Drilling deeper

Nia Kajastie looks at the evolution of underground drilling machinery and technologies, as well as the latest equipment releases for exploration, development and production applications.

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Underground drilling is a vital part of exploration and hard-rock mining activities across a wide range of applications, from diamond coring, short-hole drilling for development and long-hole drilling for production, to ground support to install rock bolts or cable bolts, secondary drilling and blasting to reduce oversize, or simply utility drilling.

In line with the variety of possible functions, the requirements of drilling equipment for exploration, development and production are dependent on a number of factors.

When it comes to exploration drilling, for example, target hole depths and core size are critical to choosing the best rig and tooling. The size of the drilling stations or tunnels is also important to the selection process.

According to Boart Longyear, tooling is specific to the core size required. Rods come in different lengths – so you can use 5ft (1.5m) rods if you are drilling in a confined space. Likewise, core barrels come in 5ft or 10ft lengths (1.5m and 3m). On smaller, less powerful rigs, the company recommends freer cutting bits, while also considering the geological formation.

*Figure 1A Joy DR-15B hydraulic jumbo drill, which features Intelsense drilling control system and hydrostatic drive for a lower profile and tighter turning radius*
The other factor to consider when selecting the right method, rig and tooling is the angle or dip of the hole. When drilling downward, gravity-deployed head assemblies are the best choice. Whereas when drilling flat or up holes, pump-in head assemblies are required to send the tooling along the hole.

Steve Bozic, senior product manager for drills, hard rock, at Joy Global, says: “For development rigs, safety and speed of drilling are important. The size of the drift will determine if the mine is using a one-boom jumbo versus a two-boom jumbo. Mining operations are looking at drilling multiple faces per shift.

“Production rigs are about drilling safely and accurately, as fast as possible. Production drill rigs can be either a top-hammer configuration or of a down-the-hole type of rig. Diameter and depth basically depict which style of long hole will be used.”

While many operations make use of mechanised drill jumbos, some narrow-vein operations are still using handheld tools, more commonly referred to as jacklegs, which JH Fletcher says it is working to minimise.

“To address the safety concerns associated with handheld equipment, Fletcher is working to mechanise many of these processes. By doing this, it is putting the operator under a protective canopy for protection from rock fall, along with reducing injuries caused by handheld equipment,” explains Ben Hardman, vice-president of domestic sales at JH Fletcher.

MacLean Engineering, which has focused its research and development efforts on specialty drilling and ground-support installation drilling, claims it has delivered a number of firsts, starting with the original Long Tom mechanised drill in the early 1970s. This was designed to lessen the negative aspects of handheld drilling and to improve drilling productivity with simplicity and cost-effectiveness.

**Developing technology**

Over the years, underground drilling efficiency has been enhanced in numerous ways, including semi- and fully automated packages and data collection. “Items such as real-time guiding and positioning of feed assemblies, being able to record drilling parameters and have them analysed, and having a 3-D layout to view holes that have been drilled all offer improvements,” lists Bozic.
With the development of technology, mechanical systems for drilling have been exchanged for hydraulic ones. However, battery technology is the latest trend as it will help improve the underground environment by eliminating emissions.

As one example of this move towards more battery-powered machinery, at MINExpo, Sandvik unveiled the DD422iE mining jumbo, which uses electric energy from an on-board battery during tramming. As the jumbo produces zero emissions while manoeuvring between headings, it can improve health and safety for miners working underground, while less diesel usage in the mine can ease ventilation requirements, as well as reduce associated diesel logistics and maintenance expenses.

In addition, hydraulic hoses get chafed on rock faces and can wear out quickly. To counteract this issue, the Sandvik DD422iE is available with a less-hose boom as an option that uses 55% less hosing than its predecessor. The less-hose boom option reduces the length of hosing from 240m to 110m, lessening the exposure to potential damage.

A fairly recent development of Fletcher’s is the Graphic Operator Angle Display (GOAD) as an option on drill jumbos. The system shows precise hole alignment along with calculating drill depth, and also retracts the drill at a proper depth and monitors flushing pressure.

“Along with other machine design safeguards, a recent innovation to roof bolters is the application of a light curtain to limit the operator’s exposure to rotational hazards,” Hardman adds.

