The Benefits of Modern Drives

Several new drive configurations offer improvement for different aspects of mine operations

BY JESSE MORTON, TECHNICAL WRITER

At the dawn of the 20th century, a potentially game-changing underground materials conveyance system was being trialed in north Britain. At a Derwent Colliery mine, near Newcastle, a prototype steel and cast-iron centipede snaked along a longwall face. The conveyor, comprised of a series of linked 6-ft-long, 6-in.-deep sheet-iron troughs, and was nothing short of revolutionary in its application. Prior to it, "the idea of carrying the coal along the face of longwall workings by means of a conveyor never seems to have been considered seriously."[1]

Bringing joy to the head office, money could be saved, if only a drive-related problem could be solved.

The conveyor was powered by a 7-hp electric motor, "wound for 180 volts." It was initially driven by flat leather belt. "This arrangement had the advantage that when the conveyor was overloaded, the belt would slip and save any damage being done to the motor."

The slippage, however, proved excessive.

The solution was a modified chain drive. "As there is no slip on a chain drive, a copper shearing-pin device is used, so that the pin will shear when more than a certain load is on, and also provide a mechanical cutout for the momentum of the armature in case of a certain jam."

Today, suppliers in the drive solution space strive for innovations that enable the same level of step change that was initiated in 1905. Reviews of some recent innovations illustrate that point.

Besting the Conventional

An ABB gearless conveyor drive (GCD) matched with a low-voltage permanent-magnet motor logged a better performance than a conventional drive-and-motor combo during a trial at an open-pit lignite mine in Cottbus, Germany, according to a white paper by ABB.

The pilot project established the feasibility of installing GCDs on mobile mining machines and shows the suitability of permanent-magnet torque motors to drive conveyors, ABB reported. The results reveal that on both productivity and energy efficiency metrics, GCDs are viable alternatives to conventional geared drives, it said. "The potential for energy savings, reduction of failure rate and maintenance have also been demonstrated," ABB reported. "The gearless solution has performed better in regard to dynamic accuracy and overall efficiency than the existing traditional solution," ABB reported in a separate press release.

Setting precedents: ABB's gearless conveyor drive, center, offers up to 500 kN-m torque. (Photo: ABB)

Leadership at Lausitz Energie Bergbau AG (LEAG), owner of the Jänschwalde mine, which staged the project, lauded the solution. "The interest of LEAG in this pilot project mainly lies in the expectations related to higher efficiency, lower wear, and hence less expenses for repairs and maintenance," said Peter Scholze, head of services, open-pit mines, LEAG. "Since commissioning has taken place, the drive has been running smoothly."

Further, Jänschwalde's "operations and maintenance team found the new system to be easy to learn, understand, and use, without any major difference in operation or handling when compared with the existing systems," ABB reported.

The proof, according to Ulf Richter, product manager, GCD, mining, ABB Process Industries, is in the numbers. "So far, during one year of operation, we measured 6% energy saving and 100% availability of the drive with just two hours inspection," he said.

The development amounts to historic precedent, Richter said. "This had not been possible to-date from technical and commercial points of view with the existing solution based on synchronous motor technology," he said. "The key point for success was the decision to use permanent magnet motors."

Tracing back to research and development initiated in 2013, the GCD package adopted by LEAG in June 2017 also included a frequency converter and a transformer. "The new gearless solution was installed on a high-capacity (15,000 metric tons per hour) discharge conveyor of a bucket-chain excavator," ABB reported.

The low-speed synchronous electric motor "is controlled by a variable-speed drive to produce a shaft rotational speed of typically 50 to 150 rpm," ABB reported.

[1] Palmer, H. (1905, May 4). Coal Conveyors in Longwall Working. *The Engineering and Mining Journal*, 853-854.

