Process and Product Innovation for a Safer, Smarter and More Sustainable Mining Industry

Electrification trends, digital transformation and a push for greater efficiency create new issues for engineers to consider and overcome

Parker

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The global mining industry dates back to the beginning of civilization and has made an impact on major economies throughout history. The world has always been dependent on mining. Modern-day mining, however, is now faced with many significant challenges that have never been seen before. Population and economic growth equate to increasing demand for materials, and this will only continue to trend upward. While extracting and processing prove to be increasingly difficult, there is also increased attention on the environment.[1]

Green initiatives for reduced emissions, along with an ongoing desire to improve safety and productivity, have been drivers for increased automation and electrification in mining. Motivations can differ by type of mine. For example, the continued electrification advances in underground mining are largely fueled by health regulations and true savings of ventilation system costs. Whereas the surface mining sector is more influenced by corporate carbon neutral programs. Whatever the motivation, many industry experts believe that automation and digital solutions will work alongside electrification to monitor energy usage and help miners reach their sustainability targets while also improving the quality of the working environment.

In recent years, mining companies have adopted a growing range of digital solutions. The COVID pandemic has accelerated that adoption. Never before have technologies and new ways of work been implemented as quickly.

Many mines have digitized their operations, effectively embracing digital transformation by adding equipment sensors and adopting unified networks to transmit data, but it seems the industry still has progress to make. According to BCG's Digital Acceleration Index (DAI), the metals and mining industry is roughly 30-40% less digitally mature than comparable industries, such as automotive or chemicals.

Yet, the rewards of accelerating digital transformation are great, offering mines the opportunity to increase productivity, adapt to a challenging labor market, better manage assets and minimize their environmental footprint. The potential environmental impact is significant given that it is estimated that mining is currently responsible for 4% to 7% of greenhouse gas (GHG) emissions globally.[2]

This whitepaper explores the impact of various changes and innovative technologies on the mining industry and identifies major trends that are shaping how engineers think of best practices when it comes to operating mines safely, profitably and aligning with the latest decarbonization initiatives.

The Electrification Journey

Many mines are already engaged in the electrification journey. This is particularly the case for underground mines, where tethered or battery-powered load, haul, dump vehicles (LHDs) are common. They significantly reduce ventilation costs while also reducing greenhouse gases. Other benefits include reduced maintenance costs, with battery vehicles having 25% or so fewer parts compared with diesel propulsion systems, and less noise, vibration and heat.[3]

In surface mining, the use of electric-powered mining trucks has historically focused on the use of trolley-assist trucks, which are diesel-electric drive haul trucks that receive the power to run the wheel motors from catenary/overhead electric wire lines constructed on specified routes.

Converting to electric drives on these vehicles is the most promising option. When compared with diesel power trains, electric drives offer significant environmental, operational and cost benefits. In addition, equipment running on batteries is versatile with superior power efficiency, good tractive effort (including high torque at low speeds) and relatively little maintenance required.

In a poll by Mining-Technology.com between March and May 2021, 30% of the 496 respondents felt that the use of battery-powered vehicles would have the greatest impact on reducing emissions from mining operations over the next five years. This compared with 16% expecting the greatest impact to come from hydrogen-powered vehicles and 21% from use of on-site renewable energy.

Challenges Along the Way

Labor Shift

Despite all the obvious benefits of electrification, adoption of fully electric fleets remains low. One challenge mining companies face stems from the perception that such a drastic transition will result in the loss of jobs while digitalization and automation replace and reduce the need for manual labor.

For mining companies to be fully committed to electrification, a reevaluation of current skills sets will need to be considered. According to strategy and consulting service company, Accenture, the future mining workforce is likely to change by up to 77% by 2024, which will be driven primarily by the adoption of new technologies such as autonomous machinery. As such, there will be a shift in the skills profile for future workers who will need to manage and engage the electric transformation in the industry.[4]

A 2019 report by EY additionally shows that electrification requires mining personnel to adopt some different skills, such as data and digital literacy and technical planning. In some cases, mine design needs to be rethought for better optimization of electric mining equipment.[5]

Thermal Management

Putting electric equipment into an environment that is hot and humid seems counter-intuitive. With mining machines, there is a tremendous amount of heat generated. Keeping batteries cooled is a common thermal management concern.

Battery thermal management presents a significant gap in the knowledge that manufacturers need to maintain safe, reliable underground mining vehicle battery systems. Emergency responders need to understand the characteristics of lithium-ion (Li-ion) battery fires and appropriate suppression agents.[6]

Beyond heat dissipation concerns, current battery technologies lag in other ways. There is an ongoing search for batteries with large capacities that have a small footprint and are lightweight. Operators need batteries to charge faster and last longer between charges as a means to reduce downtime.

