A Study on Layout Area of Roof Highly-Located Gas Drainage Holes

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***Abstract* — Based on the characteristics of contiguous seams, gassy thin coal seam, poor gas permeability and large gas emission rate for working face 1404 in FengHuang coalmine, a roof highly-located holes gas drainage method was chosen as the main gas drainage method, and a suitable layout area of roof highly-located holes and some reasonable drilling parameters were ascertained by means of field measurement of gas drainage volume and gas concentration. The practical result has shown that the layout area of roof highly-located holes gas drainage method is suitable for the actual condition in working face 1404 under the condition of contiguous seams; the gas drainage efficiency is 66.92 % in working face 1404 after gas drainage; the gas concentration in upper and down return airways is kept stable at 0.27 % to 0.35 %; the gas concentration in upper and down return airway corners is kept stable at 0.31 % to 0.63 %; the phenomenon of gas-over-limit has been eliminated; the gas drainage standards in working face 1404 have been reached; the safe and efficient exploitation has been achieved when the roof highly-located holes gas drainage method was applied in working face 1404.**

Keywords - contiguous seams; roof highly-located gas drainage holes; O-shape cycle of gas flow; layout area; relief-pressure gas

I. INTRODUCTION

Gas drainage with pressure relief technology has been widely used in gassy mines as well as coal and gas outburst mines in China. The key to reach gas drainage standard depends on how to correctly choose the gas drainage method, how to reasonably design drilling parameters and arrange the gas drainage drilling area [1-3].Under the condition of contiguous seams, gas emission in the return airway of first mining face mainly comes from mining seam, gob and adjacent coal seams, and the gas emission rate in the first mining face is the largest [4]. Based on the references [5-12], the layout area of roof highly-located gas drainage holes is experimentally studied in FengHuang coalmine 1404 working face. The practice result has shown that the layout area of roof highly-located gas drainage holes is suitable for the actual condition in 1404 working face, roof highly-located holes gas drainage method has the characteristics such as wide range of gas drainage, large gas drainage quantity and high gas drainage concentration. The phenomenon of gas-over-limit is eliminated and the gas drainage standard in 1404 working face is reached.

II. THE PRINCIPLE OF PRESSURE-RELIEVED GAS DRAINAGE

According to the theory of strata movement, stress in virgin rock mass redistribute under mining influence of key pressure-relieved layer, and mining-induced stress appears in the seam and surrounding rock. Along with mining advance of working face, immediate roof will bold and fall when the span of immediate roof is suspended to a certain limit value. Hard rock strata of roof called key strata will deform and cave, which forms the first weighting of main roof. Later, key strata will break once every certain period and length. Caving zone, fissure zone and sagging zone appears successively in the overlying strata of the gob from bottom to top. Underlying strata heave and rupture, and floor heave fissure zone and floor heave sagging zone emerge in sequence from top to bottom. Roof coal or rock mass in caving zone irregularly stacks, fissure development area around the gob four-side is distributed in O-shape cycle. Because gas is lighter than air, under the effect of air buoyancy, pressure-relieved gas in the gob is easily accumulated in the fissure development space of O-shape cycle in the upper caving zone, sketch of O-shape cycle in the gob is shown in Figure 1. Roof coal or rock mass in fissure zone get pressure-relieved expansion deformation, which leads to fissures, beddings and joints development, and connects with caving zone, which provides a good storage space for pressure-relieved gas in the gob. Meantime, gas permeability of coal seam in sagging zone is significantly increased, coal or rock mass located in upper fissure zone and down sagging zone provides a good channel to drain highly-located pressure-relieved gas. Pressure-relieved gas in the mining seam and mining-affected seams is released and desorbed after exploitation, it flows together to fissure development space in O-shape cycle. Applicable gas drainage method and suitable holes parameter is selected, and the bottom of holes are located at the fissure development space in O-shape cycle, gas with high concentration and large flow is efficiently drained [13-18].

