THE PRACTICAL METHOD OF HANDLING METHANE
IN A FULLY MECHANIZED HIGH OUTPUT COAL FACE

By

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ABSTRACT

There is a practical method of handling methane in a fully mechanized high output coal face when the methane outflow rate from the face is too high to be handled by ventilation alone, a combined method would be adopted. Before adopting this method, above all, the sources of methane outflow, which can be divided into methane in the intake airflow and methane emitted from the working seam and from the worked-out area, are determined by air-methane measurements in the tail gate and intake conveyor gate or by air-methane measurements in the working space of the coal face. Then, in the light of the methane sources, in the case of high methane outflow from the working seam, methane-predrainage and ventilation methods would be helpful; and in the case of high methane outflow from the worked-out area, the drawout of methane in the worked-out area by a gas-collecting heading or the drainage of methane of adjacent seams by boreholes (or roadways in roof rock) may be applied. Should the combined method be applied, the maximum possible productive capacity for a fully mechanized coal face under different conditions of methane outflow rate may be predicated. The briefly described practical example of a fully mechanized coal face with methane handling by a combined method (at Tangshan Coal Mine, Kaihua Mining Administration, PRC) demonstrates the practicality of the methods. The coal face produced 13446 tonnes of raw coal on Dec. 15th, 1977, the highest output on a single day basis in PRC.

1. INTRODUCTION

Nowadays coal face mechanization is developed year by year and the coal-face output is raised rapidly thanks to the development of coal mining technology, but the fact must not be ignored that there are difficulties to be faced in handling high methane and these difficulties even limit the productive capacity of the coal face. To effectively handle high methane for raising

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the coal-face productive capacity, first of all, sources of methane outflow at the coal face is analyzed.

2. PRACTICAL METHODS FOR ANALYZING METHANE SOURCES OF A COAL FACE

General — It is known that the outflow rate of methane at a coal face is the sum of outflow rates of methane from the working seam (or a working slice) and from adjacent seams or seam (other slices or slice in a thick seam) and methane quantity in the intake airflow. In order to determine each of these values, two practical methods usually applied in China's coal-mines are introduced.

First method — Air-methane measurements are made in the tail gate and intake conveyor gate of the coal face.

This method is very simple, but rough, and it is accomplished only with two measurements for a retreating face or one for an advancing face[1].

Retreating face

When the coal face has advanced 5-10 m from the start-working line and before the caving of the most adjacent seam in the worked-out area, the first air-methane measurement is to be accomplished during the regular coal production of the face as shown in Fig. 1-a. When the face has advanced for some distance and after the caving of all adjacent seams in the caved goaf, the second air-methane measurement is to be accomplished as shown in Fig. 1-b.

From these measurements, the methane outflow rate from the face wall (or from the working seam)

\[ Q_2 - Q_1, \text{ m}^3/\text{min}; \]

The methane outflow rate from the caved goaf (or from adjacent seams)

\[ (Q_2' - Q_1') - (Q_2 - Q_1), \text{ m}^3/\text{min}; \]

The methane quantity in the intake airflow

\[ Q_1', \text{ m}^3/\text{min} \]

where \( Q_1, Q_1' \) — The methane quantities to be calculated in the airflow of the intake conveyor gate at the first and second air-methane measurements respectively, \( \text{m}^3/\text{min} \);

\( Q_2, Q_2' \) — the methane quantities to be calculated in the airflow of the tail gate at the first and second measurements respectively, \( \text{m}^3/\text{min} \).

Advancing face

When the coal face has advanced for some distance from the start-working line and after the caving of all adjacent seams, air-methane measurements during regular coal production are to be accomplished at points 1, 2 and 3, as shown in Fig. 2.

From these measurements, the methane outflow rate from the face wall (or from the working seam)

\[ Q_2 - Q_1, \text{ m}^3/\text{min}; \]

The methane outflow rate from the caved goaf (or from adjacent seams)

\[ Q_2' - Q_1, \text{ m}^3/\text{min}; \]

The methane quantity in the intake airflow

\[ Q_1', \text{ m}^3/\text{min} \]

Second method — Air-methane measurements are made in the working space of the coal face.

