1998

Inseam drilling for gas exploration - recent advances

J. Hanes

Inseam Drilling For Gas and Exploration - Recent Advances

J Hanes[1]

ABSTRACT

In-seam drilling is conducted mainly to drain coal of gas and/or water prior to development or extraction. The requirements of inseam drilling for gas drainage have mainly surpassed the technical limits of rotary drilling and are mainly being addressed by guided down hole motor drilling, albeit at a higher cost. There is an increasing application of in-seam drilling to detect geological structures or other hazards or their absence in advance of mining to reduce the risks of underground mining. Close collaboration between miners, drillers, geologists, researchers and suppliers over the last four years has seen many advances made to improve the accuracy and reliability of inseam drilling. With such developments will come closer control over the ventilation and safety of future mining under deep gassy conditions, but not without costs. The paper summarises the current applications of inseam drilling, recent technological advances and the next generation survey and geophysical sensing tools which are currently being developed

INTRODUCTION

The majority of inseam drilling is conducted to drain coal of gas and/or water prior to development or extraction. However, an increasing amount of drilling is directed at detection of structures or proving their absence, and testing of gas contents especially in seams prone to outburst. With tightening of the economics of underground coal mining, what mine can afford to intersect unexpected geological structures or to experience outbursts on development? Inseam drilling provides insurance by reducing the risks.

In modern inseam drilling, guided down hole motor drilling is tending to replace rotary drilling. Rotary drilling involves rotation of a string of drill rods which extends from a stationary drill rig to the drill bit. The drill rig applies both rotation and thrust to the rods. Downhole motor guided drilling involves advancement of the hole by rotation of the drill bit by a hydraulically activated motor which resides close behind the drill bit. The drill rig applies thrust to the rods, but generally not circulation.

Until recently, gas drainage holes were mainly drilled as rotary holes of around 90mm diameter drilled from one set of gateroads, across the proposed longwall panel and beyond the next proposed gateroads. They were therefore typically around 250 to 300m long, but with the development of guided drilling technology in recent years, some holes are being extended to cover two or three longwalls. Drainage holes are typically drilled in fan patterns or as parallel holes at 15 to 20m spacings. Rotary holes are seldom straight and the resultant curve can mean that they do not cross the next gateroad panel. At most mines, all gas drainage holes are surveyed after drilling to determine where they go. Some of the holes close after drilling and cease to drain the coal. Sometimes when rotary holes intersect a geological structure, the bit bogs and cannot penetrate the structure. The more powerful the drill rig the lesser is the chance of the bit becoming bogged, and of the driller detecting a structure.

Downhole motors and some form of hole surveying are used to drill directionally controlled holes for exploration and gas drainage. The longest hole in coal to date is 1670m, drilled at Moura by Pontil Drilling from a highwall face. The longest hole drilled in an underground mine is 1538m drilled in a West Virginia (USA) mine by Advanced Mining Technologies (AMT). Although large faults and most dykes can be detected in these holes, it is difficult or impossible to detect small structures.

Consulting Gelogist

Small rotary rigs are popular for drilling relatively short holes for detecting structures or for taking cores for gas content testing. The currently used bottom hole assemblies result in curvature of holes and often unknown trajectories.

Within the next few years the major improvements to inseam drilling should come through the recognition and location of geological structures while drilling directionally controlled holes using a combination of behind-the-bit monitoring of torque, thrust and RPM, radiometrics, radar and capacitance along with reliable surveying. Use of these tools plus maintenance of borehole stability and testing of gas contents while drilling will be facilitated by borehole pressurisation. Recording of data will be facilitated by intrinsically safe computers. Survey while drilling rotary holes should be possible while modification of the torque, thrust, RPM device should enable recognition of structures. Drills will be monitored to assist recognition of structures. There is an immediate need to adopt drill monitors. The development of geosteering tools with incorporated geophysical
probes, combined with mathematical modelling of bottom hole assembles and drilling parameters
should provide a great leap forward to inseam drilling technology.