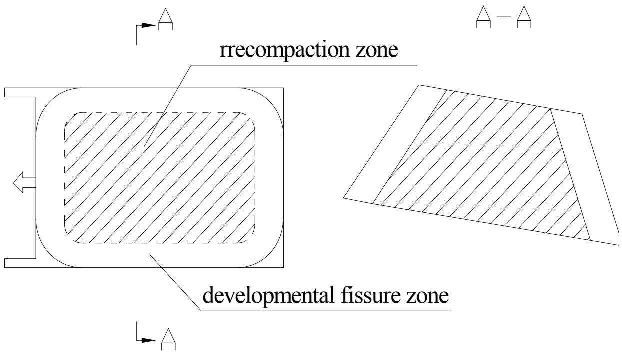

Figure 1. Sketch of O-shape cycle in the gob

III. GENERAL SITUATION IN TEST AREA

FengHuang Coalmine is identified as gassy mine, and its absolute gas emission rate is 58.64 m^3/min in 2016, which includes absolute gas emission rate 17.05 m^3/min in 1404 working face. Two 2EBC50 type gas drainage pumps are installed in mine gas drainage system, motor power is 220 kW. The diameter of main gas drainage pipe, branch gas drainage pipe are respectively 250 mm and 140 mm. The coal seam Shang Xia Lian is firstly mined in 1404 working face at the +730 m level, its thickness is 0.45 m to 0.6 m and dip angle is 5 ° to 11 °. Roof is composed of soft to medium hard mudstone, sandy mudstone and medium-thick argillaceous sandstone, and floor is composed of thick mudstone and sandy mudstone. Coal seam Shang Xia Lian is under 31.5 m away from coal seam Shuang Long and under 77.5 m away from coal seam San Huang Si Tan, it is above 35 m away from coal seam Du Lian. Double-unit longwall mining on the strike is accepted in 1404 working face, the length of double-unit working face is 2×100 m, mining height is 1.2 m. Roof is supported by DW1200 hydraulic props and DJB-1200 metal articulated roof beam, row spacing is 1200 mm, prop spacing is 700 mm. The maximum and minimum face width is respectively 3600 mm and 2400 mm, roof is controlled by partly-stowing method. The W-type ventilation method of intake air in the haulage gateway and return air in the upper and down return airways is used in 1404 working face, and required airflow is 900 m^3/min[19].Layout of double-unit working face is shown in Figure 2.

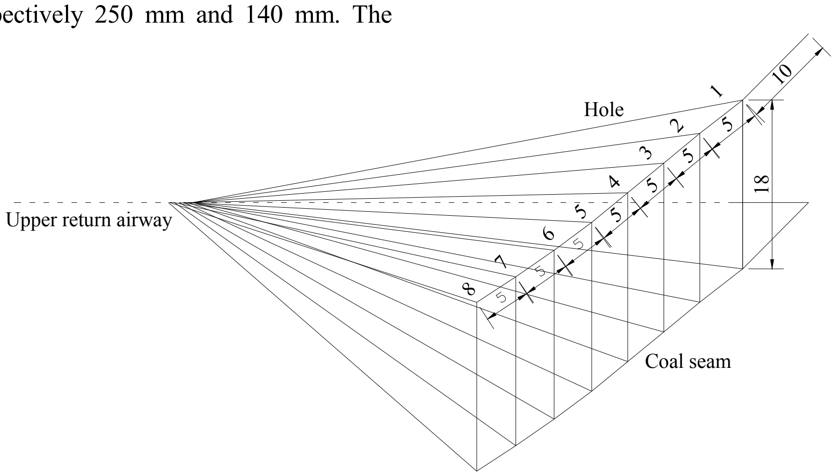

Figure 2. Sketch of roof highly-located gas drainage holes (unit: m)

IV. ROOF HIGHLY-LOCATED HOLES GAS DRAINAGE METHOD

According to the basic condition in 1404 working face and gas drainage experience in adjacent coalmines, holes parameters of roof highly-located holes gas drainage method are shown in Figure 2. Borehole diameter is 90 mm, borehole length is 60 m, the end of the borehole is 18 m away from the roof of coal seam Shang Xia Lian, dip angle of borehole in the upper and down return airways is orderly 10 ° to 16 ° and 19 ° to 26 °. No.1 to 8 boreholes are arranged in a drilling field, and these boreholes are evenly distributed within the range from 10 m to 45 m away from upper or down return airway. The first drilling field in the upper and down return airways in front of the coalface wall is arranged 40 m to 60 m away from the open-off cut, interval between drilling fields is 30 m, sealing-hole length is not less than 8 m. The coal pillar with length × width =20×6 m is reserved in the upper and down return airways behind the coalface wall. In view of the gas is lighter than air, drilling fields behind the coalface in the center position of coal pillar in upper return airway wall are only arranged, and interval between drilling fields is 15 m. The plan graph of gas drainage holes in drill fields is shown in Figure 3 in 1404 working face.

