Steven Putt, DataCloud, USA, considers the merits of seismic while drilling technology.

TRY THIS ON FOR SEIS

We know soft rock when we hear it. Or hardcore, for that matter. But what if a drill-based sensor could 'listen' to rock geology the way that we listen to rock music? And what if that information could be integrated and analysed in real time at the mine site to generate high resolution coal models? Mine planners would be equipped with the intelligence needed to increase efficiency during production by avoiding coal damage and reducing operational costs.

For DataCloud, an integrated seismic while drilling (SWD) and cloud-based analytics platform that enables mining companies to process massive volumes of drilling and geosciences data while drilling blastholes, there has never been a better time to integrate this technology into coal drill and blast operations. According to the company's CEO Thor Kallestad: "5 or 10 years ago, you couldn't have done it because Internet of Things (IoT) and cloud-based computing technologies lacked the right mix of capabilities and costs to be acceptable by the mining industry. The evolution of these technologies has made it more economical to log the rock mass."

This article explains how SWD technology works, how coal block modelling is typically done today and how SWD greatly improves upon measurements while drilling (MWD) and other methods typically used today.

How SWD technology works

Using SWD technology, IoT-enabled sensors listen to differences in the sound that the drill steel makes when drilling blastholes, measuring and recording its vibration properties. The sensors can clearly differentiate coal from overburden based on changes in the acoustic signals it measures. This data is then communicated wirelessly to an edge-computing device in the driller's cab. The data is processed and streamed to the cloud, where through the use of proprietary algorithms and machine learning, it provides mine planners with a high resolution, high accuracy blasthole measurement which can detect the boundary between coal and waste. The accuracy of this coal detection is within 0.05 m.

The data from the blastholes can then be used to generate a high resolution, detailed model of the deposit. "The cloud is where we do our computational heavy lifting, if you will," said Kallestad. "Using machine learning and geostatistical techniques, we take that information from the blastholes and infill between it on the bench to be able to tell the client in real time what the rock mass looks like."

The technology is already being used at metallurgical coal sites to solve key challenges associated with the inevitable increase in strip ratio and escalation in dilution.

How coal block models are developed today

The location of a coal seam is typically estimated based on exploration data, visual observance of coal dust in cutting piles, gamma logging and the results of near vicinity blasthole data. In locations with flat seams, although less than ideal, this method often yields acceptable but slow results. In areas where folding and orogenic events have been prevalent, this approach to mapping seams is wholly inadequate. Coal is usually dipping at some angle, as well as undulating or folding locally in any given direction. The variation from dipping and folding causes a wide differentiation between where mine planners think coal is and where it physically sits. A modern approach with automated drill-based sensors supported by cloud computing significantly improves both cycle times and recovery in geologically complex areas.

The location of coal can also be estimated by actually drilling into it. However, since drilling into coal slows cycle times and usually leads to coal damage, mine sites typically want to touch coal with the drill bit on as few holes as is required to map the seam. The resultant backfilling that is required to minimise damage takes significant amounts of time and is an inferior solution when compared to not drilling into the seam in the first place.

Another option is to trust the coal model and set every hole to an approximate design depth and assume it is far enough above coal for proper blasting. While this method does not require backfilling, planners do not have an accurate depiction of where the coal is and are therefore at a high risk of damaging coal or drilling too short. Drilling short cases blasting too far above the seam, which requires further digging all the way to coal without blasting again or using bulldozers to scrape the last few metres of rock down to coal. Both of these activities add too much extra time and person hours to the process.

Many sites often drill to touch coal on every fifth hole and use this as a guide to offset any design depths for the other four holes that do not touch coal. For example, if a touch coal hole says coal is at 40 m but it is not seen until 42 m, they assume all other depths in the area are 2 m short and correct accordingly. This process of offsetting design depths for the blastholes between is tedious and time consuming for engineers.

