team has designed the MS412 with a high lug-to-void ratio for improved wear and impact protection, providing mine sites increased protection and wear on haulage tires.

Delivering a premium E4 haulage tire to the industry, the MAXAM MS412 provides exceptional performance, minimum cost-per-hour, and a high net-to-gross pattern for maximum tread wear. The MS412 is available in one size as noted in the below chart. Available in multiple tread compounds, including the recently released ultra-cut resistant compound, innovated by MAXAM's engineering and R&D team, the MS412 is a rugged solution that maximises the haulage truck's resilience in the toughest mining environment.

MAXAM Tire currently boasts (14) haulage and support equipment models that have applications across multiple industries, bringing relevant and innovative solutions to customers in all segments. Innovative engineering, extensive testing, research, and state-of-the-art manufacturing differentiates MAXAM from its competitors. As the MAXAM MINING GROUP continues to expand globally, its customer satisfaction remains the foundation of MAXAM and therefore they continue to innovate in all aspects of the tire business. Driven by core values that are centered around innovation and commitment to create an exceptional customer experience, MAXAM's people are committed to continued advancement and to exceed expectations. It is what makes the MAXAM difference – being your business solutions provider.

Mines seen posing additional climate threat with gas leaks

New coal mines are leaking methane gases that are in some cases just as destructive to the environment as the pollution released from burning the coal itself, according to a new study.

Methane, a greenhouse gas 80 times more potent than carbon dioxide in its first two decades, leaking out of some mines could be having as much of an impact on global warming as burning the coal they produce, researchers with Global Energy Monitor, a San Francisco-based non-profit group, said in the study. The amount of methane that would leak from new coal mines currently being proposed globally would do as much damage as all of the coal power plants in the U.S. combined.

"Methane emissions from coal have received much less attention from researchers and governments than methane emissions from oil and gas," researchers said in the report. "The gap in attention has resulted in a deficit in implementation of measures to mitigate what by all estimates is one of the most significant sources of greenhouse gases."

Methane, the simple hydrocarbon that makes up most of natural gas, is the second-biggest contributor to global warming after carbon dioxide. While releases are smaller in volume and it stays in the atmosphere less time, it can trap far more heat than CO2 on a relative basis. Coal mining accounts for about 9% of human-related methane emissions, according to the Global Methane Initiative.

Methane on averages increases total greenhouse gas emissions at major operating mines by about 20% when measured on a 20-year horizon, Global Energy Monitor found, with that level rising up to 50% in the gassiest mines.

Global Energy Monitor examined potential methane releases at 432 proposed new or expanded coal mines, and found that at the gassiest of them the leaks could account for half of their total greenhouse gas impact. If all were built, about 13.5 million tons of methane would be released annually, doing the damage of an equivalent of more than 1 billion tons of CO2.

By far the largest potential source is China, where 140 new mines are under development. But the biggest single project is Valiant Resources' Hutton development in Australia, which would produce the annual equivalent of 60 million tons of CO2 if built out to full ambitions.

GFG Alliance defends Tahmoor Coal, OneSteel future

The collapse of German financier Greensill Capital has thrown the future of the GFG Alliance into jeopardy, with Australia's Whyalla steel mill and Tahmoor Coal caught in the crossfire.

Greensill was recently placed under administration as its funds were frozen by financial services group Credit Suisse, leaving GFG with a need to refinance its assets.

In a knock-on effect, Credit Suisse trustee Citibank filed a wind-up order in the New South Wales Supreme Court for GFG-owned OneSteel Manufacturing and Tahmoor Coal.

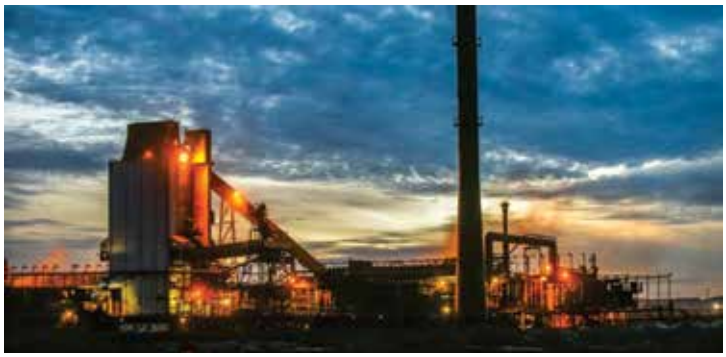
A spokesperson from the GFG Alliance said the company's Australian mining and primary steel (MPS) business would vigorously defend any proceedings filed against the company as it did not conduct any financing with and has not sold receivables to Credit Suisse.

The spokesperson said the wind-up notice was unnecessary as GFG was within reach of refinancing.

"GFG confirms it has received multiple offers of finance from large investment funds and is in advanced due diligence," the company spokesperson said.

"The term sheets as currently proposed would provide enough cash to repay the creditors of MPS. GFG Alliance expects the confirmatory due diligence to be complete within weeks before a final offer is accepted.

"GFG Alliance is in constructive discussions with Grant Thornton, Greensill's administrators, and other stakeholders to negotiate a consensual and amicable solution on the way forward, which is in the best interests of all stakeholders."



Whyalla Steelworks, South Australia

The South Australian-based Whyalla steel mill, owned by OneSteel, produces 1.2 million tonnes per year, while the Tahmoor Coal operation in the Illawara region of New South Wales produces three million tonnes per year.

The GFG spokesperson said they were well positioned to receive support at this time due to the success of the respective operations.

"The Australian businesses are performing well and generating positive cash flow, supported by the operational improvements we've made and strong steel and iron ore markets," they said.

The supreme court hearing scheduled for May.





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