Study on the relation between advance rate of single seam working face and gas drainage volume

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Abstract. In order to understand the relation between advance rate of single seam working face and gas drainage volume, the parameter of gas concentration, differential pressure, temperature, absolute pressure is measured in gas drainage pipelines after highly or low-located holes gas drainage method is adopted in 1306 working face to the strike. The relation between advance rate of single seam working face and gas drainage volume is put forward by means of regression analysis method. The study results show that gas drainage volume in 1306 working face is in turn rising slowly, rising quickly then slowly, and stabilizing totally with the stoping of working face. As the number of boreholes is continually increased, gas drainage volume in working face is not significantly increased when advance rate is more than 80 m, and boreholes with low gas concentration and low mixing flow must be closed in time.

Introduction

With the advent of twenty-first century, the total amount of coal mine gas accidents has constantly declined in China, but there are still major gas-accident occur every now and then, which often happen in illegal productive coal mines [1-3]. Gas accident has become the first killer in coal mine production in view of statistics. The key to prevent gas accident is ventilation technology and gas drainage technology. However, many factors affect the effect of gas drainage in a working face, and the current research on gas drainage does not really combine coal mining and gas drainage to achieve the purpose of coal and gas simultaneous mining [4-6]. Based on the engineering background in 1306 working face on the strike in Shengli colliery in Sichuan province, the parameter of gas concentration, differential pressure, temperature, absolute pressure in 1306 intake roadway and in 1308 return roadway are measured for four months, finally the relation between advance rate of single seam working face and gas drainage volume is put forward by means of regression analysis method.

Engineering background

Designed mine capacity is 90 kt/a in Shengli colliery. Mine absolute gas emission rate is 20.17m³/min in 2016, belonging to a gassy mine. Gas drainage system with permanent pump station is established, two type 2EB1-303 gas drainage pumps are installed, their motor power is 90kW. Gas drainage main pipe's diameter is 250 mm, branch pipe's diameter 108 mm. 1306 working face is located in -100m level at the west wing of the third section in the tenth mining areas, 1306 roadway and 1308 roadway is respectively served as the intake roadway and return roadway of 1306 working face. The working face's strike length is 575 m, inclined length is 100 m, using longwall mining on the strike without coal pillar to mine. Hydraulic props are adopted to support roof, mining height is 0.7 m, the maximum and minimum face width is respectively 3.8 m and 2.8 m, goaf treatment method is partial stowing method. Mined K10d coal seam's thickness is 0.18 m to 0.52 m, coal seam dip angle is 3° to 5°. The up distance of K10d coal seam to K10m and K10s coal seam is respectively 0.2 m to 0.35 m and 0.69 m to 1.0m, the down distance of K10d coal seam to K11 coal seam is 4 m. Main roof of K10d coal seam is light gray fine sandstone, immediate roof is sandy shale and coal line, false roof is gray shale. Gas content in K10d coal seam is 7.39 m³/t, K10d coal seam gas pressure is 0.71 MPa, gas

permeability coefficient of K10d coal seam is 0.32 to 1.76 $\text{m}^2/(\text{MPa}^2 \cdot \text{d}^1)$, belonging to a moderate drainage coal seam.

Gas drainage method in 1306 working face

According to 1306 working face's workable coal seam and its adjacent unworkable coal seams, gas source, roof caving characteristics, et al, highly or low-located holes gas drainage method is adopted in 1306 working face to drain gas with pressure relief from workable K10d coal seam and unworkable K10m, K10s and K11 coal seams within the scope of mining-induced. The first and second drilling fields are arranged in front of the coal body of 18, 36 m from the working face's wall in 1308 return roadway, drilling fields spacing is 18 m, and 2 drilling fields are always kept at both the front and the rear of the coal wall. The first drilling field is arranged in the rear of goaf of 12 m from the working face's wall in 1306 intake roadway, with drilling fields spacing every 18 m. The working face's drilling fields layout is shown in Figure 1, drilling holes parameter is displayed in Table 1. Among them, No.1, 3 drilling hole is roof drilling holes in 1306 intake roadway, and No.2, 4 floor drilling holes. No.2, 4, 6 drilling hole is floor drilling holes in 1308 return roadway, and No.1, 3, 5 roof drilling holes [7].

