Rotary Drill Technology

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Constructing a hole for containing explosives has changed little over the years. We still need some way to overcome the strength of the rock to advance a tool a prescribed depth.

All methods require a combination of elements to achieve this goal. Early on it was very labor intense, with muscles supplying the energy and hand-eye coordination the control. Now the process is mechanized with motors replacing muscle, but the controls still require human guidance.

The development of more powerful mechanisms for accomplishing the basic functions diesel engines for power, high frequency rock drills for transmitting the energy to the rock, high capacity air compressors for hole cleaning has increased productivity, but also has increased the need for more sophisticated control systems for safety and accuracy. The push for automation in the drilling process indicates we are reaching a plateau in human-guided processes. The current generation of drill rigs is designed for high productivity, quality drilling and a comfortable working environment for the operator.

The quest for automation involves a cost so why invest? Drilling a hole constitutes a small amount of the direct cost and time of mining, but has a major impact on the other production processes because it affects fragmentation, backbreak, underbreak, wall control, loading, haulage, and processing. The quality of muck produced has an impact on the cost of everything downstream.

The availability and skill level of operators is problematic. The industry is running out of experienced, highly skilled help. This increases the risk inherent in drilling. Automating functions can help reduce this. Since the processes are automated, they keep the drill operating within design parameters, helping to prevent abuse and reducing maintenance and repair costs.

Automation in the production process streamlines planning and increases consistency, thereby reducing waste. This all translates to lower total cost of drilling (TCD).

As the drilling process has basic requirements, so does automation. In terms of the machine itself, it needs to have a platform to support the discrete systems needed to execute the individual processes that go into creating a blasthole: positioning, set up, drilling, repositioning. CAN-bus technology provides the backbone of the rig control system (RCS). This system is flexible and easily expandable, allowing new units to be added anywhere along the data bus without adding another cable. The electronic modules are all developed solely for the rigs, and are ruggedized and protected from external magnetic and electric influences.

Generally on a modern rotary drill rig, there are three different styles of controls. They offer distinct advantages and limitations. Advantages of these systems range from ease of troubleshooting and maintenance on the mechanical systems to better ergonomics and remote operation on the electric-over-hydraulic and automation capability on the Can-bus. Limitations such as higher maintenance requirements on the mechanical system, an increased number of connections on the electrical system, and the need for advanced training and diagnostic equipment for the Can-bus balance out the advantages and need to be considered in the selection process.

The upside of the technology-ready platform is the ability to perform multiple functions with the same hardware. Here is an example of the RCS platform utilized across different equipment types. The hardware is similar, and software adapts each controller to the specific processes needed by the unit.

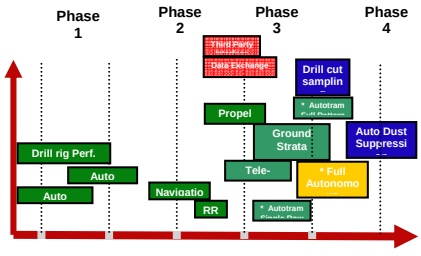
Customers can start at a low level of automation and, as their requirements change, can upgrade. New functionality can be added without major rebuilding of the machines. Due to the nature of the CAN-bus controls, they are compact and can do multiple functions with programming. This gives us excellent opportunities to improve ergonomics and reduce operator stress and fatigue.

RCS Basic provides additional software driven safety features:
• Rod support interlock – prevents damage of the rotary head and rod support by not allowing feed with rod support not in the stowed position
• Carousel No bump – prevents damage to the carousel by limiting pulldown pressure when carousel is not in the stowed position
• Breakout wrench protection – prevents damage to the breakout wrench disabling pulldown with wrench not in the stowed position

The current goal of developing rotary drilling technology is autonomy. While equipment manufacturers invest in the modules needed for autonomous drilling, users must also invest in the infrastructure and operating practices needed to enable safe operation of the unit under autonomous operation. These are a high capacity communication system, an enhanced GPS system, accurate bench mapping and preparation to name a few. Training in support and maintenance of these systems will be a high priority.

Tele Remote takes advantage of the technology modules and allows a short cut by using human judgment as the overall fault handling system.

The road map is a general guide to development of the specific modules for the technology platform. Key to the success of each is making it safe, reliable and cost-effective.



Drilling Performance Data needs a reliable hole-depth indicator that displays the rotary head position as well as the depth of the hole drilled. This also enables the additional safety interlocks (discussed later) as standard compared to the electric over hydraulic machines.

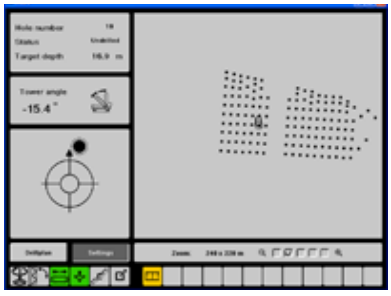
A key milestone (or roadblock) in the development of autonomy is the interface with existing mine dispatch systems. There is currently no industry standard for data protocol and communications, so each installation has the potential to become a custom piece of programming.