Enabling "exact benchmarking," the GCD system "runs in parallel to the existing geared drive" on the 2.5-meter-wide belt "located at the end of the discharge boom," ABB reported. "Both drives connect to the same pulley shaft." The belt "moves sand" and "large rocks (ice-age foundlings) that give rise to mechanical shock and vibration," the company reported.

Ambient temperatures reportedly range from -25° to 40°C (-15°F to 104°F). And that is what the technology was built to handle, Richter said. "The drives are out in the field without any additional protection" from temperature swings, he said. Mobile or semimobile conveyors generate higher shock and vibration stress than stationary equipment, he said. And contaminant "ingress must be avoided," Richter said. "This has all been incorporated in the design of the drive assembly."

The results from Jänschwalde reveal the solution's wide applicability, he said. "The solution is designed to work in all mines."

The individual GCD is designed for up to three megawatts (MW) per motor, offering up to 500 kilo-Newton-meters (kN-m) torque. A series of the drives can deliver between 5 MW to 20 MW, ABB reported.

The permanent-magnet motors can be foot-mounted or shaft-mounted, the company reported. "The latter is quicker to install, easier to align and requires no concrete foundation work."

The combo offers several benefits, the company reported.

ABB described the GCDs as comprised of "fewer parts and new motor technology" increasing "the reliability and efficiency of the overall conveyor system." A GCD system, for example, "eliminates the gearbox from the drive."

With fewer wear parts, less maintenance is required, and the lifespan is increased. "The expected lifespan for the drive train increases by more than 10 years, when compared to traditional geared systems, to a projected in-service life of 25 years," ABB reported.

The combo has a relatively compact footprint, which Richter described as "much" smaller than a conventional gearless system with a synchronous motor. That allows a GCD system, with "less weight, and a reduction in the instrumentation required to operate the system," to "be installed in smaller spaces," ABB reported.

The primary benefit, however, is savings, ABB reported.

The aforementioned energy savings of between 6% and 8% contribute to overall cost savings, the company reported. "While the upfront investment is typically higher (by as much as 30%) when compared to a conventional drive, the savings in maintenance, energy cost and downtime lead quickly to a return on investment of typically less than one or two years," ABB reported.

Then there are the intangibles that present as hidden savings. For example, Richter said, the GCD has lower operational noise levels. That pays off for mines located close to metropolitan areas with "strict noise limits to be met," he said. "The GCD reduces the noise emission of the drive drastically so that common noise-canceling housings around the drive are not needed," Richter said. "That may even lead to lower CAPEX."

CAPEX can be further reduced by higher pulley speeds, which leads to lower motor torques, Richter said. "Considering the full scope of savings in OPEX and higher production, ROI will be achieved after few years, and low production cost is guaranteed," he said.

With adoption, no additional infrastructure is needed for installation, compared to a conventional drive-motor combo, Richter said. For example, test facilities for managing the gearboxes are unnecessary, he said. "The cooler module has to be included into the annual inspection of HVAC equipment," he said. "Inspection takes two hours per drive and year."

When the savings are tallied, the solution quickly pays for itself, Richter said. "With our confidence about that, we can offer financing options," he said.

Other lessons taken from the pilot study will show up in future iterations of the solution, Richter said. "Based on lessons learned, we will improve dimensions of the cooler module and the motor by optimizing the design of the active part of the motor," he said. Those modifications "are planned and will be implemented with the next project."

Increasing Intelligence

Voith announced the impending launch of the Condition Monitoring System (CMS) 310, a torque-limiting coupling monitoring system.

First showcased at MINExpo 2016, the solution was adopted in December 2017 for beta testing at one of the world's largest open-pit gold mines. Before the second quarter, the results were in and included data and testimonials that merit banging "on the big drums this time," said Håkan Westberg, product management head, torque limiting and connecting couplings, Voith.

The CMS 310 consists of sensors mounted on the torque-limiting coupling (TLC) and a computer-based monitoring system, Voith reported. Hardware includes small sensors, connecting wires and a 20-cm by 20-cm PLC box. The interface is either an HMI panel or a web portal.