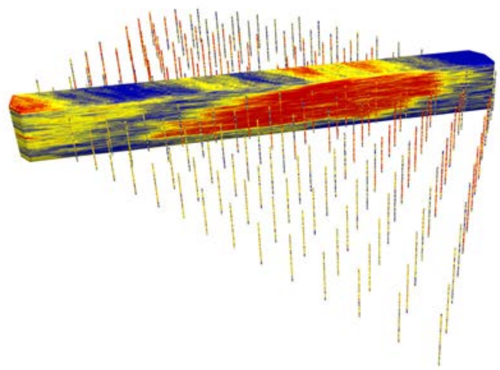

Figure 1. DataCloud's software MinePortal visualising coal and waste boundaries at a high resolution.

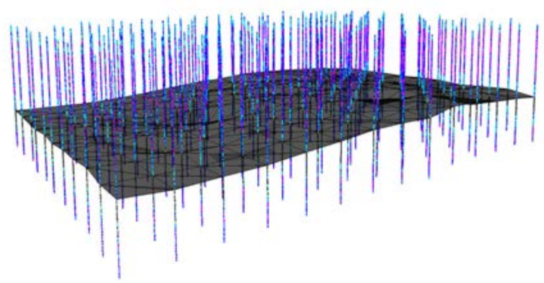

Figure 2. DataCloud's hardware RHINO, and software MinePortal, combination developing a coal model that clearly depicts the top of a coal seam.

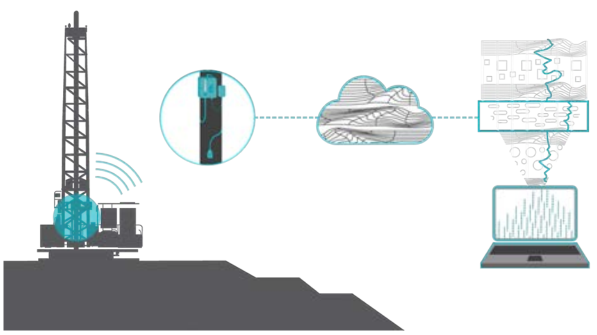

Figure 3. DataCloud's workflow from sensor to software to a browser login.

With SWD technology and cloud computing, these measurements and insights can be produced in real time and empower geologists, planners and drillers to make better decisions, faster.

SWD technology and cloud computing

"There's a big movement afoot in the industry to 'disrupt this, disrupt that'," Kallestad said. "But we don't want to disrupt anything, we just want to show up and make it painless to give our clients much better information about the rock mass."

The set-up process is configured to the types of drills being used and factors such as the type of connectivity available onsite, and the sensor is installed in about 10 min.

Still, mining companies want proof that the system's benefits outweigh its costs. "When we first told clients what we could do for them, they said, 'prove it'," Kallestad continued. DataCloud's partnership with explosives company Orica helped to open some doors, which led to a few pilot projects that yielded strong results. Microsoft is another partner; the cloud-computing applications use Microsoft's Cloud platform, Azure, making it easy to integrate the data with other Microsoft-based systems, and reassuring clients that their data will be stored securely.

DataCloud's technology was tested in the field and cross referenced with gamma ray logs proving accuracy. The SWD sensors and analysis correctly identified coal before gamma ray was initiated, offering results before blasting. And they correctly identified coal where MWD misclassified it.

Compensating for calibration error

The system is also designed to work even if the drills being used have not been properly calibrated for depth or have become uncalibrated over time. Algorithms in the cloud analyse large amounts of mine site data to actively check for depth variations and accuracy. It aggregates MWD data, in-depth knowledge of drilling operations and mechanics, and accurate high resolution measurements from modern IoT sensors while drilling blastholes to deliver calibrated, accurate results.

Part of the SWD sensor system can also be used to track and validate depth measurements, which are often treated with secondary importance on location. This new technology can detect and correct for any drilling depth variation that may be occurring. In a recent project, these devices identified a 4% error in depth in 50 m blastholes, which equated to 2 m of error. This correction was validated with independent gamma logging. Having a correct depth to top of seam automatically updated takes the guesswork out of determining where coal is and gives a solid foundation for improvement across operations.