There are still some problems to be addressed including communication of data out of the hole and straighter drilling of rotary holes. The former need to be addressed for successful application of the tools being developed now. The latter is being addressed by the mines and by the water jet assisted drilling project being conducted by The Centre of Mining Technology and Equipment (CMTE) under Australian Coal Association Research Projects (ACARP) funding.

Most of the major in-seam drilling problems identified by mine operators are being addressed and should be solved by developments which have occurred or commenced in the last four years, some as ACARP funded research, some as mine site initiatives and some by suppliers in response to industry requirements. Support by ACARP for a Co-ordinator of in-seam drilling research has facilitated these developments though improved communication between all players and minimisation of duplication.

THE CURRENT SITUATION

In 1993, around 300 km of rotary drilling and 160 km of guided drilling was conducted annually in seam in Australian collieries. In 1996 around 120 km of rotary drilling at around $30 per metre and 400 km of directional drilling at around $60 per metre were drilled. In 1997, the guided drilling distance increased to around 460 km while the rotary drilling remained at 120 km. A conservative estimate of cost for this work is $3.6M for rotary and $27.6M for directional drilling. In addition, around 400 km of cross measure drainage holes are drilled annually using rotary drilling. There is a trend towards replacing much of the rotary drilling with directional drilling to achieve better accuracy or at least to know where the holes go.

Rotary drilling technology has changed little during the last 20 years except perhaps for the introduction of the lightweight ProRam drill. With the recently introduced very stringent requirements of proving outburst-prone coal is safe to mine has come the need to survey drainage holes to prove that they have reached target. Survey is currently conducted using a single shot photographic survey tool or in some cases a multishot photographic or multishot electronic survey tool. The survey tool is pushed down the hole after drilling, either on PVC pipe or on the drill rods.
Either method is prohibitively time consuming. Survey of boreholes is now accepted as necessary for all holes in outburst prone mines as not knowing where a hole goes is nearly as useless as having no hole at all.

Directional drilling with downhole motors is revolutionising in-seam drilling. Holes can be drilled straighter but at a lower penetration rate than with rotary drilling. The use of survey tools is critical during drilling to maintain hole trajectory. In 1993, the only options for surveying were a single shot photographic tool or the Dupont electronic survey tool which resided behind the bit. The single shot tool must be pumped down the rods, a photograph exposed, the tool withdrawn and the film developed before the attitude of the bit is known. The Dupont tool communicated with the collar of the hole via a sonic pulse which was satisfactory in holes which did not intersect stone or structures and which did not contain gas bubbles. Now, in response to industry requirements, there are two electronic survey tools available which reside behind the bit. The Mecca system supplied by AMT now uses a solid communications cable installed in the rods to transmit bit attitude while the rods are stationary and is used by many mines. The Drill Scout supplied by Surtron Technologies is a true measure-while-drill (MWD) tool and communicates data out of the hole via a single strand wire cable fitted to a mandrel.

There is currently no in-hole tool available for detecting small geological structures in boreholes during or after drilling. Longhole drilling requires that the seam roof be intersected periodically (such as each 50m to 80m) to provide horizon control. This necessitates a pullback of the hole and deflecting (drilling of another branch).

The popular drill rods used today (eg BQ, NQ) are not capable of sustained use for very long (+1500m) holes (Gray,1992). The rod joints do not have adequate tensile strength, especially for the heaviest duty of withdrawal from long snaking holes.

REQUIREMENTS FOR THE NEAR FUTURE

The need is increasing for drilling patterns to confidently drain gas to below levels which can cause outbursts or unsafe emissions, while detecting and accurately locating all geological structures which are significant to mining. Economics demand that these demands be met at a reasonable cost.
Rotary drilling is generally favoured for routine gas drainage drilling because of its cost advantage,
but drilling accuracy must be improved. A robust survey tool located behind the bit which can either provide accurate survey data during drilling or on retrieval of the rods is required. Such a tool would, at least, allow rotary drilling to be used without the time consuming need for post drilling survey. If hole trajectories are irregular enough to leave gaps in the drained coal, directional drilling could be used to target the undrained areas. Better directional control of rotary drilling or replacement with a more accurate drilling method at a similar cost is desirable.