The system is promoted as an add-on or upgrade to any of the company's line of hydraulically pressurized, friction-based TLCs, the SafeSet, SmartSet, SlipSet and AutoSet.

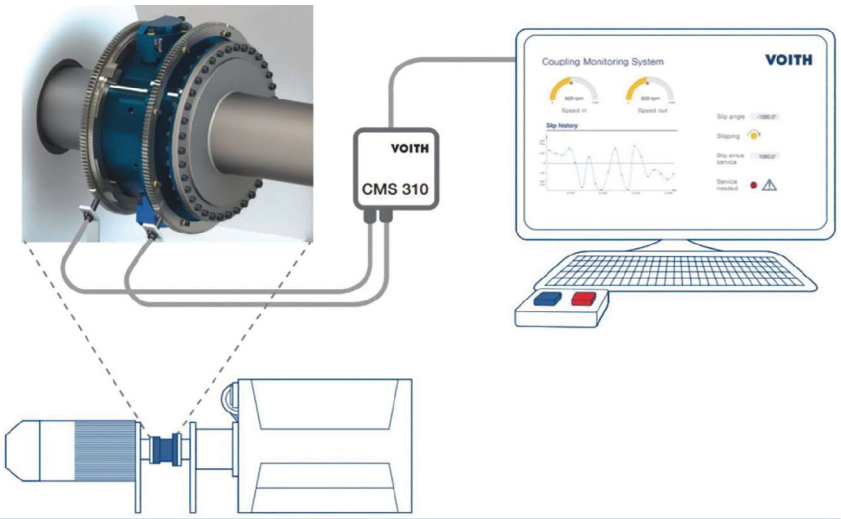
The need for the CMS arose from the common phenomenon of "nuisance" trips causing machine downtime, Westberg said. "That is momentary machine overloads without full blockage," he said. Such overloads might do nothing or they might damage the drivetrain. Either way, the resulting automatic machine shutdown might cause machine downtime. "Hence, we started developing SmartSet and SlipSet slip-enabled TLC," Westberg said. "And we wanted to have a system to provide feedback to the operator."

For example, "the SafeSet TLC immediately releases when the set torque has been exceeded," which, the company reported, "allows your driveline to operate at the maximum level" without exceeding the machine's design capacity.

Westberg described the SmartSet and SlipSet TLCs as containing two specially coated friction sleeves that are engaged with applied hydraulic pressure. The TLC is "like a mechanical fuse," Voith reported. "In an overload situation, when the set torque is exceeded, the SafeSet releases" the hydraulic pressure instantly and freely rotates on internal bearings transmitting no torque through the driveline, saving it "from catastrophic failure."

That design keeps the machine humming along after nuisance, short duration, torque peaks that otherwise might have caused a shutdown. And in a truly anomalous torque spike, it effectively shields the drivetrain.

Add on the CMS 310 and a user can monitor the TLC remotely. "Slip angle is



Increasing intelligence: the CMS 310. During a slip, the pulse difference of the fine-toothed trigger wheels is measured and the data sent. (Photo: Voith)

continuously measured and calculated to determine if and how much the TLC has slipped," the company reported. "The status information can then be used to quickly identify any need for action."

Measurements are made by inductive sensors mounted in close proximity on each side (input and output) of the TLC, Voith reported. "Fine-tooth trigger wheels mounted to the coupling allow the CMS 310 system to sense the relative movement between the two sides," Westberg said. "This provides remote visibility of a machine overload."

If the coupling slips, the pulse difference will be sensed, and the control system will inform the operator, Voith reported. "As soon as the TLC starts slipping, it gives feedback to an operator that it is slipping, how much it is slipping, and in which direction," Westberg said. "After an alert is given by the CMS 310, the operator can choose to do countermeasures or just leave it be for a while," Westberg said.