“On ‘man up’ roof bolters the operator is in close proximity to the drilling mechanism, usually a rotary percussive drill. The reason for having the operator close to the drill is to install bolts along with plates, mesh and mats. Rotational hazards are a concern whenever the hazard cannot be isolated with a permanent steel barrier. The operator must install and remove drill steels, sometimes multiple steels per hole along with placing bolts in the drill head prior to insertion, so it is impractical to have a fixed guard in place.

“Similar to the common light beam at the bottom of your garage door to prevent the door from closing on someone, the roof bolter light curtain spreads a beam of light between the operator and rotational hazard, very quickly stopping rotation once a hand or arm breaks the light beam.”
To meet customer expectations, Mine Master, in turn, applies monitoring and operator-aiding systems, as well as automatic control of technological processes, to the machines it manufactures. The collected data provides information on operating conditions of subassemblies of the machines.

A basic system that monitors the drilling process is the Drilling Monitoring System (DMS), which provides information on feed pressure, impact pressure, rotation pressure of the drill, temperature of oil in the hydraulic system, current position of the drill in the drill guide, current depth of a hole, and number and length of holes drilled.

Mine Master’s Lesław Ostapów and Piotr Ławicki explain that this information contributes data for tests of particular components of the operating system, for example, the influence of pressure on seals of the drill, the selection of optimal materials for hydraulic sealing and the selection of parameters of the operating system in regards to a given working area. The data also allows the testing of the strength of drilling consumables. Any data that is essential for the operator is displayed on a screen in the work stand.

A more advanced system in comparison to the DMS is the Feeder Guide System (FGS), which monitors pressure just like the DMS, but is equipped with additional sensors used to map the position of the drill guide in the 3-D space. The software aids the operator’s work by displaying the blasting pattern and the position of the guide on the computer screen. Reports provided by the FGS system allow analysis of the operator’s work and testing of blasting-pattern efficiency.

Monitoring of machines will inevitably become more and more advanced as wireless networks become more available in mines.
“Due to this, machines being operated underground may be monitored online,” say Ostapów and Ławicki. “Meeting expectations of customers and new technologies, we have developed a data recorder that may be adopted to control language protocols used in particular mines. A data-recording format may also be adopted to a format that is used in a given mine. The recorder is installed in a dedicated housing made of acid-proof stainless steel and may be attached to any place in the machine.”

MacLean’s BH2 blockholer

With the rise of mass mining and the corresponding increased need for specialty units for secondary breaking, MacLean introduced a boxhole drill or ‘blockholer’, developed as a dedicated rig to deal with low hang-ups and draw-point oversize.

A blockholer drill is effectively a self-contained utility drill with integrated radio-remote control (RRC) and equipped with a versatile drill feed and boom arrangement to allow the operator to drill holes and place explosives in order to blast oversize ore in stopes, or bring down hang-ups in block-cave mines.

To date, MacLean has commissioned over 100 blockholer drills around the world. The drills can safely and efficiently treat oversize but also improve scoop availability. At the same time, the use of blockholers to reduce oversize also reduces parts costs on scoop trams, MacLean claims, especially for major items in the drive train such as planetary gear boxes, drive shafts and differentials, and in the mucking action for cylinders, linkages, and buckets.

When not in use dealing with ore flow issues, blockholer drills can also be used for any number of drilling tasks through the mine cycle, taking the place of the jackleg for all miscellaneous drilling tasks.
With the evolution of self-contained drills onto articulated mine carriers with extension booms, improvements that have been achieved in all-round positioning capability, and the move to bigger drills to match the power output of the diesel engine, MacLean says blockholing has become a default mining method of its own.

**Underground future**
As mines go deeper, underground drilling will have to overcome new challenges. Ventilation, safety, heat and rock stress are just some of the issues.

As a natural development, underground drilling is thus moving toward autonomous remote operation. Fletcher's research and development team is working on semi-automatic drilling, advancing toward programmable automatic rigs.

Boart Longyear will also continue to address the demand for more autonomous drilling, as well as safety innovations that remove drillers from hazards. Barkom, in turn, highlights the importance of ease of use and ease of portability of future equipment, which should require less man power to place the rig in underground galleries.

Development jumbo drills of the future will also need to have the ability to multitask – drill, bolt and scale. “Then add in a battery power source and you eliminate emissions – for a machine that can do more and requires less,” says Bozic.