V. THE LAYOUT AREA OF ROOF HIGHLY-LOCATED HOLES

The relation between gas drainage volume in front of working face and the distance to the coalface wall is shown in Figure 4. All of 8 boreholes in a drilling field in upper return airway have gas flow. When the strike distance is 5 m to 7.5 m away from the coalface wall, gas drainage volume of 8 boreholes in a drilling field is fast increased from 0.18

m^3/min to 0.75 m^3/min, and gas concentration of boreholes is 16 % to 33 %. Gas drainage volume of 8 boreholes in a drilling field is upward when the strike distance is 7.5 m to 32 m away from the coalface wall, gas drainage volume of 8 boreholes in a drilling field is increased from 0.75 m3/min and 1.19 m3/min, gas concentration of boreholes is 32 % to 68 %. When the strike distance is beyond 32 m to 50 m away from the coalface wall, gas drainage volume of 8 boreholes in a drilling field is reduced to 0.6 m3/min, gas concentration of boreholes is 56 % to 68 %. Only No.3 to 8 boreholes in a drilling field in down return airway has gas flow. When the strike distance is 2.5 m to 17 m away from the coalface wall, gas drainage volume of 6 boreholes in a drilling field is fast increased from 0.02 m3/min to 0.34 m3/min, and gas concentration of boreholes is 14 % to 56 %. Gas drainage volume of 6 boreholes in a drilling field is reduced to 0.22 m3/min from 0.34 m3/min when the strike distance is 17 m to29.5 m away from the coalface wall, and gas concentration of boreholes is 56 % to 48 %. Gas drainage volume of 6 boreholes in a drilling field is 0.2 m^3/min to 0.28 m^3/min, and gas concentration of borehole is 41 % to 50 % when the strike distance is 29.5 m to 45 m away from the coalface wall.