The system can speak to a parent PLC system. It "uses Profinet communication standard for easy integration in existing industrial process monitoring systems," Voith reported.

It can be set to provide alerts for maintenance. When a defined number of slips occur, "the CMS 310 will indicate that a service is needed by showing a service indicator light on the screen," Voith reported.

The system produces history logs that help the user set the maintenance alerts, Westberg said. "This is good for the customer, to only do service when necessary, not on a time basis but on a performance basis."

After the unveiling of the CMS 310 in Vegas, prototypes were developed and de-

ployed for testing. A gold major promptly inquired about the system as a potential solution for two parallel primary crushers that historically had issues with shutdowns.

The adoption of Voith's SlipSet and the CMS 310 proved to be the remedy. "The new system, which allows more slips, is more intelligent," Westberg said. "The short-torque spike can be dampened, and it can limit the torque during the torque spikes without disconnecting the whole machine."

With the CMS 310, the miner "can choose whenever they want to see how much it slips," Westberg said, "and they can choose to reset it during a normal maintenance stop."

In January, the system was operational. "In February, we received the first history log to see that they had two slippages without release, which with the old system would have caused two shutdowns," Westberg said. That means the system "saved them two or three hours uptime," he said. "We're talking about $50,000 to $100,000 per hour."

That illustrates the value of the system, Kyle Kluttz, vice president, new business sales, Americas, Voith, said. "One of the benefits to the customer is they have a record of events that affect the crusher drive," he said. With it, "they can see details of torque overloads in the crusher."

With the previous setup, the user would have known only that a release occurred. "They don't know what led up to that: Were there high-torque events over a long period of time or was it instantaneous?" Kluttz said. "And now they have the data behind their crusher drive performance, as we've seen with the data log from the field test," he said. "It gives them more intelligence on how their system is performing and allows the user to adapt their operations to mitigate downtime."

The miner was "very pleased with the reduced number of resets and the increased uptime," Westberg said.

The CMS 310 is set for launch at bauma 2019.

Being the Step Change

One of the hallmarks of success with any innovation is its adoption by one of the titans in the sector.

That is what is set to happen to Horton's RCV2000 Fully Variable Fan Drive, according to Manish Virmani, vice president, global market development. "I think we are on the cusp of that," Virmani said. "We expect it to become the standard solution in the industry in the years to come."

The latest addition to a burgeoning family of drives, the RCV series was conceived in 2013, announced in the fourth quarter of 2016 and launched in early 2017. Received well, it has been in validation testing by a major global mining equipment manufacturer for much of the first half of 2018.

Such an outcome might have appeared inevitable as the solution, promoted by the company as a simple retrofit that afterward pays for itself rapidly and requires little maintenance, saw widespread adoption upon release. "There have been in many installations around the world: Australia, Mexico, Canada, U.S., Belarus," Virmani said. "A lot of mines have been running it, testing it."

The drive is described as a fan-speed control device. Installed between the engine and the fan, the stand-alone closed-loop system leverages sensors and a controller to detect and measure subtle fluctuations

in temperature. It reacts by adjusting fan speed to the optimal level, nixing parasitic loss to cut unneeded fuel burn and preserve hp. In short, it optimizes engine cooling to improve engine performance.

Along with the published list of offered benefits backed by field test results, its striking simplicity remains a primary selling point. "It does not require complicated integration," Virmani said. "All you do is bolt it onto your fan," he said. Horton provides the required bracket and pulley, and a preprogrammed controller, he said. "You bolt the drive on, plug the controller to the ECM, and you are good to go."

Another is the fact that it is a proven technology, ubiquitous in other sectors for decades. It is based on predecessor fan drives developed and furthered by Germany's ZF Sachs and sold for use in metropolitan Europe. Think over-the-road trucks, vocational trucks and busses. From there it migrated to off-highway equipment such as agricultural tractors, excavators and forklifts. Aware of the potential for the tech in an era of growing environmental consciousness, Horton bought Sachs' viscous drive division in 2003.

