International Journal of Mining Science and Technology 24 (2014) 403–407

Contents lists available at ScienceDirect

International Journal of Mining Science and Technology

journal homepage: www.elsevier.com/locate/ijmst

Formation of methane hazard in longwall coal mines with increasingly higher production capacity

Krause Eugeniusz, Skiba Jacek *

Central Mining Institute – Experimental Mine "Barbara", Katowice 40-166, Poland

ARTICLE INFO

Article history:
Received 10 October 2013
Received in revised form 15 November 2013
Accepted 8 December 2013
Available online 29 April 2014

Keywords:
Methane hazard
Labour safety
Production capacity
Methane emission

ABSTRACT

Increasingly higher hard coal production capacity in Upper Silesian Coal Basin (Poland) in the last two decades led to significant increase of methane hazard occurrence in the workings of exploitation areas. An increase of methane content in the exploited seams and in the surrounding strata, associated with increasing depth of mining, results in higher methane emission into the longwall areas from exploited seams and degassing seams in the mining-induced de-stressed zone. Operational experience gained by the collieries confirms that reducing methane release during longwall operations often requires decreasing operating speed of a shearer in a shift. The paper presents an analysis of the parameters and factors, which have critical influence on the formation of methane hazard in longwall areas with high production capacity.

1. Introduction

Increased methane emission into longwall areas, observed over the last two decades, is a result of increased production capacity and exploitation of longwalls in the seams of higher saturation with methane, which is directly associated with the mining depth. The change in properties of coal seams, observed with increasing depth, i.e., an increase in methane content and a decrease in gas permeability, caused that, due to low efficiency of preliminary methane drainage, it was decided to give it up.

Simply increasing length of longwall working face at an unchanged advance rate results in an increase in both the production and the absolute methane content emitted into longwall areas. Ventilation methods of fighting methane hazard and the obtained results of drainage turned out to be insufficient to provide safe conditions for mining operations. The research confirmed discrepancies between forecast and real methane emission during exploitation. Underestimating the magnitude of methane emissions for a longwall design has a negative impact on appropriate selection of ventilation and methane drainage [1,2].

At the designing stage, such parameters as length, height and advance rate of a longwall determine its capacity, yet without considering vertical and horizontal haulage capacity and forecasted methane hazard.

Designing exploitation of longwalls situated in the seams with no or low methane content (methane content below 2.5 $m^3/CH_4/t_{daf}$) can be based upon the above mentioned parameters with assumed haulage capacity. In the seams with methane content over 2.5 $m^3/CH_4/t_{daf}$, a different approach is needed to determine safe production capacity.

Accurate estimation of methane hazard level, at the designing stage of exploitation, should be based upon the results of forecast with assuming different variants of longwall parameters (length and exploitation advance rate). Values of forecasted methane emissions for designed longwall constitute basis for selecting a ventilation system, ventilation parameters and methane drainage methods, as well as when specifying acceptable and safe production capacity.

The article describes an influence of basic parameters of a longwall on the forecasted volume of methane emissions into its area, taking into consideration of an assumed production capacity.

2. Influence of parameters on the volume of methane emitted into a longwall area

Methane emissions into a longwall area is a sum of its desorbable resources, released from the exploited seam, as well as from the current working face and adjacent seams as a result of mining-induced de-stressing of the rock mass [3].

Total methane content R_m, which is emitted into a longwall area, including impact from the desorption zone can be expressed with Eq. (1):

* Corresponding author. Tel.: +48 32 3246603.
E-mail address: jskiba@gig.eu (J. Skiba).

http://dx.doi.org/10.1016/j.ijmst.2014.03.020
2095-2686/© 2014 Published by Elsevier B.V. on behalf of China University of Mining & Technology.

$$R_m = R_{me} + \sum_{i=1}^{i=n} R_{mgi} + \sum_{j=1}^{j=m} R_{mdj} \quad (1)$$

where R_{me} is the desorbable methane content in the exploited seam, m^3CH_4; R_{mgi} the desorbable methane content in "i-time" underworked seam, m^3CH_4; R_{mdj} the desorbable methane content in "j-time" overworked seam, m^3CH_4; n the number of the underworked seams; and m the number of the overworked seams.

The magnitude of methane emissions depends on longwall advance rate, associated with developed fractures and de-stressing of the rock mass volume, which are triggers for methane emissions from coal seams and direct its flow to gobs and workings face.

The volume of desorbable methane content emitted while degassing the underworked and overworked seams, within the de-stressing range of an exploited longwall, is largely influenced by its length and inclination, which, in turn, influences the vertical cross-section through the desorption zone, and as a product of multiplication with the longwall advance, the volume of the de-stressed seam over and under the exploited longwall.

Determining the range of mining-induced de-stressed area, on the basis of the length and inclination angle of a longwall, allows identifying the underworked and overworked seams, which will be included in the desorption zone.

