THE DIRECTIONAL DRILL MONITOR FOR LONG HOLE GAS DRAINAGE IN COAL MINES

G. SKYBEY¹

ABSTRACT

The Directional Drill Monitor (DDM) is an advanced instrument for real time in hole surveying. It was developed by Du Pont (Australia) to suit Australian gassy coal mining conditions.

The instrument consists of three units:

i. Down hole transmitter
ii. Acoustic transducer
iii. Data receiver processor unit (i.e. up hole unit).

This paper describes the function of each unit in detail and highlights the importance of the DDM in long hole drilling efficiency.

Surveysing is carried out independent of hole depth. Each survey takes 2-3 minutes to complete, the frequency of surveying to control borehole trajectory is determined by the accuracy required for a particular hole.

The DDM is currently used successfully for long hole drilling in a number of coalfields. A high degree of directional control has been achieved. Borehole trajectories were controlled to within +/- 2.5m of the planned path with intersurvey distances varying between 6 to 18 metres over distances up to 700 metres.

INTRODUCTION

Long hole drilling for gas drainage in Australian coal mines is a commonly used practice for extracting harmful and dangerous gases from coal formations in the Sydney and Bowen Basins. Gas removal prior to mining helps to eliminate the dangers associated with their presence (e.g. gas outburst) permitting more rapid development and extraction cycles thus contributing to the ground stability of the mining operation.

The key to successful long hole drilling is a reliable down hole survey instrument with the ability to transmit signals from 700m plus depth, without the use of a cable.

The Du Pont DDM was developed to meet these requirements. It transmits the data in an acoustic phase modulated wave via the drill pipe to the acoustic transducer which receives the signal and passes it to the data control module. These signals are processed using both analog and DSP (Digital Signal Processing) techniques which filters out unwanted interference, decodes the digital data, checks for valid data, and then presents the information in the form of azimuth, tool face orientation, hole lateral and vertical deviation.

One of the bonuses of long hole in-seam drainage can be the geological information obtained, the DDM provides for accurate and rapid location of structures that the borehole encounters.

DESCRIPTION OF DDM COMPONENTS

The DDM consists of three main units.

i. Down hole transmitter
ii. Acoustic transducer
iii. Data receiver processor unit (the up hole unit)

DOWNHOLE TRANSMITTER

The transmitter is housed in a 3.18m long, 50.8mm diameter, non-magnetic (‘N’ 54 mm diameter) wireline copper beryllium rod and is positioned directly behind the down hole motor.

1. G. Skybey, Technical Engineer, Du Pont (Australia) Ltd

11th International Conference on Ground Control in Mining, The University of Wollongong, N.S.W., July 1992.
The sensing equipment consists of triaxial accelerometer and triaxial magnetometer for altitude and heading sensing. The transmitter digitally encodes the sensor data and converts it to an acoustic phase modulated carrier. It then transmits via the drill pipe to an acoustic transducer.

This unit enjoys a very high degree of accuracy rating as follows:

- Magnetic Headings: +/- 1°
- Pitch: +/- 0.1°
- Roll: +/- 1°

THE ACOUSTIC TRANSDUCER

The transducer is a mechanically tuned vibration sensor that detects the carrier's steady tone (whine) and converts it to an electrically equivalent impulse transmitted via a cable to the up-hole receiver process unit.

The principal of the acoustic transducer is similar to that of a microphone except that this sensor is tuned, therefore it can only respond to a narrow range of frequencies which carries the borehole data.

THE RECEIVER PROCESSOR (I.E. UP HOLE UNIT)

The unit is housed in a robust water resistant metal box containing a computer programmed to process data received from the down hole unit, using both analog and digital signal processing (DSP) techniques. A liquid crystal display 240 x 64 dot matrix displays the relevant data (Fig 1). The primary display values are hole depth, Azimuth, pitch, roll, vertical and horizontal deviation and indicator noise correlation.

![Display Unit Layout Diagram](image)

**Figure 1 - Display Unit Layout Diagram**

**TYPICAL LONG HOLE DRILLING EQUIPMENT**

The main items of equipment are drill rig, water pump, Directional Drill Monitor (down hole unit) and the down hole motor. (Hungerford F. et al, 1987).

**DRILL RIG**

A typical drill rig is an electric hydraulic machine with a 37kw capacity and generates 73.8KN and 62.0KN push and pull forces respectively. It is fitted with an N (54mm diameter) size chuck.

**PUMP**

The pump is a high pressure water unit to power the down hole motor. It generates 6.64MPa water pressure and delivers variable volumes from 0-248 litres per minute.

**THE DOWN HOLE MOTOR**

The motor (non magnetic body and rotor), is powered by the water pump. The operating water volume is between 116-270 litres/minute which generates bit speed between 300-700 rpm. The bit is guided with a bent housing (Fig 2) placed immediately behind it and deflects the bit between 0° and 1° 15'°. The choice of the angle of the bent sub is determined by drilling conditions.