**Recent releases**
MM asked a selection of OEMs about their latest underground drilling product releases and their new features

**Atlas Copco**
Atlas Copco exhibited its latest underground core drilling rig, the Diamec Smart 8, at MINExpo 2016. According to the manufacturer, the rig will set a new standard for safety in underground mineral exploration and boost long-term productivity due to a new software-hardware combination.

The Diamec Smart 8 features a new rod-handling system that is fully integrated into the rig's upgraded rig control system (RCS) platform.

“Thanks to new integration of the rod-handling system it can now be operated from a safe distance,” says Ebrahim Nikafroozi, global portfolio manager, exploration, and product
manager at Atlas Copco. “Positioning is more flexible and we have also increased the reliability of components, which are longer lasting and better tuned to the working conditions.”

The rig consolidates functions in the main control system and enables automated wire drilling, which simplifies the process of extracting core barrels from the inner tube.

Atlas Copco unveiled the Boomer S2 at MINExpo

At the show, Atlas Copco also unveiled the Boomer S2, which it said is the first automated drill in the small face drilling segment. According to the company, all aspects of the rig, from the rock drill to the carrier, have been improved, and it was designed with robustness, automation and performance in mind.

It is a two-boom face drill suitable for mine development and smaller construction tunnels. The new S segment boom consists of double rotation devices to ensure a fast and precise positioning with high durability. It is also Atlas Copco’s smallest mining and tunnelling rig with intelligent control.

Furthermore, earlier this year the company introduced a new and improved model in its production drill category. The Simba S7, a hydraulic, long-hole drill rig built for small spaces and tough drilling conditions, is the latest model in the company’s Simba series, which was originally launched in 1960.

The Simba has been developed into a fully automation-ready production drill. It combines the RCS, an integrated angle instrument and automated software options, enabling the rig to adapt according to rock conditions and to drill with high precision.
Barkom
The company started manufacturing its BDU 400X and BDU 600 underground diamond coring rigs in 2015. Due to positive results and improvements made according to user feedback, they were quickly adopted by different mines in Turkey and abroad. Testing was conducted at mine-exploration sites in underground galleries, consolidation operations, injection applications and for soil investigation.

BDU 400X features include:

- Powerful electrical engine and hydraulic system;
- Available on separate units and/or single chassis;
- Mast moves freely for vertical and table drilling;
- Mast complex can rotate 360° on base;
- Suitable for deep drilling with high rotation;
- BQ-600m drilling capacity;
- Operator-friendly with ergonomic panel design;
- Hydraulic system cooled by water; and,
- Suitable for standard and external mud pumps.

The BDU 600 is designed to improve on the performance of the BDU 400X, as well as adding new features to it. It comes with:

- 55kw electric motor, powerful hydraulic system and 36kW diesel engine available;
- Mast system can be moved on the chassis with hydraulic and chain drive;
- BQ-800m drilling capacity;
- Automatic wireline system available with 600m capacity; and
- Additional seating system increases operator safety and usability.

Boart Longyear
Boart Longyear’s patented rod handler and Drill Control Interface (DCi) are available on new rigs as well as for retrofit on older rigs.

The rod handler offers drillers a safer working environment by removing them from risks associated with adding or removing rods from the drill string.

Sensors ensure the drill rods are loaded in a safe position and hard stops guarantee fast and accurate rod alignment. The rod gripper rollers and breakout assistance from the rotation unit enable hands-free making and breaking of rods. Traditional drilling practice requires the operator to lift the rod into the drill string at whatever angle the feed frame is
positioned and then manually thread the rod. This can result in operator injury due to awkward lifting, twisting and straining.

Rod-handling devices are a safer alternative, allowing the operator to load rods into the rod handler horizontally at a comfortable height. The rod is then mechanically loaded into the rod string and pre-threaded for drilling. During rod-pulling operations, and after breaking the threads with the rotation unit, the rod handler un-threads from the drill string and presents the rod in a horizontal position for removal by the operator.

![Boart Longyear's MDR700 coring drill was tested in Finland and is now in use in Australia](image)

The DCi is a fully electronic interface that allows one operator to control both the drill rig and the rod handler, while providing real-time feedback on drilling conditions. The DCi incorporates Controller Area Network (CAN bus) technology to enable communication between the drill rig, the rod handler and the DCi to self-monitor and semi-automate most drilling operations.