A geometric cross-section through the desorption zone for longwall length L_s and inclination α is presented in Fig. 1.

A vertical cross section through the desorption zone allows to calculate the values of degassing ranges h_g and h_d of the underworked and overworked layers, based on the equations [4]:

$$h_g = \frac{L_s}{G_g} \text{ and } h_d = \frac{L_s}{G_d} \quad (2)$$

where L_s is the longwall length, m; h_g the distance from the degassing range of the underworked seams, m; h_d the distance from the degassing of range of the overworked seams, m; and G_g, G_d the calculated values of coefficients for the longwall inclination angle between 0° and 50°.

The calculated values of the coefficients G_g and G_d for an inclination angle from 0° to 50° (every 5°) are presented in Table 1.

Fig. 2 shows, as a nomogram, values of h_g and h_d depending on longwall length L_s in the range from 0–400 m, and longwall inclination angle α between 0° and 50° [5].

The longwall length has a significant influence on the amount of methane emitted into the area. The influence of an advance rate is smaller. Assuming a constant area of exposed roof of the exploited longwall in a given time for variable parameters of length and advance rate, it is longwall length that has bigger influence on the size of mining-induced de-stressing zone, and also on the amount of methane emitted from the de-stressed seams [6,7].

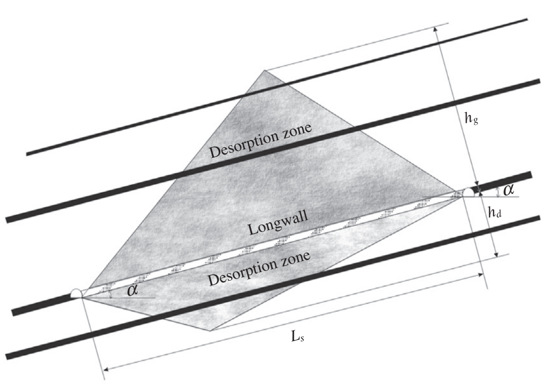

Fig. 1. Vertical cross section through the desorption zone of a longwall; length L_s, inclination α, h_g and h_d are respectively the distances of degasification range of underworked seams (in the roof) and overworked seams (in the floor).

Table 1
Values of coefficients G_g and G_d for different values of a longwall inclination angle.

Inclination angle of longwall (°)	G_g	G_d
0	1.45	3.91
5	1.47	3.96
10	1.49	4.00
25	1.60	4.21
30	1.64	4.28
35	1.70	4.43
40	1.76	4.57
45	1.94	4.95
50	2.12	5.33

The range of degassing coal seams surrounding a longwall is directly proportional to the length, and inversely proportional to its inclination. A vertical cross-section through the desorption zone consists of two triangles of which bases equal to the longwall length, and the volume of de-stressed seam is proportional to the face advance.

Fig. 3 below presents the areas of vertical cross-section de-stressed through exploitation with the longwalls of 150, 200, 250 and 300 m.

Table 2 presents the values of the area of a vertical cross section through the desorption zone of inclination 0° and length L = 150, 200, 250 and 300 m.

The volume of desorbable methane content emitted as a result of degassing an exploited seam, and the underworked and overworked seams (within the de-stressing range of the exploited longwall), is influenced by: longwall length and its inclination, which determines the area of a vertical cross-section through the desorption zone; and, as a product of multiplication with the longwall advance, the volume of de-stressed coal from the underworked and overworked seams, methane content of the exploited seam and the underworked and overworked seams, longwall height and the distance of the underworked and overworked seams from the exploited seam affecting the values of their degasification degree, roof management (caving, backfill).

For longwall design, the values mentioned in the points (2) and (3) depend mainly on geological and mining conditions and gas properties of the coal deposit. Considering above, the length and advance rate of the longwall have a substantial influence on the volume of de-stressed deposit, being degasified during coal exploitation in the underworked and overworked seams.

In the further part of the analysis, roof management in longwall exploitation was referred to caving method.

Methane emission into a longwall area depends on two designing parameters, i.e., longwall length and its advance rate. Increasing the length of a longwall at the unchanged advance rate has a much bigger influence on the amount of methane emitted into a longwall area, than increasing the advance rate at the unchanged length. Based on such a hypothesis, for a designed longwall, calculations of forecast methane emission were made with caving method, assuming different values of longwall length and advance rate for constant longwall production of 4000 tons per day [5].

The following assumptions were made: height of the longwall: h = 3.0 m, cutting depth of 0.8 m, methane content of the seam M_o = 7.57 $m^3/CH_4/t_{daf}$.

The calculated variant values of absolute methane-bearing capacity forecasts for the longwall with the lengths L_s = 150, 200, 250 and 300 m are presented in the consecutive rows of Table 3, as: amount of methane emitted directly into the longwall working, amount of methane emitted to the gobs of the longwall, total amount of methane emitted into the longwall area.