In-mine methane drainage strategies

A coal mine methane drainage approach that considers long underground directionally drilled boreholes is appealing to many coal mine operators, write REI Drilling's **Dan Brunner** and **Jeff Schwoebel**.

Adverse surface topography, deep cover, geologic and reservoir characteristics, and the multiple seam mining approach of some US and many international coal mines force coal operators to consider underground oriented methane drainage strategies.

Advances in directional drilling technology – such as higher capacity underground drills and water pumps, higher torque down-hole mud motors, rapid penetration drill bits, precise steering and geophysical tools – allow for precision placement, ultra-long borehole depths, and drilling at larger diameters.

As a result, directional drilling technology now enables development of in-seam boreholes that: drain larger areas in advance of mining; can be placed strategically as in-fill boreholes between vertical CMM wells to further reduce gas content; can be placed precisely to effectively drain CMM from lower permeability coal seams using hydraulic stimulation; or can enhance methane recovery techniques. Advanced directional drilling technology also enables the development of high performance horizontal gob boreholes.

Optimizing the CMM Drainage Approach

Computer programs using finite volume numerical analyses are used to determine the effect of various CMM in-seam drainage strategies and help to optimize the approach. For example, numerical modeling is used to determine the required spacing of in-seam boreholes needed to achieve target residual in-situ gas contents within the available mining schedule. Modeling is also used to evaluate the benefit of simulation through hydraulic fracturing and enhanced recovery techniques such as inert gas stripping.

Many longwall operations practice "just in time" management to coincide gateroad and bleeder development with (rather than significantly in advance of) the onset of longwall mining.

Therefore, longwall panels have limited accessibility for drilling and minimal time available for gas content reduction through conventional in-seam drainage techniques. These mines seek a low-cost CMM drainage approach that will drain gas quickly.

In coal seams which are permeability constrained, mine operators can benefit from hydraulic fractures generated at intervals along in-seam boreholes to increase wellbore conductivity and therefore reduce drainage times.

Enhanced methane drainage uses a series of horizontal in-seam inert gas injection boreholes coupled with adjacent horizontal in-seam methane collection boreholes that can effect stripping of adsorbed methane and further reduce gas drainage times.

Figure 1 illustrates the significant benefits of hydraulically stimulating horizontal in-seam boreholes and of enhanced in-seam methane drainage in a permeability constrained coal seam.

The chart presents the percentage of gas content reduction achieved with each technique relative to the gas content reduction achieved using conventional in-seam boreholes. The chart illustrates that in-situ gas contents can be reduced by 50% in 7.2 months with enhanced CMM techniques and 12 months with hydraulic fracturing, compared to 24 months with conventional in-seam drainage.

Precision placement

Several operators in the US that are mining in areas that have used hydraulically stimulated surface initiated vertical CMM wells may still find that the residual gas content needs further reduction to allow safe, productive mining.

Underground CMM drainage techniques can be used to accelerate further gas content reduction in a short period of time. However, accurate placement is required to successfully navigate in-seam boreholes near the vertical wells.

Borehole stability problems arise near the hydraulic fractures, which can also lead to fluid circulation problems when intercepted. Although fracture orientations are generally known, the exact location and extent are not.

Advanced directional drilling technology enables precise placement to adhere to safe drilling zones, particularly at borehole lengths in excess of 5000ft.

In order to reduce gas content in advance of mining in very gassy, tight coal seams, in-seam drainage strategies demand very closely spaced boreholes, stimulation by hydraulic fracturing, or the use of enhanced methane drainage techniques.

In some low permeability-high gas content anthracite coals in China, for example, boreholes spaced between 15ft and 50ft are required, depending on the time available for drainage and the in-situ gas content.

Advanced drilling technology enables precision placement of closely spaced in-seam boreholes along the longitudinal axis of longwall panels, or across multiple longwall panels, such that they do not intersect, particularly if hydraulically stimulated, of if implemented for injection and recovery for enhanced CMM drainage.

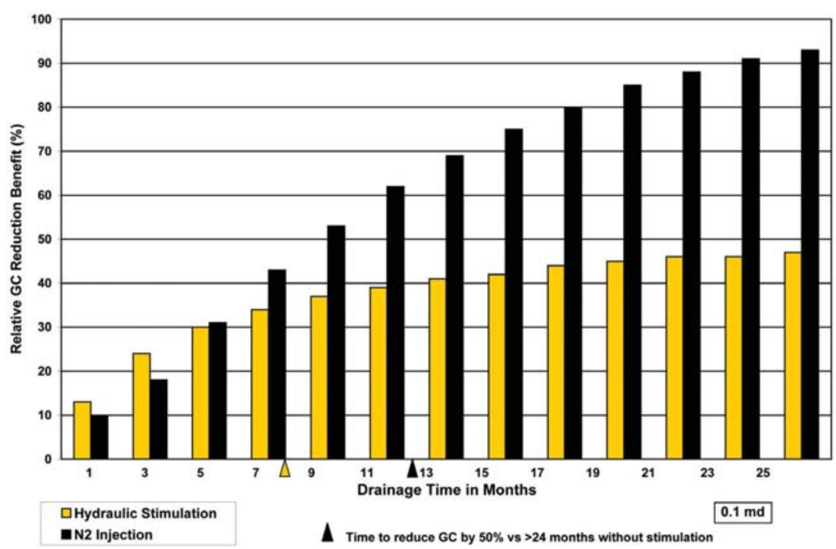

Figure 1: Effectiveness of hydraulic stimulations and enhanced CMM drainage with horizontal in-seam boreholes.