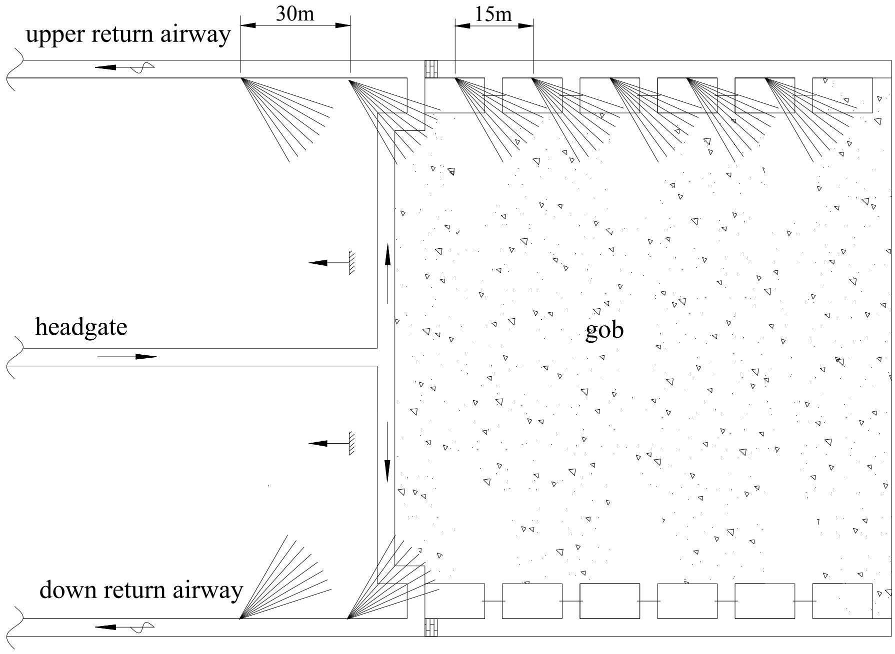

Figure 3. The plan graph of double-unit working face and drilling fields

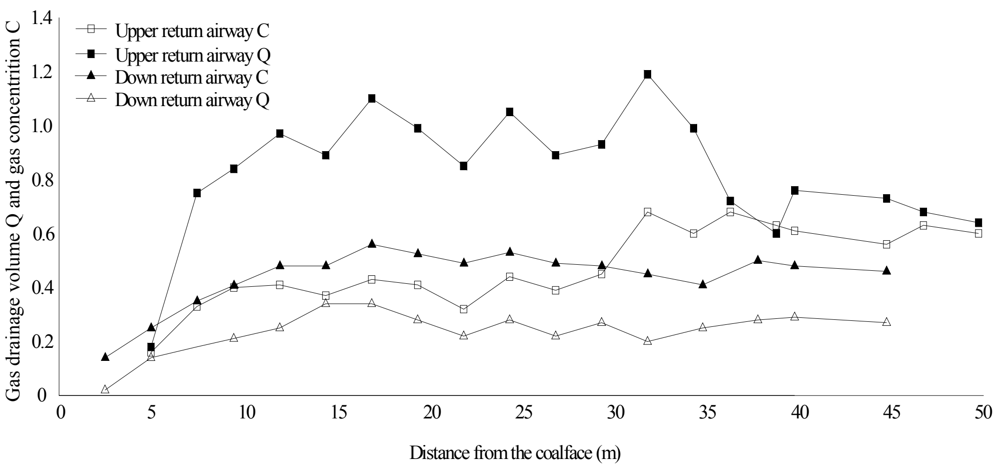

Figure 4. The relationship between gas drainage volume in front of working face and the distance

The relation between gas drainage volume in front of working face and the dip distance to upper or down return airway is shown in Figure 5. Gas drainage volume in a drilling hole is increased in upper part of working face when the dip distance is 10 m to 20 m away from upper return airway, and the largest gas drainage volume in a drilling hole is 0.194 m^3/min at the dip distance 20 m away from upper return airway, and gas concentration in a drilling hole is 24 % to 44 %. When the dip distance is 20 m to 40 m away from upper return airway, gas drainage volume in a drilling hole is reduced from 0.194 m^3/min to 0.092 m^3/min, and gas concentration in a drilling hole is 44 % to 52 %.When the dip distance is 40 m to 45 m away from upper return airway, gas down return airway, gas drainage volume in a drilling hole is kept from 0.034 m^3/min to 0.038 m^3/min, and gas concentration in a drilling hole is increased from 37 % to 46 % when the dip distance is 30 m to 40 m away from down drainage volume in a drilling hole is reduced from 0.093 m^3/min to 0.04 m^3/min, and gas concentration is reduced from 51 % to 39 %. Gas drainage volume in a drilling hole is upward gradually in down part of working face when the dip distance is 10 m to 30 m away from down return airway, and the largest gas drainage volume in a drilling hole is 0.038 m^3/min at the dip distance 30 m away from down return airway, and gas concentration in a drilling hole is 34 % to 40 %. When the dip distance is 30 m to 45 m away from return airway, then gas concentration is fast reduced to 20 % within the distance of 40 m to 45 m away from down return airway.

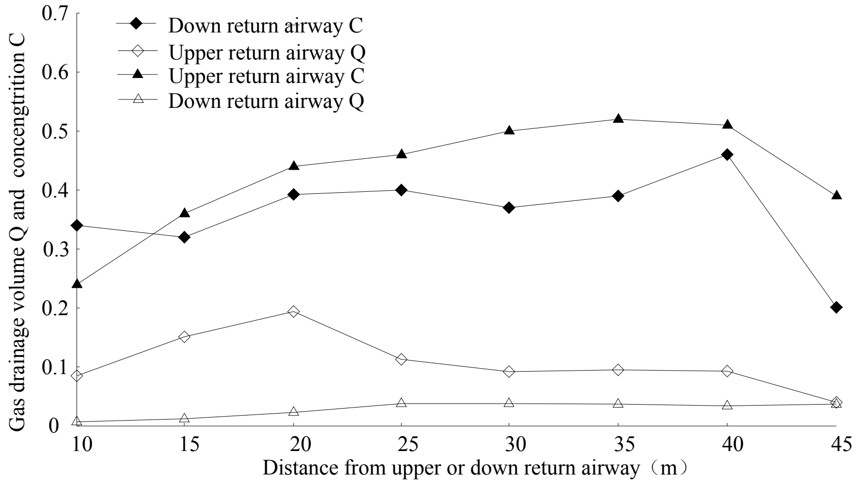

Figure 5. The relationship between gas drainage volume in front of working face and the distance