Complete control system integration and sensors provide feedback of drilling conditions and record both event and drilling conditions data for reporting and analysis. Sensors provide real-time status display on rotation speed and pressure, feed and holdback pressure, water flow and pressure, penetration rate, bit force, diagnostics and alarms.

The DCi facilitates unattended drilling, allowing the rig to complete a rod run while letting drillers complete a shift change. The driller sets up operating parameters and a laser beam near the drill and the DCi will automatically shut down drilling if either the drilling condition parameters or the laser beam is breached.
The MDR700 underground coring mobile drill is the latest addition to Boart Longyear’s line of underground rigs, featuring both the DCi and rod handler. The design of the integrated positioner and turntable offers wide drilling angles and good reach to make positioning and drilling a series of holes easier. The rig features sophisticated articulations with three turning points so you can drill 270 degrees horizontally and vertically up to vertically down. The MDR700 can drill in a spherical manner without having to reposition the unit.

The MDR700 drilling functions are powered by a 90kW electric motor and feature the LM 700 feed frame, delivering 81.4kN of pullback. The MDR700, coupled with the HQ rotation unit, is suitable for all coring diameters up to HQ.

JH Fletcher

Fletcher’s narrow-vein model J101-AD/E is a single-boom drill jumbo, with dimensions as small as 1.4m wide by 11.2m long. Another recent addition is the J152-AD/E, which is a dual-boom design for development and production drilling in mid-size headings.

Fletcher products are actively in use across a variety of applications, including, but not limited to, potash, limestone, salt, lead, copper, platinum and frac sand. Its latest products have been tested in narrow-stope metal mines, resulting in positive feedback relative to safety gains versus jackleg drilling.

Joy Global
The Montabert HC95 drifter (18Kw) is a new design that is intended to offer high production and can be adapted to all types of development and bolting rigs with minimal effort for a variety of applications.
The HC95 is being tested in different mines throughout the world, and feedback so far has been positive. The drifter can operate up to 800 hours between seal changes. One of its main strengths, hammering with hydraulic reverse percussion, is included as standard.

**Sandvik**
Sandvik’s new battery-trammed mining jumbo comes with an intelligent power management system that can help customers meet ever-increasing productivity requirements, despite often limited underground electric power capacities.

Using the mine’s existing electric infrastructure, Sandvik driveline technology enables the jumbo’s battery to recharge during the drilling cycle. The battery will also recharge while the DD422iE is tramming downhill, using energy generated by the braking system.

Sandvik’s new battery-trammed mining jumbo, the DD422iE

Equipped with a multi-voltage compliant system that gives customers freedom to move the drill from one country to another, the jumbo operates easily in different networks ranging from 380V-1,000V, and both 50Hz and 60Hz, the manufacturer explains. The molten salt (sodium-nickel chloride) battery technology used in Sandvik DD422iE has a reduced risk of fire and is regarded as a safer system for underground mining use.

In addition to releasing its first battery-powered mining jumbo, Sandvik also unveiled the first in its next generation of in-the-hole (ITH) underground production drill rigs. The new DU412i is automation-ready and is built on a modular standardised platform.

The DU412i is suitable for highly accurate production drilling, as well as drilling service holes and slot raises. It drills with ITH hammers that are powered by on-board high-pressure screw boosters. These can be used to drill holes with a diameter of 89-216mm. The compressor control system controls the flow of air to remain constant, not just unloading when the pressure reaches maximum, which increases safety interlocks and full-time monitoring and data collection.

Earlier this year, Sandvik introduced the DT912D, aimed for both tunnelling and underground mine production. It is a self-contained, air-mist flushing, diesel-hydraulic high-reach single-boom jumbo, with a 25kW high-frequency RD525 rock drill. The 24t machine is designed for fast and accurate drifting and production drilling of 12m² to 125m² cross-sections.
According to Sandvik, it is equipped with the most powerful engine on a diesel-hydraulic jumbo, the Cummins Tier 4 Final with 205kW. As standard, the jumbo has an electrically controlled drilling system with added automatic functions, including one-hole automatics. It is also equipped with a SB150 universal boom for large, optimally shaped coverage and full automatic parallelism. In addition to face drilling, the boom may also be used for crosscutting, bolt-hole drilling and extension drilling.