Figure 2: Directional drilling of horizontal gob boreholes underground at the Belozyorskaya Mine in Ukraine.

Longer Boreholes

In-seam boreholes can effectively reduce gas content of large reserves in advance of mining. Longer boreholes can extend into areas that will not be immediately mined and typically can drain gas for longer periods of time (before intercepted by mining).

CMM drainage strategies involving drilling long in-seam boreholes from mine infrastructure developed in advance, such as ventilation shafts, can at current market rates for natural gas provide a revenue stream to more than offset the advanced development (depending on reservoir conditions). Radial in-seam boreholes developed into coals at multiple levels from a shaft, for example, can produce as much as 2 billion cubic feet, depending on reservoir conditions.

High Performance Horizontal Gob Boreholes

Horizontal gob boreholes are directionally drilled over the mining seam in advance of the longwall face and placed vertically in what will be the fracture zone when the gob forms, and typically along the lower pressure side of the gob in the horizontal plane. Various parameters affect the performance of horizontal gob boreholes: (i) diameter and length; (ii) vertical and horizontal placement relative to the working seam and mine ventilation system; (iii) borehole integrity following undermining; and (iv) borehole production issues related to vacuum and dewatering.

Horizontal gob boreholes have been applied at several mines in the US, and overseas in China, Japan and Europe, with varied success (Figure 2). Typically, a 3in to 4in diameter borehole, 2000ft to 3000ft in length, placed between 75ft and 125ft above the mining seam, produces 200–400Mcfd (thousand cubic feet per day) of gob gas under vacuum.

Optimal vertical placement is dependent on the location of gas contributing strata and the geo-mechanical characteristics of the gob.

If placed too low and near the rubble zone, the horizontal gob boreholes may not maintain their integrity when undermined, and/or may draw significant volumes of ventilation air above the face, diluting recovered gas concentrations.

Horizontal gob boreholes placed too high intercept fractures that are less conductive and may not be as effective as boreholes placed at optimal horizons.

Advanced directional drilling technology allows for development of longer horizontal gob boreholes at larger diameters. Both of these parameters affect the resistance of the borehole to gob gas flow.

Using actual gob gas composition, vacuum pressure and flow data from horizontal gob boreholes employed at the Willow Creek Mine in Utah, correlation exercises determined that the gob gas flow capacity for a 3280ft horizontal gob borehole drilled at 5.75in in diameter, operating at a vacuum of 6in Hg, is three times that of a borehole drilled at 3.8in (standard size) in diameter (300Mscfd to 950Mscfd).

Directional drilling a smaller diameter pilot borehole and then reaming using mud-motor reaming techniques also enables the development of larger diameter horizontal gob boreholes that can be lined with perforated steel so that integrity is maintained irrespective of vertical placement. Lining ensures that all holes will remain intact and will produce gob gas even if placed too low in the gob. AL

Equipment safety focus

AS PART of a goal to improve and build upon miner safety practices, the Association of Equipment Manufacturers and the US Mine Safety and Health Administration have joined forces to establish and disseminate materials for mines on equipment operation and maintenance best practices.

The alliance was signed by the two groups in January during a special Washington, DC ceremony, with both citing the importance of all mines and workers having knowledge of proper, safe use of restraint systems (such as seat belts) as the impetus for the project.

"This agreement between MSHA and AEM is another step this agency is taking to make safety and health the number one priority," said MSHA assistant secretary Richard Stickler.

AEM president Dennis Slater added: "We have a long history of cooperation with MSHA. Equipment manufacturers are committed to investing time and resources to have a positive impact on safe machine operation, and this new alliance provides a unique and direct way to accomplish this goal."

To accomplish their goal, AEM and MSHA have gathered a steering committee made up of individuals from both agencies that will convene on a regular basis to track the progress of the alliance's efforts and continue sharing information that can further the project. MSHA will provide representatives from technical support, educational policy, and both coal mine and metal/nonmetal safety and health, while AEM has designated persons from throughout its technical and safety council.

Among the groups' plans for the alliance agreement are cooperative plans such as the development of a central information source on mining equipment safety materials, bulletins, advisories, DVDs and manuals.

Additionally, the alliance will advocate to equipment operators and maintenance workers the importance of joining MSHA's Professional Miners Program. The purpose of the program is to permit miners to continue developing and polishing health and safety skills.

The two groups also said they plan to speak and make appearances at MSHA or AEM events as well as other industry conferences to promote the alliance's efforts as well as to encourage safe equipment use and maintenance. They will also participate in forums and other discussions regarding the avoidance of hazards and "help forge innovative solutions".

Lastly, the AEM and MSHA committee will play a role in programs, short courses and activities at MSHA's National Mine Health and Safety Academy in Beckley, West Virginia, and its other facilities as well as AEM member companies' training complexes. The review of final accident reports to develop solutions for equipment health and safety for the future will also be part of the groups' goals.

"MSHA and AEM will work closely together to address issues related to mining equipment safety and, thereby, foster an improvement in safety and health for working miners," Stickler said.