LIMITATIONS AND REQUIREMENTS OF GAS CONTROL METHODS FOR HIGH PRODUCTION LONGWALL MINING

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ABSTRACT

The high gas emissions which are associated with high production longwall mining have provided a need to investigate the limitations and requirements of the various gas control methods. The major relationships between gassiness and various other parameters are presented with computer analysis being adopted to assess the respective correlations. Some of the relationships are studied in detail with emphasis being placed on methods for overcoming the changes in conditions resulting from high production levels.

The importance of the various drainage systems which can be adopted to combat high gassiness levels are analysed.

Logical and necessary steps are also proposed for gassiness prediction and data monitoring as well as various combinations of gas drainage systems.

The gassiness prediction methods which are discussed outline the need for a sound knowledge of the established worldwide methods together with a comprehensive study of the local mining and geological environments in order to develop a system which is adaptable to the changing conditions. This is particularly important in mines where high coal production levels are anticipated and the need for accurate gassiness relationships is essential.

SUMMARY

The gassy conditions experienced at any colliery will vary greatly depending upon the local geological and mining environment.

Most of the recognised gassiness relationships which have been developed worldwide were based on European mining conditions where relatively low production rates from one longwall were experienced. The main criteria which was analysed in preparing these relationships was the characteristics of the gas sources, their corresponding methane content values, and the surrounding strata behaviour.

In the initial stages of designing a colliery, it is important to evaluate the gas content of the working and adjacent seams by taking samples from the exploration boreholes. This information can then be used to form an initial evaluation of the ability of the gas sources to release methane into the underground workings. The exploration boreholes should also provide sufficient information about the stratigraphy which is essential for analysing strata relaxation behaviour.

When access to the underground workings is reached, the accuracy of both the gas content measurements and the local stratigraphy can be further enhanced. These initial stages of investigation into gas content measurements are used extensively worldwide irrespective of whether the direct or indirect method of analysis is used.

For practical purposes, and with due consideration to both the time and cost constraints, the US Bureau of Mines direct method (modified for Australian conditions) was adopted. Together with the stratigraphic analysis, this gas content value was then used to predict gassiness levels for both development and longwall extraction.

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Several selected European methods were also used for gasiness prediction calculations in order to design the ventilation system and gas drainage layout for both the longwall and colliery conditions.

All data which was gathered during both production and non-production periods was continually analysed and corrections made to the various predictions and designs in order to establish the system which was most adaptable to the local conditions.

From these results, it was established that the gasiness levels experienced in Australian coal mines varied greatly in comparison with the European conditions due to the following factors:

- production rates in Australian longwall panels are much greater than those experienced in European mines. (Presently up to 15000 tonnes per day per longwall unit),
- the contrast in geological conditions which creates different forms of strain relaxation resulting in varying degrees of gasiness,
- the shallower depths of mining which are operated in Australia (up to 300 metres).

**MAJOR RELATIONSHIPS CONCERNING GASSINESS INVESTIGATIONS**

In order to estimate the level of gasiness for comparatively very high coal production longwalls with respect to the local geological and mining conditions, the following relationships were established from the Sydney Coal Basin with particular reference to Pacific Colliery as a case study for Australian underground coal mines.

**Total Absolute Gasiness with respect to Time and Coal Production**

Before the longwall reaches its "maximum average" gasiness level, which is normally obtained after the first major goaf fall, the total absolute gasiness steadily increases with time. This length of time is dependent on the rate of advance, the geometry of the longwall, seam gas content and the stratigraphic conditions. For the remainder of the longwall the gasiness level is dependent primarily on changes in coal production. (See Figures 1 & 2).

**Fig. 1. Total absolute gasiness and daily coal production versus time over the first two months of production from Longwall 7 at Pacific Colliery.**

**Fig. 2. Total absolute gasiness and weekly coal production versus time over the life of Longwall 2 at Stockton Borehole Colliery.**

After our results over a series of longwalls were analysed by computer methods, it was confirmed that the relationship previously established between total absolute gasiness and coal production (Myszor, 1974), as shown below, was valid.

\[ Q = a \sqrt{P} \ (m^3 \text{ CH}_4/\text{a}) \]

where \( Q \) = total absolute gasiness,
\( a \) = co-efficient of proportionality,
\( P \) = production rate

For creating this relationship for Australian conditions it was necessary to evaluate the proportionality co-efficient for the higher specific coal production levels.
Total Absolute Cessiness and Methane Drainage with respect to Face Position and Time.