This method means a great deal for retreating faces. First of all, a measuring cross-section of the coal face is selected 5-10 m below the tail gate, and further, the measuring cross-section is divided into 4-5 measuring spaces with nearly equal widths. The air-methane measurements are accomplished for each space. After these measurements, a diagram can be plotted as shown in Fig. 3.
the quantities advanced in the intake converge the first and second respectively, m3/min; the quantities advanced in the intake tail gate 2 and 3 respectively, m3/min. The results of analysis of methane sources for one coal face can be applied to new faces under similar geological and mining conditions. The principle of combination of effective methods of handling methane for a fully mechanized face is as follows:

When the methane outflow rate of a coal face is too high to be handled by ventilation alone, a combined method, including ventilation, the pre-drainage of methane in the working seam and either the drain-out of methane in the worked-out area or methane drainage directly from the adjacent seam, would be applied.

The applicability of the combined method is described as:

1. By face ventilation — An airflow is used to pass through the working space of the face for diluting methane emitted from the face wall to an allowable concentration and to bring the air-methane mixture into the tail gate.

2. By the method of methane pre-drainage in the working coal seam with its methane content = 10 m3/tonne[2] — If the methane content of the working seam is 10 m3/tonne, methane emitted from the face wall or broken coal is approximately 7.5 m3/tonne[2]. When such methane is handled by face ventilation, the productive capacity is limited to 3587 tonne/day, see Table 2. Should the coal face produce more coal, the methane pre-drainage in the working coal-seam by boreholes would be applied. The applications of borehole layouts for the methane-predrainage are shown in Table 1.

In general, the efficiency of 3 years' methane-predrainage in a working coal-seam of Pusan Coal Mining Administration, PRC is 20-30% of methane content of the coal seam[2].

It is of interest to note that the methane-predrainage efficiency is much higher when the upper or lower adjacent seam has been mined within an effectively pressure released area.

(3) By the method of handling methane emitted from adjacent seams only with an absolute methane outflow rate = 1.5 m3/min[2]

— When the methane outflow rate is 1.5 m3/min, the methane can be utilized as domestic fuel for 1800 households, because one household generally uses 9 m3 of 406 G everyday in coal-mining areas, PRC. When a coal face has advanced for some distance and adjacent seams cave in the gob or they are in a pressure-released state, the methane from such adjacent seams first outflows into the gob. If no airflow carries such methane away, methane comes into working spaces of the face. In order to avoid methane outflowing into the working spaces of the face, there are two methods usually applied for handling methane emitted from adjacent seams.

a. Drawing out of methane in the worked-out area by a gas-collecting heading. Let a small amount of air leak through the worked-out area for carrying the methane emitted from adjacent seams to a cut-through and to a special designed gas-collecting heading, as shown in Fig. 4.

In order to seal cut-throughs
the face one after another in allowable environment, the fresh air should be supplied to the gas-collecting heading, as shown in Fig. 4.

b. Draining out methane directly from adjacent seams by boreholes — Before methane emitted from adjacent seams moves into the worked-out area, methane-drainage boreholes are drilled for upper adjacent seams in the flexing zone, in order to decrease the fracturing and blocking of the boreholes, the length at the upper part of the borehole passing through the flexing zone should be as short as possible, as shown in Fig. 5. For lower adjacent seams, it is necessary to drill methane-drainage boreholes to lower adjacent seams.