Detection and accurate location of geological structures in the hole are prime requirements of both rotary and directional drilling. There is a need to accurately identify structures varying in magnitude from mylonite 1cm thick to large faults. There is also a need to detect and define changes in gas parameters along the hole. Detection of structures during drilling is desired to allow prompt action for maintenance of borehole wall stability.

There is a need, especially during the drilling of directionally controlled holes, to know where the bit is located with respect to the boundaries of the coal seam. Currently the intersection of stone in a hole is confusing as it takes considerable effort to determine if the stone is roof, floor, a band, a fault or a dyke. If stone is intersected, it might be necessary for the rods to be partly withdrawn and a new branch of the hole commenced.

There is a need to record drilling parameters in each hole to provide accurate data for detection of geological hazards and to maximise drilling efficiency. The current method of manual recording is too haphazard and needs to be replaced by automated recording, data processing and drill control.

FINDING SOLUTIONS

The Exploration Taskforce of the Australian Coal Association (ACA) initiated an ACARP funded scoping study of in-seam drilling research requirements in 1993. This study defined the industry's research requirements which have been addressed by research projects funded in 1994, 1995, 1996 and 1997. The research is coordinated by the Taskforce with the author acting as the Taskforce's research coordinator. Coordination is minimising duplication, assuring the research is directed and facilitating communication among all players.

Commercially available survey tools are improving and are partly satisfying industry's current needs. Tools to detect geological structures during drilling and the means of controlling the borehole environment to permit use of these tools are currently being developed under varying levels of ACARP support. To enable use of geophysical probes during drilling, the AGA Consortium (AGA) project on Pressurisation of Boreholes was approved. A borehole collar pressurisation system was developed to allow drilling of holes under a fluid pressure which is sufficient to prevent gas desorption during drilling. This pressure should help maintain borehole stability and will provide a water-filled hole for use of geophysical logging tools. AGA have incorporated a sampling vessel for accurate determination of gas desorption pressure of cuttings samples thus promising a rapid assessment of the potential for outburst. Lunagas was funded to design a system for detecting changes in gas make during drilling and the resultant gas recovery system is being considered for trials by Lunagas and AMT.

Tools to detect structures are being developed. Funded by ACARP, AGA are developing detectors of drilling parameters including bit torque, load and RPM which will be installed behind the bit initially in rotary drilling bottom hole assemblies and later in directional drilling. The tool will incorporate a survey device being commercially designed by Sigra Pty Ltd. Changes in coal strength indicated by the sensors should be correlatable with geological structures. Australian Coal Industry Research Laboratories (ACIRL), with ACARP funding, has developed a prototype caliper tool for detecting changes in borehole diameter associated with structures. Partly funded by ACARP, CMTE developed two tools for structure and roof/floor proximity sensing. These are a radar and a radiometric tool. The radar successfully located the roof and floor proximity, but has been temporarily shelved because of the lack of an electromagnetically transparent drill rod housing. The radiometric sensor can only detect the roof or floor boundary when within 40cm of the stone, but shows potential for recognition of the radiometric signature of parts of the coal seam and should therefore be applicable for horizon control of the bit. The radiometric sensor will be incorporated with the AGA sensors and the Sigra survey tool plus other geophysical sensors to produce a drill guidance system. The CMTE and CSIRO tested a dielectric capacitance tool over a mylonite zone at West Cliff Colliery and demonstrated its ability to delineate the mylonite quite clearly. ACARP is funding further development and proving of this sensor. AMT, the developers of the MECCA survey system, are considering the incorporation of geophysical sensors into their popular survey tool to enable detection of roof/floor proximity and structures. BHP Research with ACARP funding, developed an intrinsically safe portable computer for underground use and used it to
collect data from a monitored Proram rotary drill rig. It provides data on changes of drilling
parameters at the drill rig with drilling of varying geological structural conditions and allows identification during drilling of geological structures and gas inrushes. There is a desire to automatically monitor drilling parameters on all rigs to reduce the human elements of error and lack of interest in detailed data recording and to maximise useful data capture.

