Title: What's New in Longwall Mining

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Over the past several years there have been significant changes in the processes and equipment used at America's longwall mines. This paper will identify several of those changes. Descriptions will be provided of these new or improved processes and equipment. Explanations will be presented as to how these processes and equipment have been applied by mine operators. Where possible, resulting changes in mine safety and efficiency will be described or quantified. Emphasis will be on different and creative applications of these new processes and equipment and how they may be employed at American longwall mines. This paper is intended to disseminate to longwall miners how we can use change in processes and equipment to make our mines safer, healthier and more competitive.

Topic 1 - Selection, Training and Development of Longwall Staff – Longwall mines are much more technically demanding than in years past. Mechanical, hydraulic and electrical components which have the ability to be more rugged, longer lasting, but require more technical sophistication to attain the availability and life. Simultaneously, there have been increased retirements by older miners and expansion of operations which has certainly caused a "human resource hole". It is desirable to develop the skills of experienced miners while recruiting and incorporating into the workforce inexperienced miners. Issues of selection of both experienced miners for advancement and new miners for entry positions, classroom and in-mine training, by both operators and vendors, and the continuing assessment and development of miners' skills are the issues for this topic.

- Concerns – Increasing technological complexity requires a more skilled, educated workforce. Both supervisors and miners must be capable of handling the mining environment, understanding gasses, ground control and required parameters, and mastering the sophisticated longwall operating and control systems

- Negatives - For the past several years, it has become increasingly difficult to retain and hire experienced miners. While there are some experienced miners available their technological skills, and their willingness to improve these skills, are often inadequate. New, inexperienced miners are not knowledgeable of the mine environment; nor have they attained the skill sets to properly handle such standards as ventilation and ground control.

- Positives – The new, inexperienced miners are technically much more advanced and anxious to master the new longwall systems than the older miners. The vendors and operators have recognized the personnel challenges facing the mine operators and are working towards devising training and development classes, materials and support that are responsive to the operators' needs.

- Current State-of-Art

- Innovative systems – Operators are screening new applicants to determine their mechanical and technical aptitude. Testing is often at a level comparable to entrance exams for specialized technical schools. Operators are assessing applicants' mechanical and electrical experience, both in and out of mining. Inquisitiveness and a willingness to learn are key factors in selecting personnel for assignment to longwalls; mining experience is not as critical a factor. Operators are also using mentor programs which have particularly experienced miners working with and teaching new miners how to handle the mine environment.

  Vendors are trying to increase the quality of trainers; some have in excess of 25 years of mining experience; the trainers know what the trainees need to know. However, vendors are losing some of their best people to the operators. Trainees generally lack self-confidence, so many of the lessons are interactive sessions. Trainees are often working with computer-based modules; and the comfort with the computer makes a trainee comfortable with the system and therefore accelerates learning.

  The training modules use a great deal of animation. Video is nearly always used. Trainees are therefore comfortable with the learning environment and focus on the materials presented, not on the vehicle used to present the materials.

  Classes can be for any number of days. It is the customer who specifies the level, duration and frequency of the training. Vendors have in-house curriculum development staffs to continually update the material and improve the quality of the presentations. Vendors are now working to understand how students learn.

  Vendors also have in-house video production staffs.

  Classes can be provided by vendors at a customer's site, off-site or at regional training facilities operated by the vendors. Some vendors even offer portable training facilities that can be set up and utilized at the minesite.

  As the vendors have developed communication systems to monitor equipment performance, they have the communications systems which will eventually allow distant-learning. They may also be able to soon develop web-portals specific to each customer.

  At some classes the trainees have used audience response tools; hand-held clickers for the trainees to anonymously indicate whether they comprehend the materials or there is a need to repeat sections of a module.

  While trainers and service techs are not interchangeable, they receive very similar training. The trainers know what the service techs know. One group may be better able to apply their knowledge, the other group should be better at imparting their knowledge.

  Vendors can provide customers and their people with panel boards, computers during classes, guide books and pocket guides for use in the workplace.

- Results – Improved selection and training of longwall miners have improved the capabilities of these people, resulting in a continuing improvement in the safety and efficiency of longwall mines. This is critical to prepare a new generation of longwall miners.

Topic 2 – Communications Systems – Communications systems enhance operating efficiency, assure emergency messages reach miners, and some systems provide equipment diagnostics, and allow mine monitoring to perform more effectively. Some systems are longwall face or area specific and some are mine-wide. The industry and manufacturers are currently trying to respond to federal legislation which is fast approaching its deadline for implementation and has caused a period of significant research and development.

- Concerns – there are three areas of concern. First is compliance with new MSHA regulations, or at least utilizing developing technology to improve longwall mines generally through the application of new communications technology. Second is communication between those working with the longwall; both on the face and during moves. Third is the transfer and use of data acquired from the longwall equipment.