The efficiency of any methane drainage system is dependent upon the following factors:

(i) the number, position and orientation of the drainage holes during both the pre-drainage and post-drainage phases,

(ii) the type of ventilation system employed during the extraction of the longwall, and

(iii) whether an independent coaf drainage system is adopted.

Figure 3 indicates that the efficiency of the methane drainage system was fairly low during the initial extraction period from Longwall 5 as a result of the small number of uholes drilled and the lack of drainage from the coaf area. However, once 600 metres of the longwall was extracted, several uholes had become active and the efficiency of the drainage system then remained fairly constant.

As an effective Z-ventilation system was employed for the extraction of Longwall 5, this allowed a large quantity of air to be delivered to the face and enabled the concentration of methane in the return to be maintained below the permissible levels despite the drainage efficiency being only 50%.

When a U-ventilation system was adopted for later longwalls (6 and 7), a far more efficient drainage system was required as it was not possible to regulate the drainage holes behind the face as this area could not be accessed. This was managed by drilling more coaf cross-measure holes deviating 45° towards the longwall face and introducing an effective independent coaf drainage system.

As illustrated in Figures 4 and 5, when such a system is employed it is possible for the gas drainage to contribute up to 87% of the total absolute cessiness and for the coaf drainage to produce as much as 47% of the total drainage from the longwall.

Fig. 3. Total absolute cessiness and methane drainage flowrate versus Longwall 5 face position, Pacific Colliery.

Fig. 4. Total absolute cessiness and methane drainage flowrate versus time for a two month period from Longwall 7 at Pacific Colliery.

Fig. 5. Contributions of coaf and uhole drainage flowrates to the total drainage from Longwall 6 over a period of one month at Pacific Colliery.
In order to operate an efficient goaf drainage system, effective sealing of the goaf area was also introduced. This included the design of the tailgate which incorporated shorter pillars at the start of the longwall to enable early sealing of the goaf area, and adopting an adequate type of seal so that leakage could be minimized. Sound results were achieved in Longwall 5 when "Rigiseal" was used for closing the cut-throughs in the tailgate and sealing off the longwall block when extraction was completed.

Figure 6 highlights the effectiveness of "Rigiseal" when used on Longwall 5 in comparison to the use of brick stoppings as was employed for sealing Longwall 1.

(C. Clarke, L. Lunarszewski, 1987)

Methane concentrations captured from the goaf areas of Longwalls 1 and 5 after sealing with brick stoppings and "Rigiseal" respectively.

Methane Flowrate from Cross-measure Holes with respect to Suction and Face Position

The quantity of gas captured from any cross-measure hole depends primarily on:

(i) the richness of the gas sources which are intersected by the hole,

(ii) the paths of the cracks and how they are connected within the strata surrounding the hole, and

(iii) the magnitude of suction on the hole.

These factors vary greatly from hole to hole irrespective of whether or not they are drilled with a similar geometry.

Suction is the source for transporting gas through the drainage system and its magnitude plays an important role in determining the quantity of gas which is captured.

The maximum quantity measured for different cross-measure holes at Pacific Colliery varied from 20 to 180 litres CH4/s with the relationship between flowrate and suction being logarithmic with a levelling out of the flowrate at a suction of between 150 and 200 m Hg. As illustrated in Figure 7, when the suction is stopped, small quantities of methane are still experienced under free flow conditions with the magnitude of this flowrate being dependent upon the in-seam pressure and resistances in the drainage line.

The relationship shown in Figure 7 is similar to that established for cross-measure holes drilled around a series of longwall systems in Poland.

(Lunarszewski, 1976)

Fig. 6. Methane concentrations captured from the goaf areas of Longwalls 1 and 5 after sealing with brick stoppings and "Rigiseal" respectively.

Fig. 7. Quantity of methane captured versus suction for one of the drainage holes drilled above Longwall 6 at Pacific Colliery.