Consequent to the Moura disaster inquiry, two valves to allow automatic closure of gas pipelines or flow of gas from holes are being developed under ACARP funding. They are designed to automatically stop gas flow in any occurrence of abrupt change of gas pressure within the gas drainage circuit as would occur during an explosion. Both units should be commercially available in 1998.

The downhole sensing tools being developed will have to communicate their data to the drill collar. The AMT MECCA survey system does this via a cable-in-rod system and the Drillscout survey tool communicates via a single core cable. Other communication systems are also being considered. AGA completed an ACARP project which aimed to develop standard electrical and mechanical connections for downhole tools. Because of the wide diversity of requirements, standardisation is not really practical, but the project provided useful guidelines. Data communicated out of the hole will have to be stored and processed and geologically interpreted.

As the problems of hole surveying, roof/floor proximity sensing and drill monitoring are overcome, there will be a need to drill longer holes to beyond 2000m to explore and predrain proposed longwall blocks. Gray (1992) showed that currently used rods will not be suitable for such long holes. With further ACARP support, Sigra have built a drill rod test rig and will be testing various drill rod joints to assess their suitability and to facilitate design of more appropriate joints. Both Lama (1995) and Gray (1992) emphasised the need to introduce more science into drilling if longer holes are to be successful.

To improve straightness of rotary holes, the mines have conducted their own site-specific trials of various bottom hole assemblies and communicated their results to colleagues at regular drill operator and supervisor meetings. Most major mines have opted for the improved accuracy of guided drilling. Only one company successfully uses rotary drilling for long holes, employing down hole motor drilling to correct major deviations. It appears that the drilling of long holes by rotary drilling is only successful when used by patient expert drillers. CMTE and BHP funded initial trials of waterjet drilling and waterjet assisted drilling at Appin Colliery to compare these types of drilling with conventional rotary drilling. ACARP funding was approved for extensions of the project in 1996 and 1997 to increase the productivity and reliability of waterjet assisted rotary drilling and development of direction control methods. This method offers some promise for improving accuracy of rotary drilling.

CONCLUSIONS

Finding solutions to in-seam drilling problems requires a multifaceted approach. ACARP funding of research into in-seam drilling totals around $500,000 per year for 1994, 1995, 1996 and 1997. This funding alone is insufficient to address all problems nor to find solutions to the many day to day problems experienced by the mines. The funding allows investigation and initial development of solutions for medium term challenges. The mining companies and drilling contractors put a lot of effort into solving their immediate problems, assisted by their suppliers and they share their achievements with other operators in the industry. Researchers funded by ACARP typically contribute funding to accelerate their projects. Suppliers are funding their own developments and assisting some of the research projects. Progress on all fronts is communicated at regular meetings of all players organised by the author as inseam drilling research coordinator.

The ACARP Exploration Taskforce, industry and service providers are showing that industry challenges can be successfully addressed when all players are involved to firstly define the priorities, then to find the solutions. Regular communication between researchers, suppliers and industry assures that the projects are focussed and that minimal duplication of effort occurs.

ACKOWLEDGEMENTS

The willing cooperation and sharing of information by all my in-seam drilling colleagues in the mining industry, suppliers and researchers should ensure development of successful solutions to the industry's in-seam drilling challenges.

REFERENCES

Gray, I.,1992; *Optimisation of Long Hole Drilling Equipment*, Final Report on ACARP Project C3023.

Lama, R.D., 1995; *Evaluation of Inseam Borehole Stability in Coal Mines*, Final Report on ACARP Project C3029.