Sustainability made simple: the RCV2000. The variable speed drive is a closed system with a long history and a growing fanbase. (Photo: Horton)

"The remarkable thing about this product is that we took a technology that is proven, that is well-understood, and we scaled it up, and had to deal with a lot of other challenges," Virmani said. "But we've been very conservative in scaling up in that we made it extra durable so that we don't have any issues."

That means designing the drive to survive mining-scale dust, vibration and, frankly, neglect. "Reliability and durability standards have to be really exceptional," Virmani said. "Serviceability would have to be such that you wouldn't have to service it at all."

Thus, the bar was set. The result was a system that "theoretically runs forever," Virmani said. "This technology is very interesting in that it doesn't have any friction liners or anything like that," he said. "It doesn't have any wearable components to it."

Which is not to say it is unsophisticated. The optimized magnetic design speeds reaction time, improving modulation and cooling performance, Horton reported. The fan bearing is up front, reducing the temperature of the pulley bearing. And the housing and cover are designed to maximize heat dissipation. When needed, the drive can lower a fan's idling speed to a paltry 100 rotations per minute or lower. The tangible benefits of this are lower fuel burn, additional runs and a quieter mine site, Virmani said. "A fan, at full speed would typically use up 10% of the total power that a mining truck engine would generate," he said. "The payback period is usually a matter of months not years."

The typical fan blade sizes are 68 in. to 96 in. Horton's HTEC thermoset composite fans, which can be custom-designed and are described by the company as more efficient and quieter than metal equivalents, "couple really well with these fan drives," Virmani said.

The drive offers up to 22,000 in.-lbs torque. A qualifying engine is in the 1,700-hp to 4,000-hp range.

For installation, Horton provides both the parts and service. "We can work on any equipment brand," Virmani said. "If it is a first-time installation, we send out our application engineers on-site to get the retrofit done so the dealers can see how it is done, they can learn, they can ask questions, and if they need help they know who to talk to to find the answers."

After installation, the maintenance schedule synchs with that of the engine. "It is optimized for the mines so they are not taking a truck down just to do some maintenance on this," said Kevin Albers, associate marketing manager, Horton.

And maintenance is limited to re-greasing bearings. "We have a special Zerk-fitting for it, and the interval that we recommend is 2,500 hours," Virmani said. "Quite possibly in the near future, we might increase it to 5,000 hours."

Since the release, it has been tested on or deployed to "a wide range of applications," Albers said. "We've had them on generator sets, wheel loaders and mine haul trucks."

The feedback so far has taken two forms.

The first is data from the mine sites, who report the solution has met or bested expectations.

For example, a diamond miner in arctic Canada needed the drive to remedy "over-cooling issues that resulted in engine reliability and durability" concerns on wheel loaders, Virmani said. "We installed our fan drives in there and they shared data that showed that fuel dilution problems completely went away."

Two hemispheres away, a Western Australian miner adopted the drive to improve fuel efficiency on a hauler. Later, Horton offered to replace it with the latest model, only to be rejected. "They said, 'no, it is working just great, and we don't want to change it,'" Virmani said.

The second form of feedback is increased demand. For now, that means the company is busy with retrofits. For tomorrow, it means the drives could come standard on entire lines of mining equipment. "There are two top-five mining equipment OEMs" currently collaborating with Horton toward that end, Virmani said. Details are proprietary, he said, but "one of them is very close; one of them is a year or so out."

Marrying the solution off to a major OEM could be fitting inflection point in the bigger Horton story, Virmani said. It would speak to one of the company's core philosophies. "Considering the environmental consciousness that has grown in the world," people could one day see the drive and its proliferation "as a step change in the sector because it could reduce fuel consumption on mine sites quite a bit," Virmani said. And by that, "we feel we're making a contribution to the sustainability of the planet."