Research on Gas Treatment Technology in The Work Surface of Dasher Coal Mine

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Abstract: Based on the principle of gas formation on the coal mining work surface, the article analyzes the main source of gas in the mining area of Dashe coal mine, finds out all kinds of problems existing in the pumping of the upper angle intring tube, and summarizes the real reasons for the backwind of the work surface and the gas exceeding the limit of the upper angle. In view of these reasons, combined with the principle of the formation of the upper angle gas, the mine on the upper angle intring process construction of the intring depth, height and interception area of the investigation, to obtain the best pumping value under different conditions, and according to the results of the inspection in the 21704 work surface test and transformation, and achieved a better pumping effect; According to the test results, the field effectively controls the work surface and the upper angle gas exceeding the limit, ensures the safe production of the work surface and the mine, and provides reference and reference for the treatment of the angle gas on the work surface under the same type of condition.

1. Introduction
In recent years, with the increase of coal mine service time, the mining area has been increasing, and the area of many mining areas has gradually increased. At the same time, many mines in the coal seam mining process, only pay attention to the mining of coal seam gas extraction and management, for the safe distance, mining value is not much of the adjacent layer, but ignored gas management; Coupled with the work surface of the traditional U-type ventilation method cannot be very good to solve the problem of the back-to-the-surface angle gas over-limit, resulting in many mines in the work surface re-extraction process, easy to cause the work surface angle gas over-limit "[1-2].

Dasher Coal Mine is in the north and west of Shizong County, 350 degrees direction, the nature of state-owned enterprises. The mining area range is determined by 11 inflection point coordinate coils, the mining area direction (north-south) length average of about 1.36km, the tendency (east-west) width average of about 1.33km, the mining area of about 1.8075km², mining height of 2050m to 1518.6m. Mine recess able reserves 9539kt, design production capacity of 300kt/a, mine design service life of 22.7a. There are 10 coal seams in the whole area, of which M17 is the coal seam that can be extracted in the whole area, and it is also the main coal seam in the mine. M3, M6, M16, M19, M21, M21², M22 are locally available coal seams, and M6, M16 and M20 are non-mining seams.

In order to prevent the occurrence of coal and gas prominent accidents, to ensure the safe production of the mine, and effectively implement the national "first pumping and then mining (excavation)"
policy[3], the mine in 2007 installed an extraction system, and the mine's main coal seam, mining area, upper corner, etc. After extraction by gas, the concentration of backwind gas on the work surface decreased significantly compared with the previous one, and the number of gas exceeding the upper angle gas was also reduced. However, due to the lack of technical force of the mine, the construction process of the angle pumping method on the work surface is not mastered enough, resulting in the phenomenon of angle gas over-limiting on the work surface occurs from time to time. In order to completely solve the problem of gas exceeding the limit on the work surface, Dashe Coal Mine commissioned the relevant gas treatment unit, carried out on-site investigation and search on the problems of the gas treatment process in the upper angle, and put forward solutions to the problem, and arranged 21704 work surface for testing.

2. **Construction of gas extraction system**

Dashe coal mine is a high gas mine, the mine commissioned the relevant units to design the gas extraction system, and in accordance with the design requirements of the system construction. A total of two sets of extraction systems (high and low negative pressure systems) were built in the mine, of which the high negative pressure system was equipped with two 2BEC-420 water ring vacuum pumps, with a motor power of 185KW, a maximum pumping capacity of 120m³/min, and 1 ready for use. Low negative pressure system equipped with 2BE1-353 water ring vacuum pump 2, motor power 132KW, the maximum suction capacity of 90m³/min, 1 ready for 1 use, its pipeline selection see Table 1.

### Table 1  
**Dashe coal mine gas extraction system pipeline selection table**

| Name of gas pipeline | Unit | Pipe diameter of high negative pressure system | Pipe diameter of low negative pressure system | Pipe type          |
|---------------------|------|-----------------------------------------------|---------------------------------------------|--------------------|
| main line           | mm   | Ф500×29.7                                      | Ф400×23.7                                   | polyethylene pipe  |
| trunk line          | mm   | Ф450×26.7                                      | Ф400×23.7                                   | polyethylene pipe  |
| branch line         | mm   | Ф355×21.1                                      | Ф300×18.7                                   | polyethylene pipe  |
| branch line         | mm   | Ф160×9.5                                       | Ф225×13.4                                   | polyethylene pipe  |

3. **Principle of gas accumulation in upper corner**

In the coal mining process, the angle of the work surface is the air leakage and leakage of the mining area, because of the floating movement and diffusion movement of the gas, the gas in the mining area escapes outwards, resulting in the accumulation of gas in the upper corner. At the same time, the upper corner of the wind is easy to form a vortex area, the accumulation of gas is difficult to be taken away by the wind, easy to cause gas over-limit, is a major hidden danger of coal mine safety, directly affect the speed of work surface propulsion, restrict production[4-10].

![Figure 1  Schematic diagram of the upper corner return air eddy current form](image-url)
It can be known from the principle of gas accumulation in the upper angle that the accumulation of gas in the upper angle is the result of the floating motion of the gas, the diffusion movement, the pressure difference inside and outside the upper angle, and the leakage of the working surface. Therefore, the effect of the discharge of the buried tube is not only related to the width of the upper angle integer (the width of the interceptor surface), but also related to the height distribution of the buried pipe [11-15].

4. The construction process and effect of gas treatment in the upper corner of the mine

4.1. Analysis of the source of gas in the upper corner
(1) The coal wall parses the gas
With the advance of the work surface, the newly exposed coal wall under the joint effect of stress and gas pressure, will continue to pour out of the analytical gas to the return work surface, this part of the gas is affected by the flow of the work surface into the work surface mining area. Although this part of the gas gushing out is not large, it is also one of the factors affecting the size of the gas gushing out of the upper angle.