Table 1 Drilling holes parameter in 1306 working face

Drilling sites	Hole	Hole diameter[mm]	Angel with roadway[(°)]	Hole angel [(°)]	Hole length[m]	Distance to (floor)roof[m]
intake roadway	1	65	40	29	30	17.5
	2	75	60	-22	40	20
	3	65	50	21	40	19.6
	4	75	70	-18	50	22.8
	5	75	30	-26	40	14.3
	6	75	90	-14	60	23.4
return roadway	1	65	40	29	30	17.5
	2	75	30	-26	40	14.3
	3	65	60	21	40	19.6
	4	75	60	-28	40	13.5

Figure 1. Layout sketch of drilling fields and drilling holes in 1306 working face

The relation between advance rate of single seam working face and gas drainage volume

Regression analysis method is used to analyze the measured data between the intake roadway's gas drainage volume, the return roadway's gas drainage volume, the working face's gas drainage volume and advance rate shown in Figure 2 [8]. The relation between the intake roadway's gas drainage

volume, the return roadway's gas drainage volume, the working face's gas drainage volume and advance rate is put forward.

Figure 2. The relation between advance rate and gas drainage volume in 1306 working face

With the stoping of working face, when advance rate is 12.1 m to 50.6 m, gas drainage volume in 1306 intake roadway is slowly increasing to 1.2 m³/min. When advance rate is 50.6 m to 84.7 m, gas drainage volume in 1306 intake roadway is sharply rising from 1.2 m³/min to the maximum 3.1 m³/min. When advance rate is 84.7 m to 167.2 m, gas drainage volume in 1306 intake roadway is around 3 m³/min. The relationship between the working face's advance rate x (m) and gas drainage volume in 1306 intake roadway Q_1 (m³/min) is shown in equation 1.

$$Q_1 = -0.0002x^2 + 0.0534x - 0.7659, R^2 = 0.9211 \quad (1)$$

Where, R^2 is the determination coefficient of regression equation.

With the stoping of working face, when advance rate is 12.1 m to 68.2 m, gas drainage volume in 1308 return roadway is slowly increasing up to the maximum 1.64 m³/min. When advance rate is 68.2 m to 167.2 m, gas drainage volume in 1308 return roadway is slowly declined from 1.64 m³/min, then slowly increasing to about 1 m³/min. The relationship between the working face's advance rate x (m) and gas drainage volume in 1308 return roadway Q_2 (m³/min) is shown in equation 2.

$$Q = \begin{cases} 0.0004x^2 - 0.0102x + 0.1624, R^2 = 0.9654 \\ 0.0002x^2 - 0.0477x + 3.9521, R^2 = 0.8745 \end{cases} \quad (2)$$

Gas drainage volume in 1306 working face is termed as the sum of gas drainage volume in 1306 intake roadway and gas drainage volume in 1308 return roadway. With the stoping of working face, when advance rate is 12.1 m to 50.6 m, gas drainage volume in 1306 working face is slowly increasing to 2.06 m³/min. When advance rate is 50 m to 89.1 m, gas drainage volume in 1306 working face is rising from 2.06 m³/min to the maximum 4.34 m³/min. When advance rate is 89.1 m to 167.2 m, gas drainage volume fluctuates in the level of 4 m³/min. The relation between the working face's advance rate x (m) and gas drainage volume in 1306 working face Q (m³/min) is shown in equation 3.

$$Q = -0.0003x^2 + 0.0785x - 1.0045, R^2 = 0.9074 \quad (3)$$

The average gas drainage volume in 1306 intake roadway and in 1308 return roadway is respectively 1.5638 m³/min and 0.6296 m³/min, gas drainage volume in 1306 intake roadway is 2.48 times more than that in 1308 return roadway. The reason is that there are only 4 drilling fields in 1308 return roadway when 1306 working face is advanced. But a new drilling field is arranged in 1306 intake roadway every 18 m, the number of drilling fields is naturally increased.

Gas drainage volume in 1306 working face is respectively increasing slowly, rising rapidly then slowly, and stabilizing totally with the stoping of working face. When the working face's advance rate is more than 80 m, gas drainage volume in 1306 working face is not significantly increased as the

number of drilling holes is continuously increased, that is, gas drainage volume is generally stabilized on about $4\text{m}^3/\text{min}$.

Conclusion

Gas drainage volume in 1306 working face is respectively rising slowly, rising quickly then slowly, and stabilizing totally with the stopping of working face.

Under certain conditions of mine gas drainage ability, as the number of boreholes is continually increased, gas drainage volume in 1306 working face is generally stabilized on about $4\text{m}^3/\text{min}$ when advance rate is more than 80 m, and boreholes with low gas concentration and low mixing flow must be closed in time.

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