- Negatives – Wireless technology is nonexistent as a standalone, TTE, two-way voice communication system. Communications must be used in concert with existing, hard-wired systems.

- Positives – Vendors are aggressively attempting to connect longwall faces with vendors' resources, both systems and people, which will allow remote diagnostics and problem resolution. Skilled miners, when their skills are critically needed, can be immediately contacted, unlike in the past where only when they were near a stationary wired or trolley phone could they hear a call.

- Current State-of-Art

    - Innovative systems – A longwall mine is stringing coaxial cable from a face which has finished a panel along the entire route to the new panel. Everyone along the entire route is in constant communication with everyone else involved in the move; all are using Kenwood radios. Every advance or setback in the move is immediately communicated. The General Manager estimates move time has been reduced by nearly two days, approximately a 10% reduction.

    - Some mines have installed RFID tags on parts and supply cars and readers located along transportation routes. This allows the continuous identification of what items are in transit and where they are located.

      Systems are in use which monitor many functions of face equipment. Data is gathered and transmitted to the headgate, to an operator's surface installation and, in some cases, to a vendor's remote site. Mine site personnel generally review data daily. Vendors review data only when requested by the customers. Some of the measures include
        - CSTs
        - Load-sharing
        - Pressures
        - Shield loads
        - Shield and shearer travel time

- Vibration

  Vendors agree that while vibration data can be useful, there is generally not sufficient history and expertise to make this data as useful as it will eventually become.

- Results - There has been a noticeable improvement in the efficient utilization of skilled miners and transportation systems. Critical longwall equipment is more likely to receive preventative maintenance than repair after a failure.

Topic 3 – Ground Control – Areas of concern include the immediate face, gate entries, bleeder entries and adjacent panels in all dimensions and is very site specific. Ground control begins with panel and gateroad design. Roof and rib control systems are employed primarily during development and supplementally during longwall face retreat. Support systems include, among others, roof bolts of all varieties, trusses, standing support, gluing, meshing and chainlinking and steel sets. This topic has a relationship to geologic setting, overburden depths, rock and coal strengths and panel geometry (panel width and length), as remaining reserves become more challenging.

- Concerns – The current regulatory climate towards ground control events is extremely critical at this time. The technical and operational expertise in all facets (regulatory, academic or industry) along with ongoing research has been reduced for many years. This has a restrictive effect on the ability to analyze or plan in the current critical reserve remaining in some regions of the country.

- Negatives – Incorrect analysis, planning and design or inappropriate interpretation of events could lead to decisions which significantly limit recovery of reserves.

- Positives – There is a greater amount of weapons in the ground control arena to meet and match ground control conditions.

- Current State-of-Art

  - Innovative systems – the best longwallers always use professional geotechnical engineers to analyze and recommend support systems. Some use in-house experts, but there are independent experts available.
    A wide array of support systems is available. Among the many systems frequently used, and nearly always used in concert, are the following.

    - Pillar design
      - Yield pillars
      - Yield and support pillar combinations
      - All support pillars
      - Panel – barrier or in- panel barriers

    - Roof bolting system design
      - Tensioned or non-tension system
      - Fully grouted resin
      - Combination bolts

    - Cable bolts
    - Trusses – entry and intersection
    - Specialty trusses – floor

- Surface control products
    - Straps or mats of different kinds
    - Roof mesh
    - Rolled roof mesh
    - Rib mesh/bolting
    - Pillar wrap and cabling

- Standing supports / Specialty products
    - Cans
    - Wooden cribs
    - Pumpables, at distances of at least 3,000 feet from main station
    - Wooden props (timber, square sets, cluster props)
    - Fluid filled props
    - Polyurethane grout
    - Cavity filler / foams

There are several means of support installation, on cycle and supplemental supporting off cycle or after development is complete. Frequently off cycle or retreat supplemental installation is completed by contractors to reduce cost for this intermittent operation. Can handlers mounted on small diesel movers are frequently used in the west to alleviate the difficulty with these bulky systems. Roof support during development can be by place-changing or the use of integral bolter-miners where mines where full bolting is not required on the first pass. Place changing is becoming the preferred method. The most efficient development is accomplished with an idle period each day, during which supplemental support is added to roof bolts installed on the production shifts.

There are a variety of methods and materials utilized to effectively prepare extraction faces for safe recovery of longwall equipment. In addition, the advance development of recovery chutes or complete recovery faces are also utilized depending on local conditions.

During longwall face recovery at least two face roof bolting machines are used.

One-step Hilti bolts are used by an operator where roof conditions on faces being recovered are difficult, with a substantial reduction in time required per bolt.

- Results – Ground stability, both on the longwall face and outby, results in more continuous production. Time and resource to learn an individual property and refine applications pay large dividends in safety and resource recovery.