There, two drilling fields which drilling fields interval is 30 m are respectively arranged in upper and down return airways in front of 1404 working face, which totally comes to 32 roof highly-located holes. Six drilling fields which drilling fields interval is 15 m are arranged in upper return airway behind 1404 working face, which totally comes to 48 highly-located holes. The actual measurement results of gas drainage volume in upper and down return airways of 1404 working face are shown in Table 1.The average gas drainage volume in upper and down return airways of 1404 working face is respectively 10.95 m^3/min and 0.46 m^3/min. So, the gas drainage volume of 1404 working face is 11.41m^3/min, and its gas drainage efficiency is 66.92 %. Besides, gas concentration in upper and down return airways of 1404 working face is kept stable at 0.27 % to 0.35 %, and gas concentration in upper and down return airway corners is kept stable at 0.31 % to 0.63 %, and gas drainage standard in 1404 working face is reached [20-22].

TABLE 1. GAS DRAINAGE VOLUME IN 1404 WORKING FACE

Measurement time [date/month]	1/8	3/8	5/8	7/8	9/8	11/8	13/8	15/8	16/8
upper return airway [m^3/min]	10.9	10.65	10.89	11.09	10.2	10.45	11.58	10.42	10.42
down return airway [m^3/min]	0.4	0.45	0.49	0.46	0.41	0.54	0.5	0.56	0.56
Measurement time [date/month]	18/8	20/8	222/8	23/8	25/8	27/8	29/78	30/8	31/8
upper return airway [m^3/min]	10.72	11.3	11.64	11.13	10.94	11.21	11.12	10.673	10.73
down return airway [m^3/min]	0.43	0.44	0.68	0.68	0.56	0.36	0.28	0.36	0.34

The results has shown that roof highly-located holes gas drainage method is suitable for the actual condition of 1404 working face, gas emission rate from the mining seam and mining-affected seams is greatly reduced after drainage, the phenomenon of gas-over-limit is eliminated and the gas drainage standard in 1404 working face is reached, which provides guarantee for safe and efficient production in 1404 working face. The reasonable layout area of holes mainly includes the following contents, two drilling fields are respectively arranged in upper and down return airways in front of 1404 working face, interval between drilling fields is 30 m, drilling fields are only arranged in upper return airway behind working face and interval between drilling fields is 15 m, 6 holes in a drilling field are evenly distributed within the range from 20 m to 45 m away from down return airway, 8 holes in a drilling field are evenly distributed within the range from 10 m to 45 m away from upper return airway.

Overlapping length between drilling fields ahead the coalface wall is only 0.1 m to 5.8 m when interval between drilling fields is 30 m, there interval between drilling fields in front of 1404 working face is reduced to 25 m to ensure continuous and stable gas flow.

VI. CONCLUSIONS

Roof highly-located holes gas drainage method is technically feasible in 1404 working face under the condition of contiguous seams, gassy thin coal seam, poor gas permeability and large gas emission rate, so this method is suitable for the actual situation of 1404 working face.

The phenomenon of gas-over-limit is eliminated, and gas drainage standard in 1404 working face is reached after drainage. Safe and high-efficient exploitation is achieved when roof highly-located holes gas drainage method is applied in 1404 working face.

Reasonable layout area of boreholes mainly includes the following contents, two drilling fields which interval between drilling fields is 25 m are respectively arranged in upper and down return airways in front of 1404 working face,40 m to 60 m away from the coalface wall, drilling fields which drilling field interval is 12.5 m is only arranged in upper return airways behind the coalface wall, 6 holes in a drilling field are evenly distributed within the range from 20 m to 45 m away from down return airway, 8 holes in a drilling field are evenly distributed within the range from 10 m to 45 m away from upper return airway.

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