Battery Storage Capacity

As a result of the low energy storage capacity of batteries, the autonomy of electric vehicles is limited. Limited autonomy, along with the heavy weight of suitable battery packs and their cost are still serious hurdles in the development of powerful electric mining equipment working under much heavier loads than passenger cars.

Such challenges are forcing engineers to rethink the entire machine and how it is powered. Today, batteries still need to be charged more often than diesel engines need to be refueled, leading to downtime concerns. Diesel remains the most efficient combustion engine fuel source, carrying 38 kilowatt hours of energy in every gallon — 27 times that of lithium ion batteries.[7]

One newer option is to use machines with batteries that can be easily swapped. When one battery runs out, the machine simply exchanges it for a fully charged one. The used battery is then recharged while the machine continues to operate.[8] Some machines are designed with batteries that can be exchanged between shifts.

Making Mining Safer

Mining is an inherently dangerous profession. Miners typically face risks ranging from flying debris to a full mine collapse to vehicular incidents. Oversized equipment and lack of visibility could cause bodily harm to miners. Plus, there are ongoing air movement/ventilation issues. In underground mining, methane is one of the biggest safety concerns, as even a small spark could cause a catastrophic explosion.

Advances in technology and the introduction of strict safety regulations by MSHA have resulted in a reduction of workplace incidents in recent years but have not completely eliminated the possibility of safety hazards. Some of the more impactful advances in the area of safety include:

- Increased use of sensors and controls
- Greater reliance on autonomous vehicles
- More durable hoses to limit bursting

Sensors

Sensors can be used to provide remote diagnostics, predictive maintenance, asset tracking, emission and groundwater monitoring, as well as monitoring the after-effects of blasting, providing wearable tech, and helping to implement smart ventilation systems. Real-time, constant monitoring not only makes mines smarter, but also safer.

Two noteworthy advances in sensor technology include Parker's UTS-ID Universal Tilt Sensors and Global Positioning Systems (GPS). The UTS-ID Universal Tilt Sensors offer customizable features which, among other things, detect impact, communicate impact events and acceleration signals of impact magnitude and acceleration orientation information using SAE J1939 CAN bus protocol.

The GPS enable operations to track the velocity, point in time and location (latitude, longitude and elevation) of equipment. When a GPS is fused with an Inertial Measurement Unit (IMU), it's easy to obtain a clearer indication of the attitude of the vehicle, allowing workers to project trajectory and time of arrival, manage traffic and understand where and when vehicles are likely to intersect. This greatly assists in developing collision avoidance technology, which can lead to a reduction in vehicle-to-vehicle incidents.

Autonomous Vehicles

Mining automation is a key component of many companies' digital transformation strategies. It promises improvements to safety, productivity and reduced labor costs. The use of partially and fully autonomous (driverless) trains, trucks and other robotic assistants programmed to handle some of the more difficult and dangerous tasks traditionally handled by people is a major step toward reducing injuries.

These technological advancements are shifting mining from being a labor-intensive industry to one characterized by more digitally automated processes that can take the form of either process/software automation (IT automation) or the use of self-driving robotic technology (OT) automation.

Despite the many defined benefits of autonomous vehicles, their use in mines is still small. One estimate stated that less than 3% of current mobile mining equipment is autonomous.13 However, it's expanding rapidly due to multiple OEMs now offering autonomous equipment, such as hauling trucks, load/haul/dump (LHD) machines and drillers, among others.

While the beginnings of autonomous mining focused on driverless vehicles, today's savvy mine operators are looking at ways to harness modern-day technology to improve efficiencies across a wide array of operations.

Parker has helped advance the feasibility of electric autonomous systems with its GVM electric

motors with up to more than 400KW of power. These high-power density, compact motors offer the highest efficiencies in the market. The innovative design of the GVM allows it to be used as a motor or a generator. This feature facilitates efficient system energy recovery whether from smart system design or braking solutions. The GVM can provide a means of reducing expensive battery costs, extending the range between charges, and reducing overall machine operating costs.

Durable, Reliable Hoses and Fittings

Given the high pressure and the high duty cycle of mining, a worn hose can be problematic. That's why so much research is focused on improvements that make hoses stronger and longer-lasting.

When considering which hoses offer the greatest reliability and safety, attention should be paid to their design factors. All Parker hydraulic hoses, for example, offer a 4:1 design factor, which means if the hose is rated at 5,000 psi working pressure, the burst pressure will be 20,000 psi. This type of added cushion is critical considering the possibility of major pressure spikes that occur in a normal mining operation.

Recognizing that an operating system is only as strong as its weakest link, Parker's

GlobalCore Hoses are the world's first high-performance cohesive hose and fitting system. Designed, built, and tested to the ISO 18752 specification, the GlobalCore product family simplifies specification for OEMs and end-users around the globe by providing a comprehensive family of robust hose assemblies for the most commonly used constant working pressure classes.