The instantaneous flowrate which is captured from any cross-measure hole is also significantly affected by the longwall face position. Prior to the longwall face reaching the position of the hole, the flowrate from the hole is quite low, however once the face line has passed, a peak quantity is released for a short period before levelling out for some distance and finally dropping back to a relatively low flowrate as shown in Figure 8. The point at which the peak flowrate is obtained and the length of the longwall for which gas may be efficiently drained is dependent upon the longwall geometry and strata relaxation behaviour.

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GAS CONTROL PROCEDURE FOR LOCAL CONDITIONS

For any geological environment and proposed mining conditions, the gas content test and stratigraphic study are examined in order to form an initial evaluation of the gassiness conditions. The validity of such an examination depends on the accuracy of the input data used for assumptions and the feasibility of methods available for both investigations and calculations. The recommended sequence for gassiness analysis is outlined on the flowchart in Figure 10.

Fig. 8. Methane captured from one uphole versus Longwall 4 face position, Pacific Colliery.

Post Drainage from the Sealed Roof Area

After the longwall is extracted and sealed from both ends, gas is still being emitted into the roof area from the surrounding strata and the unmined working seam. It is important that the correct quantity of gas is captured from the roof area during this post drainage period in order to maintain an equilibrium with the amount of gas being released from the strata.

Figure 9 represents the relationship which was typical for all the longwalls measured for post drainage with the initial flowrate being the main difference between the various longwalls. For the longwalls measured thus far, it has been determined that proportional relationships exist between the initial sealed roof gassiness and time.

Fig. 9. Methane captured after sealing the roof area of Longwall 4, Pacific Colliery.

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The selected method of gassiness prediction was based on a sound knowledge of the established worldwide methods (Borho & others, 1980) relevant to the conditions being experienced. The various assumptions made in each of the methods are assessed together with a comprehensive study of the local mining and geological environment to form a system which is acceptable to various conditions with particular attention to high coal production levels from the longwall. (Lunarzewski, 1987).

As more data becomes available, the accuracy of the gassiness predictions are continually modified in order to design an efficient ventilation system and gas drainage layout. The most effective system for monitoring the gassiness conditions involves computerised statistical methods based on establishing the caving zone together with regular gas balance and drainage flowrate measurements. This is particularly important when high coal production levels are anticipated from longwall panels.

As indicated in Figure 11, the predicted gassiness is the basis for planning the ventilation system at a colliery. If the available quantity of air is not sufficient to dilute the gas to acceptable values, then depending on the gassiness levels being anticipated, some combination of the following systems should be adopted:

(i) predrainage,
(ii) post-drainage during longwall extraction, and
(iii) drainage from the sealed goaf area.

The ability of the drainage system to capture gas should be considered as well as the limitations involved with various aspects of the operation such as:

- the inability to effectively predrain some working seams due to low in-seam permeability and porosity,
- limited access for drilling surface boreholes due to private properties or unsuitable topography,
- the inability to seal some goaf areas as a result of adjacent strata being previously relaxed,

However, if high production levels are anticipated for future longwalls, and each of these drainage systems are adopted (including sufficient lead time and the use of in-seam headings if required), it should be possible to maintain gassiness levels below the statutory requirements.

Fig. 11. Logical and necessary steps for designing the drainage systems at a colliery depending on the conditions being predicted.

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CONCLUSIONS

The basic relationships between gasiness and other parameters have been conducted for various Australian collieries resulting in the following:

- There is a strong correlation between total absolute gasiness and longwall coal production.
- For longwall coal production up to 15000 tonnes/day, selected gasiness prediction methods can be adopted to suit the local conditions if sufficient data is available.
- Drains from in-seam holes, cross-measure holes, and sealed goaf areas can be effective if such methods are used individually or simultaneously under different conditions.
- The ventilation system, coal drainage lead time, and the magnitude of the suction in the drainage line play important roles in obtaining high efficiency from the gas control methods.
- The proper sealing techniques adopted during and after longwall extraction can effectively control the emission of goaf gasiness for both safety and gas utilization purposes.

For very high coal production levels, a modified system for gasiness analyses is recommended which incorporates the establishment of the caving zone, gas balance, and gas drainage flowrate measurements during both development and longwall extraction.

When mining is conducted under a new environment involving high production levels, the existing ventilation methods and some combination of the drainage systems illustrated in Figure 11 may be successfully adopted if carried out in an efficient manner.

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