Topic 4 – Wide Faces – As faces approach 1,500 feet in width, more demands are placed on standards for face control, ventilation, communication and all face equipment, particularly AFC's

and their drive capacities and components. Face moves can also take longer. Compatibility with less extensive reserves can create mine planning challenges.

- Concerns – With the fact that there has never been improvement over the years in development technology as compared to longwall retreat improvements, other solutions have been created to keep from overrunning the mine's longwall panel development.

- Negatives – life of face component equipment (life of main sprockets, face and stageloader chain and many shearer components such as rack wheels, trapping shoes, ranging arms and drums) and increased electrical demand and resulting electrical supply equipment.

- Positives – reserve recovery greatly improved, longwall development minimized, longwall / continuous miner production ratio increased

- Current State-of-Art

    - Innovative systems – many improvements for topics 5 and 6 involve the vendors' ability to improve materials and increase manufacturing quality control. Largest panel now being developed is 17,000 feet by 1,400 feet (could be over 8 million raw tons). Chain tensioner improvement because the life of chain is a function of efficiency of chain tensioner. Expect most chains to be 48mm in the near future and with continued new chain design improvement. Need up to 5,000 Hp on drives. There will soon be 5,700 Hp on one face. Blockage detection is needed to maintain chain life. The average width of longwalls in the country exceeds 1000 feet.

- Results - Faces over 1,400 ft wide have been proven effective. Faces 1,400 ft can reduce by 25% the number of gates required and they can reduce the number of face moves by 25%.

Topic 5 – Long Panels – Issues related to wider faces are all applicable to longer panels. In addition, there are also issues regarding development timing, equipment lives and panel belt conveyors.

- Concerns

- Negatives – Most time this requires multiple belt drive setups, either booster or tripper systems or complete additional drives. Time allowances must be made for both installation and removal of these drives.

- Positives – Frequency of longwall moves is decreased and increased time of longwall production

- Current State-of-Art

    - Innovative systems – greater planning for in-panel maintenance and component changeout. Longer lived components which allows for greater tonnage in panels between changeout or rebuild such as power trains on AFC drives or face conveyor or stageloader chains with some chain lives up to 20 million tons.

- Results – As with wider panels, the length of the panel directly reduces the frequency of moves, and it also reduces the need for mains development.

Topic 6 – Two Meter Wide Shields – Wider shields result in fewer shields for a set face width. There may be fewer parts to maintain and inventories may be reduced. However, the wider shield must support a greater load, so many shield components must be larger and heavier. Wide shields, being larger both dimensionally and in weight, create challenges during moves. Move plans and the move equipment must be modified or created to accommodate wide shields.

- Concerns

- Negatives – One operator is concerned that given the limited leg size which is currently available in the USA support densities are compromised if 2 meter shields are used, with the largest current USA shields have a maximum bore of 400 mm. Leg size can also be a limitation if a 2 meter shield is not used with not enough room available in a 1750 mm support envelope. Continued development in leg technology will continue to evolve with support requirement. Movement of the larger shields into, through and out of the mine is also challenging. Larger shield dimensions create difficulties in moving the shields and create hazards for miners. Roadways, whether track or trackless, must be extremely well maintained. Wet roadways create major impediments, in regard to both speed and safety. Oftimes, due to ground control, entry width must be maintained very narrow which poses additional transport challenges. Another consideration is the required width of the setup entries to install the supports which create extremely dense roof support requirement to develop and maintain through setup.

- Positives – Wide shields have allowed a reduction in the number of shields which must be recovered, transported and placed on a new face for the move of a set face width. There are also fewer parts to repair, transport, inventory and purchase. The demands on operations are lessened from the initial order through installation, operation and relocation.

- Current State-of-Art

  Innovative systems – Improved systems for trackless haulage maintenance include motor-graders, watering systems and quick-set patches. Shield haulers for recovery from the face or transport to a new face have capacities of in excess of 50 tons. As surface trucks have expanded to over 400 tons capacity, design of tires for underground applications has improved greatly. Solid rubber tires are an advantage when transporting particularly large shields.

  One shield manufacturer is near commercial application in the USA of a 425 mm leg. The largest legs that will be used to date will be in Australia with a 450 mm leg.

  A very efficient longwall mine uses a T or E-bar to pull shields off the face and a set of large diesel shield haulers.

  The 50-ton shield haulers have been successful for transporting even the largest shields. However, most of the units on the market at this time in this capacity are

battery and they are limited in distance and time due to battery life. Some developments for diesel units are being made currently to introduce into the field. Diesel regulation approval on the units have been a concern and a stumbling block over the past years.

- Results - For a set face width, 12% fewer 2.0m shields are required versus 1.75m shields, and 25% fewer 2.0m shields are required versus 1.5m shields.