Also helpful in the harsh, non-stop mining operations is Parker's recently launched ToughShield™ Plus, a patent-pending standard zinc-nickel plating, which increases fitting service life by offering superior corrosion resistance. This means mine operators benefit from less frequent and easier maintenance, extended fitting service life, and increased resistance to the migration of rust to adjacent components. For manufacturers, it means a decrease in warranty claims and aesthetic quality concerns due to corrosion. ToughShield Plus is the first commercially available standard plating system to provide up to 3,000 hours of resistance to red corrosion per ASTM B117 neutral salt spray testing.

Increased Focus on Productivity and Profitability

Nothing kills a mine's profitability more than downtime. According to Caleb Barnhart at Parker, if a surface blast-hole drill rig goes down, it could cost the mine operator up to $10,000 per hour or more.[9] That's why any effort to reduce downtime can yield major financial improvements. Design of long-lasting equipment and failure-proof components is critical.

And today's mining equipment and machines are more connected than ever before. Harnessing this complex data is key to maximizing uptime. Parker's Mobile IoT makes it easy to identify usage trends and field-based problems with unparalleled intellectual design and operational insight.

According to Anne Marie Johlie, Parker's Internet of Things (IoT) and connected products business unit manager, "The utilization of a remote monitoring solution can increase productivity up to 20%, reduce recordable accidents up to 30% and reduce fuel consumption up to 20%, which has a direct impact on a company's profits."[10]

The key to improving the efficiencies of the off-road and mobile equipment used in mines is being able to easily combine and understand data from different sources, such as sensors, industrial control systems, infrastructure and IT systems and deliver valuable new insights into asset health. Detailed understanding of equipment performance through IoT can help identify and prevent problems in the following ways:

- Provide advance warning of equipment degradation or failure to avoid unplanned downtime.
- Carefully monitor production line quality. The data can present signs indicating if the equipment is properly calibrated or if adjustments are needed. IoT can signal alarms to alert the managers when component metrics begin to divert from prescribed dimensions, track process parameters (speed, time, temperature, etc.) to ensure they stay within the target range and accurately determine and remedy root causes of quality problems.
- Analyze the historic process and performance data to optimize scheduled maintenance planning, leading to lower maintenance costs, reduce materials and supplies, and higher equipment availability.

Parker's hydraulic monitoring cloud-based solution is specifically designed to provide sophisticated data, condition monitoring and performance control capabilities. Parker engineers developed machine learning (ML) algorithms that identify failure modes in pump data. The system converts this information into actionable messages to alert the operator of impending damage to the pump or system.

One example of in action is the Parker Gold Cup® - IE pump, which combines the brawn of Parker's Gold Cup series pumps with the intelligence of operational sensors so you can avoid future issues that could slow production or drive costs up. The sensors are the key components that enable all the relevant data to be analyzed before it is processed to spot anomalous trends in the data—which can represent potential downtime in the operations.

> *"The utilization of a remote monitoring solution can increase productivity up to 20%, reduce recordable accidents up to 30% and reduce fuel consumption up to 20%, which has a direct impact on a company's profits."*
>
> **— Anne Marie Johlie**

Stock Management and Ordering

Maintaining adequate inventory is critical for any product-intensive industry. In the context of mining, ease of ordering, as well as advance stock arrangements, are crucial considering the high-risk environment. Yet, predicting the need for safety stock is the biggest challenge that mining operations face today. The onus then falls on the procurement teams to deep dive into identifying the future requirements of commonly used materials and also analyze the historical stock consumption trend to maintain adequate stock levels and manage advance orders accordingly. If supply chain predictions are not accurate, products need to be obtained locally in an efficient manner.

Parker developed the Parker Tracking System (PTS) in response to market concerns over product availability. PTS offers a better asset management approach by speeding up the product ordering and replacement process. This proprietary system features long-lasting, thermally printed tags with comprehensive product information, including the date and composition of manufacturing. Having access to accurate product information speeds replacement regardless of where or when the original component was created. Because tagged products can be replaced sight unseen, PTS eliminates the need to wait for removal before new parts can be acquired, thus reducing transaction time to realize significant gains in productivity and equipment uptime.

Looking at the Future of Mining

Mine operators are today reappraising new technologies, ideas and approaches. Everywhere you look, there are signs of increased collaboration among suppliers, academia and large mining companies that have come together to rethink innovative business models and technologies.

As global economies become even more reliant on mined minerals and resources, forcing mine operators to dig deeper into the earth, mining operations must be able to identify creative ways to handle the increased demand. The challenge is not simply about increasing productivity and output and meeting stricter environmental standards but, rather, a need to work smarter with greater connectivity and unprecedented human-automation interaction. Tomorrow's mines must have the vision and agility to profitably maintain reliability, sustainability and safety.

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