Automated leveling systems lack the judgment of a human operator. Limits need to be set on the conditions under which the machine will level. Bench preparation needs to ensure that the slope is within the unit's capability to enable the leveling process to work.

Auto drill is applying feed, rotation and flushing to develop a hole to a proscribed depth. The building of a collar and the hole cleaning are key to achieving a useable hole. It is fairly simple to program the drill to punch a hole to a given depth. Getting something that you can load requires feedback to indicate that there are no obstructions in the hole and that the surface is stable. The consistent depth achieved will benefit both planning and bench development. Furthermore, this feature allows increased production by enabling the operator to accomplish other tasks while drilling.

As of now, this is for single-pass drilling only as pipe changing has not been added due to the inconsistency of disconnecting joints. Despite ever increasing sophistication of the feedback, there still exists the risk of having a collapsed hole.

GPS hole navigation has been developed for the RCS platform. This hole navigation system uses antennas mounted on the tower rest and radio antennas on the cab to produce an accurate bit position. Drill plans designed with the local mine coordinates are imported, and the bit position is provided in real time. Taking into consideration the elevation on a bench, this provides the operator with the correct depth to drill each specific hole. This feature also provides a moving map display with zoom functions as the rig is trammed closer to the desired blasthole location.



Auto propel requires a path planner to optimize coverage while avoiding the crest and previously drilled holes. It must remember where it has been and provide data as to where to go next.

The tram interlocks not only require the jacks and rotary head to be in a safe position, but also provide a dead man function requiring a switch to be depressed in order to move the machine.

Accurate bench mapping must be done to prevent holes or access to holes being positioned over unsafe material. Without a human operator, a method of detecting and avoiding obstacles and the crest need to be employed. This requires more set up time and an investment in equipment.

An interim step to full automation is tele-remote operation. Removing the operator to a healthier and safer working environment is a plus. Providing the ability to control multiple units can dramatically reduce cost. This feature uses the mine's wireless network, either 2.4 or 5.2 GHz frequency, and allows an operator to utilize the machine functions from a remote location, including drilling, leveling, tramming, and GPS hole navigation. A dedicated communication channel that guarantees bandwidth and latency times for real-time control of the drill is required. The package can be equipped with a four-camera system that is compressed to limit bandwidth for viewing of the machine from remote locations. This module also includes a dedicated safety system independent of the RCS package. If communication is lost between the remote station and the machine, then it will shutdown. Additional safety systems like object avoidance and systems detecting when people enter the working area should be combined with the mine's specific safety instructions.

Current tele-remote packages mirror the standard controls on the drill itself. The office package is basically the pod from the drill, complete with chair. An additional screen is needed to display video feed from the drill in order to ensure safe operation when line of site is not present. Portable varieties condense this to a compact size that can be set up most anywhere. Both require dedicated communications equipment.

The **R**ig **R**emote **A**ccess (RRA) system gives a customer the ability to connect the drill rigs to a standard computer network on a work site. The RRA system allows access information on the drill rigs from any authorized point in a network or via phone modem or any (mobile) phone. The RRA system basically consists of a communication server onboard the drill rig and a network adapter. The server supplies the user with three functions:

- a web server that can connect to any standard web browser;
- an FTP server enable transferring of data (files) to and from the drill rig; and
- a server process that enables any data to be integrated into the user's administrative systems.

RRA is also a tool for a more advanced service and maintenance procedure. The operation of the rig can be followed remotely and monitoring of drill rig status can be made online using a standard web browser on a remote PC. "Web pages" are set up similar to the native RCS display on the rig. Troubleshooting can be done remotely using the built-in menus in the RCS system enabling maintenance to schedule parts and labor to fix the unit, which results in

better availability and reduced maintenance costs. Since it can be accessed from the web, technical expertise can be sourced from anywhere.

Other data modules that can be installed include strata recognition systems. These graphic representations of material hardness and consistency assist in planning shots. Precise hole loading reduces explosive costs, controls fragmentation and results in lower wear and tear on downstream loading and processing equipment. This information can also be transmitted through the RRA allowing the loading crews to plan the shot, which reduces the cycle time on a face.

Another add-on piece of upcoming technology that can benefit from RRA is remote sampling. The onboard system gives accurate hole logging in real time, allowing production to partition ore and waste without waiting on samples to be transported and analyzed. It also gives management a clearer picture of what to expect as far as recovery after processing. The trick is again to make this reliable and affordable.

In conclusion, technology for rotary drills provides features to:

- Improve production;
- Reduce TCD; and
- Increase safety.

However, mine infrastructure must be designed to support this technology, and mine operating practices need to support safe operation.

Thanks to Dustin Penn whose Technically Speaking article I shamelessly plagiarized.