Reducing frequency of gamma logging

Blasthole gamma ray logging is expensive, time consuming, subject to operator error and a delay to production. These sensors typically have a large offset between the bottom of the probe and the actual gamma ray detector, which impairs their ability to log the deepest sections of the blasthole. In many cases, the holes that are designated to be logged with gamma end up having material slough into the hole from the cutting piles, hampering the process. Drill-based IoT measurements are a true 'at bit' measurement, which provides log data all the way to the bottom of the blasthole, in every blasthole. This ability to log at the drill bit while drilling is incredibly valuable in helping to accurately and quickly identify the top of coal seams. It also removes the need for manual interpretation of the gamma logs by the geologists and drill and blast engineers to determine the coal surface.

Reducing operational delays and improving workflows

Geological review and the manual mapping of coal surfaces is a lengthy process with great room for error, and consolidation of data in Excel from handwritten blasthole logs occupies countless hours every week. Automating the coal seam identification and surface creation takes human error out of the equation and offers results in real time.

As Kallestad explained: "The real time data goes to the drill and blast engineer, the onsite geologist and other mine planners, and they use it to inform their workflow schedules."

By acquiring geological data when drilling blastholes and allowing cloud computing to interpret this data with other data sets, mines can empower their employees to gather more accurate results even faster and automate many drill and blast processes, therefore significantly improving cycle times and allowing geologists to focus on higher value activities.

Detecting shale bands often misidentified as coal

The risk for dilution is significantly higher when mines are blasting through seams. When drilling and blasting through multiple, steeply angled coal seams, contacts need to be clearly identified to properly alternate decking and explosives at the correct depth. Doing so allows operators to avoid coal damage.

This makes knowing the coal location even more critical. With more precise digging equipment, mine sites have more of an opportunity to separate any shale or low quality coal from high quality coal during the digging process if they know the exact location of this material. If they know the quantity of unsaleable coal vs saleable coal, they can also improve dilution calculations and therefore improve forecasting and reconciliation of planned vs actual recovered material.

Increasing dig rate

Blasting hard and soft zones with similar products leads to oversize and erratic fragmentation, which ultimately reduces dig rates and puts machinery and people at risk. Improvements in dig rates have been seen after detecting and adjusting for soft and hard bands in overburden. Knowing where the hard zones are can help in planning explosive loading charges and optimally placing boosters for proper energy pull. Following the same principle, detecting at a high resolution where soft shale or weathered coal bands sit will help avoid placing boosters in these zones so they do not compound the issue of soft areas stealing energy.

Geostopping: predicting the top of the coal seam

By unleashing machine learning on your geology, this new technology will go beyond measuring and analysing. It will begin to know and understand your coal and will be able to predict the top of coal seams. "With metallurgical coal, one of the services we provide is geostopping, the ability to stop the bit at the top of the coal seams," said Kallestad. This will allow drillers to avoid damaging the coal, recover more coal and increases cycle times.

Conclusion: know the rock

Mine sites all over the world are already equipped with sensors of all kinds. They measure, they record, and the data is easy to access for operators. Software that analyses data and offers insights for operations are also running simultaneously. In essence, they are already 'listening' to their own genre of music, whether it is to track vehicles, plan work schedules, handle camp logistics or monitor any number of onsite activities. When taken together, the data from various sources can be integrated to form a seamless real time image of what they are all listening to – a bit like the parts of an orchestra, all working together.

Installing an IoT sensor on the drill to measure rock mass properties and allowing cloud-computing processes to reconcile this data with all the other data sets around the mine, adds percussion and a composer to the orchestra, to feel and see the rhythm of operations. With this in place, a mine site is able to unlock fast, highly accurate, automated geological modelling like never before, enjoying synchronised, smooth music as well as streamlined operations, improved production, a strip ratio closer to geological strip ratio, and better profitability overall. WC