**TYPICAL DOWN HOLE UNIT**

This unit is housed in a copper beryllium block connected immediately behind the down hole motor (Fig 2).

**DESCRIPTION OF DOWN HOLE SURVEYING PROCEDURE**

The first step taken before commencement of drilling is resetting the tool i.e. align the electronics with actual tool bent face, (Hyde L., 1991) which is done as follows:
1. Orientate bent housing to 12 o'clock
2. Set display to receive data in automatic mode (i.e. P0)
3. Route the rods to activate the downhole unit, the transmitter will provide the up hole unit with the necessary data to determine tool face orientation.

The second step is to enter the entry heading and target heading for the borehole. Once these headings have been entered drilling can commence. The unit will automatically calculate and display the deviation from these preset reference headings.

The procedures for down hole surveying are as follows:

1. Turn the water off to the down hole motor
2. Activate down hole unit by rotating drill string
3. After data is received enter meterage value for that transmission
4. Should the transmission fail, repeat step 2 and enter the meterage value again.

THE BENEFITS OF THE DIRECTIONAL DRILL MONITOR IN LONG HOLE DRILLING APPLICATIONS

The major objective of using the Directional Drill Monitor in long hole drilling is to keep the borehole trajectory at a planned path. This can achieve numerous benefits (Sturgesford, Kelly, Sagar and Williams) which are:

1. **ECONOMICAL**

   The economical benefits of using the DDM in long hole drilling is best illustrated by comparing it to that of the pump down survey tool and rotary drilling operations.

   **a. The Pump Down Survey Tool**

   It is estimated that the DDM as a cableless survey tool, increases drilling efficiency from 30% to 60% per shift. Through frequent surveying and reduction in hole branching, this can realise between 25% to 30% savings on cost of drainage per tonne of coal to be mined (Williams, 1991).

   **b. Rotary Drilling**

   From experience, it has been realised that rotary drilling is an inefficient method for gas drainage due to a number of reasons:

   1. Less time available for gas capture
   2. Increased costs of labour and consumables.

   Progress of hole drilling by the rotary method is directly related to the development rate of longwall headings. Hence, less time is available for gas capture. This prolongs the time required for efficient gas drainage of a longwall block. On the other hand, gas drainage by longhole methods is not dependent on the longwall headings being developed in advance. The holes can be drilled into the block (parallel to its direction) independent of heading development which increases the time available for gas drainage and capture.

   It is estimated that gas drainage by the longhole method reduces drilling requirements by approximately 30% (Williams, 1991). This generates large savings in labour costs and use of consumables such as pipe, methane drainage pipe and fittings.

2. **EXPLORATION**

   A significant bonus in gas drainage by directional long hole drilling is early detection of geological discontinuities. Long hole drilling is probably more useful in defining areas that are clear of structures rather than defining structures themselves. However, if a structure is indicated by seismic or some other method then long hole drilling can confirm the structure, its location and trend. The cost involved with delays in longwall production due to unexpected geological structures can be costly to a mine's profitability.

3. **INCREASED GAS CAPTURE**

   In predrainage applications, directional long hole drilling provides greater drainage time as the hole can be drilled well ahead of development allowing time for the capture of large quantities of gas unlike short hole drilling where the roadway has to be
developed first before any drilling can take place.

Directional long hole drilling can also be used for post drainage applications. The underlying seams in the Sydney basin can contain significant volumes of gas which can migrate upwards into mined out areas. Long hole drilling for gas drainage of the underlying strata can reduce this problem (Fig 3).

Surveying was mainly conducted at 6m intervals (each rod addition) allowing adequate control of borehole trajectory with 1°15' bent housing.

Hole horizontal and vertical deviation (Fig 4) were controlled by constant checks to bent housing orientation and regular roof and floor intersection, respectively.

Fig 4: Hole vertical and horizontal deviation
Surveyed by EDM

Hole data was logged in a special log sheet (Table 1) to record the drillers comments as drilling progressed. Hole trajectory is determined by tool face orientation.

Table 1: Typical Long Hole Drilling Log

Drilling was conducted on a two shift basis, an average of 65m per shift was achieved. This rate of advance was considered to be a good result considering the limited experience the drilling crews had with using the EDM. The hole was drilled to 750m and with branches involved, a total of approximately 850m was drilled.
CONCLUSION

The trial established that it is much easier to achieve successful long hole drilling with the aid of a cableless survey tool able to transmit signals from depths up to 1,000 metres plus.

The Du Pont DDM proved to be a very reliable instrument and performed extremely well during the trial. The DDM is now a commercial tool with several units currently under trial and increasing interest being shown from potential end users.

REFERENCES

4. Williams R, Gas Drainage in Australian Coals. Symposium on seam gas organised by the GSA Geology Specialist Group and held at the School of Mines, University of New South Wales, 4-5th February 1991.