4. MAXIMUM POSSIBLE PRODUCTIVE CAPACITY OF A FULLY MECHANIZED FACE WITH METHANE-HANDLING BY FACE VENTILATION ALONE

In the case where methane at the coal face is handled by face ventilation alone, productive capacity of the face will be limited by the allowable concentration of methane, and the maximum possible productive capacity ($T$) can be predicated by the following expression:

$$ T = \frac{864 \times 25 \times V \times C}{Q_{CH4} \times K}, \text{ tonne/day} \ldots (1) $$

Where $S$ — the effective cross-sectional area of powered supports for ventilation, $\text{m}^2$;

$V$ — The allowable maximum air velocity at a coal face, m/s (4 m/s set in the China's "Underground Coal Mine Safety Regulations");

$C$ — The allowable maximum methane concentration in the airflow of the tail gate, % (1.5% set in the China's "Underground Coal Mine Safety Regulations");

$Q_{CH4}$ — relative outflow of methane for the face, $\text{m}^3$/tonne;

864 — a constant, namely $24 \times 60 \times 60$.

Using the expression (1), Table 2 shows the maximum possible productive capacity for a fully mechanized coal face, assuming that $V=4$, $C=1.5$ and $K=1.3$.

5. MAXIMUM POSSIBLE PRODUCTIVE CAPACITY FOR A FULLY MECHANIZED FACE WITH METHANE-HANDLING BY THE COMBINED METHOD

The ideal handling of methane at the face is as follows:

(1) Methane emitted from the working coal seam — Methane is handled by methane-predrainage for 3 years, the drainage efficiency may reach 20-30% (average 25%) of the methane content of the working coal-seam. The rest of methane emitted from the face wall is cleared off by face ventilation with a sufficient quantity of air;

(2) Methane emitted from the adjacent seams — All of methane in the worked-out area is drawn out with a sufficient quantity of air through the worked-out area by a gas-collecting heading, or methane from adjacent seams is directly drained out by boreholes, its efficiency may be 50-70% (average 60%)\(^2\).

Thus after the methane-handling by the combined method, the maximum possible productive capacity of a fully mechanized face can be predicated as follows:

a. After methane in the working coal-
seam with its methane content \( \cong 10 \text{ m}^3/\text{tonne} \) has been pre-drained by boreholes, methane emitted from the face wall is cleared off by face ventilation and all of methane in the worked-out area is drawn out to a gas-collecting heading by leakage airflow, then the maximum possible productive capacity for a fully mechanized face can be predicated as:

\[
T = \frac{864 \times S \times V \times C}{K \times q_{\text{CH}_4}} \text{ tonne/day}
\]  

(2)

(for \( CH_4 \) content of the working coal-seam \( 10 \text{ m}^3/\text{tonne} \))

where \( q_{\text{CH}_4} \) — the relative outflow of methane for methane emitted from the face wall, \( m^3/\text{tonne} \).

\[
T = \frac{864 \times S \times V \times C}{K \times 0.75 \times q_{\text{CH}_4}} \text{ tonne/day}
\]  

(3)

(for \( CH_4 \) content of the working coal-seam \( \cong 10 \text{ m}^3/\text{tonne} \))

Again using the values \( V=4 \), \( C=1.5 \) and \( K=1.3 \), we can obtain the values of \( T \), calculated by expressions (2) and (3) which are shown in Table 3.

b. After methane in the working coal-seam with its methane content \( \cong 10 \text{ m}^3/\text{tonne} \) has been pre-drained by boreholes, methane emitted from the face wall has been cleared off by face ventilation and 50% of the methane has been drained out directly from the adjacent seams by boreholes, the maximum possible productive capacity for a fully mechanized coal-face can be predicated as:

\[
T = \frac{864 \times S \times V \times C}{K(q_{\text{CH}_4}+0.4(q_{\text{CH}_4}+q_{\text{CH}_4})} \text{ tonne/day}
\]  

(4)

(for \( CH_4 \) content of the working coal-seam \( \cong 10 \text{ m}^3/\text{tonne} \) and for methane emitted from adjacent seams with the absolute methane outflow rate \( \cong 1.5 \text{ m}^3/\text{min} \))

\[
T = \frac{864 \times S \times V \times C}{K(0.75q_{\text{CH}_4}+0.4q_{\text{CH}_4})} \text{ tonne/day}
\]

(5)

(for \( CH_4 \) content of the working coal-seam \( \cong 10 \text{ m}^3/\text{tonne} \) and for methane emitted from adjacent seams with the absolute methane outflow rate \( \cong 1.5 \text{ m}^3/\text{min} \))

Again, using the values \( V=4 \), \( C=1.5 \) and \( K=1.3 \), the values of \( T \) calculated by expressions (4) and (5) are shown in Table 4.

6. PRACTICAL EXAMPLE — A FULLY MECHANIZED COAL FACE PRODUCING 13446 TONNES OF RAW COAL ON DEC. 15TH, 1977, THE HIGHEST OUTPUT ON A SINGLE DAY BASIS IN PRC

This face No.5257 worked in No.5 seam with thickness of 2.2 – 2.6 m and dip of 10-15\(^\circ\) at Tianshui Coal Mine, Kailuan Mining Administration, PRC. The face plan is shown in Fig. 6. The length of the face was 300 m. This face was equipped with 2 EDW-170L type shearer, IK100/500HD frame type power supports. Before the start of the face, the values \( q_{\text{CH}_4}=2.5 \text{ m}^3/\text{tonne} \), and \( q_{\text{CH}_4}=1.5 \text{ m}^3/\text{tonne} \) were predicated. During the coal extraction, the methane at the face was handled by a combined method, namely by face ventilation and drawing-out of methane in the worked-out area. Air-methane measurements are shown in Fig. 6, by calculation \( q_{\text{CH}_4}=2.20 \text{ m}^3/\text{tonne} \) and \( q_{\text{CH}_4}=1.26 \text{ m}^3/\text{tonne} \). For this face the maximum possible productive capacity
7. CONCLUSIONS

(1) When the methane content of a coal seam is nearly 40 m$^3$/tonne or more, methane of this coal seam can be pre-drained out for a fully mechanized high output coal face;

(2) When upper or lower adjacent seam or seams exist and methane from adjacent seam or seams can be drained out at 1.5 m$^3$/min for a fully mechanized high output coal face, the methane drainage can be applied to the adjacent seams or seam or all of methane emitted into the worked-out area can be drawn out by a gas-collecting heading;

(3) A fully mechanized high output coal face could become a reality in the foreseeable future with the help of a combined method of handling methane, and it can be predicated that the combined method of handling methane will help more practicable methane handling method to come out so that the methane problem with fully mechanized high output coal face is to be solved in the 21st century.

REFERENCES


D. Guoguan and N. Yuanping

Fig. 1 — Air-methane measurements for a retreating face
1. 1' — measuring point at the intake conveyor gate;
2. 2' — measuring points at the tail gate; 3 — start-working line

Fig. 2 — Air-methane measurements for an advancing face
1 — measuring point at the intake conveyor gate;
2. 3 — measuring points at the tail gate;
4 — start-working line

Fig. 3 — Methane concentration against the measuring cross-section of the face

Fig. 4 — Layout of a borehole for draining out methane directly from adjacent seams
1 — working seam; 2 — upper adjacent seam;
3 — lower adjacent seam; 4 — caved zone;
5 = fractured zone; 6 — heating zone;
7 — boreholes; 8 — intake conveyor gate;
9 — tail gate; 10 — methane-drainage gate

The AusIMM Illawarra Branch, 21st Century Higher Production Coal Mining Systems—Their Implications, Wollongong, NSW, April 1988
305.
The maxima possible productive capacity for a fully mechanized coal face with methane-handling by ventilation method above T = 3000m, tonnes/day

Table 2

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The maxima possible productive capacity T (measured for a fully mechanised coal face with ventilation by a ventilation method) above T = 3000m, tonnes/day

Table 3

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306.
Table 8
The method possible pitch of face capacity $V$ (cubic m/s) for a fully mechanized coal face with overall/ventilation by a system of methods (including face ventilation; the methane drainage in the working coal-face and directly from adjacent seam)

<table>
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Notes: 1. by face ventilation; 2. by the methane drainage directly from adjacent seam; 3. by the methane ventilation in the working zone.