(2) Work surface fall coal analysis
Although the Dasher coal mine pre-pumped the coal mining surface, but because of the poor breathability coefficient of the coal seam, the coal seam gas content is higher, the coal body is relatively soft and other reasons, coupled with the mine in the extraction process did not take any measures to increase the penetration, resulting in the mine gas pre-extraction effect is not very ideal, the residual gas content of the coal seam is still high. Therefore, in the process of the work surface in the process of propulsion, with the completion of the coal discharge process, a large number of complete coal body into a higher degree of fragmentation of coal blocks and coal powder, part of the gas from adsorption state to free state and release, and with the work surface wind flow into the mining area, resulting in an increase in the amount of gas gushing out of the upper angle. The gas gushing out of the broken coal body is one of the important reasons for the gas gushing out of the angle on the working surface of the Dasher coal mine.

(3) Gas Emission from adjacent coal seams
It can be known from the geological survey data of the mine that the Dashe coal mine is a coal seam group, and there are many locally extractable coals seams in the top and bottom plates of the M17 coal seam. Moreover, the Dasher coal mine has not taken any pumping measures on the adjacent seams. As the work surface advances, the top floor will create many fissures in the coal seam after the pressure is discharged, and the breathability of the coal seam will increase, and adjacent layer gas will flow directly along the fissure out of the mining area. The gas gushing out of the adjacent layer will be the main reason that affects the gas exceeding the angle on the working surface of the M17 coal seam of Dashe Coal Mine. In addition, there are a small amount of coal seams left in the mining area, which will also release some of the gas, but this part of the gas gushing out is relatively small.

4.2. Work surface pre-pumping and upper angle gas treatment process
(1) The gas extraction effect of the work surface
The gas treatment of Dasher coal mine is mainly carried out by the pumping method which is mainly based on drilling pre-pumping in the lower layer of the mining layer and is supplemented by the pumping and discharge of the upper angle burial pipe. Before the work surface is re-harvested, the mine drills the work surface down-layer pre-pumping. Drilling spacing is 5m, drilling diameter is 75mm, the pre-pumping time is tentatively set at 6 months (if the gas content is higher than 8m³/t at the time of inspection reasonable extension of the pre-pumping time). Due to the high gas content of M17 coal seam gas (the original gas content is 11.2m³/t, the local area is slightly higher than this value), the breathability is poor, the mine did not take measures to increase the permeability measures; Coupled with the weak technical force of mine gas treatment, there are some problems in drilling construction, sealing process and so on, so the pre-pumping effect is not ideal. From the effect test analysis, the residual gas content of the work surface can only meet the requirements of anti-burst, but cannot meet the requirements of extraction standards.
(2) The gas treatment process in the work surface mining area

In order to prevent the work surface return wind and the upper angle gas concentration exceed the limit during the work surface propulsion, the mine for the work surface angle investor pumping. In the process of inuring pumping construction, the mine uses a 225×13.4mm polyethylene tube inserted into the upper angle, the inuring depth (the pipe port and bag strong inner wall distance) is 0.5m, the pipe is stacked on top of the soleplate, parallel to the backwind laneway. In order to prevent cinders and so on from entering the tube, the tube port is wrapped in a screen. Sealing walls are made of cement fiber bags filled with cinders, and the bags and bags are self-sealed using cinder gravity without adding any sealing measures or materials. The height of the bag wall is consistent with the height of the drop in the upper corner, and the bag is placed in the wrong place between the bag and the bag. The width of the closed wall is the horizontal width of the two rows of bags, about 1.2m wide, and its buried pipe pumping construction process diagram is shown in Figure 2.

Figure 2 The arrangement of the angle inserting tube on the working surface of the Dashe coal mine

4.3. Gas extraction effect

According to the site inspection, the upper angle gas pumping mixture is 21m3/min, gas pumping concentration is 5% to 7%, pumping purity is 1.05 m3/min to 1.47m3/min, the negative pressure of the tube mouth is small. Although the upper angle buried pipe pumping to a certain extent reduced the number of upper angle gas over-limit, but the work surface angle gas over-limit phenomenon has not been effectively controlled, buried pipe pumping did not achieve the desired purpose. The upper angle gas concentration exceeds the limit more times, the maximum gas concentration can reach about 3%, the working surface backwind gas concentration also has the phenomenon of exceeding the limit, the gas concentration can reach 1.3% during the discharge.

4.4. The cause of the angled gas exceeds the limit on the work surface

Through on-site research and analysis, the main reasons for the over-limiting of gas on the surface of Dashe Coal Mine are as follows:

(1) The work surface gas extraction did not achieve the real extraction standard according to the provisional method of extraction standard

Although the mine pre-pumped the work surface, from the effect evaluation report analysis, although the residual gas content of the work surface to meet the requirements of anti-burst, but not in accordance with the requirements of the provisional measures to meet the extraction standards, the gas content was reduced to below the specified value, the residual gas content and resolvable gas content is still high.

(2) No extraction measures were taken for adjacent coal seam gas, and the pressure relief gas was larger

Through on-site investigation, it was found that the mine did not take any measures on the adjacent coal seam gas of the main coal seam, resulting in a large amount of pressure-relief gas in the adjacent layer, which is one of the reasons for the over-limiting of the gas in the corner of the work surface. At the same time, the mine coal mining process for gun mining, each gun drops a relatively large amount of coal, the work surface instantaneous gas gushing out of a larger amount.
(3) The method of gas extraction of buried pipes in the mining area is not standardized
The pumping of the upper angle insert is not standardized, resulting in poor gas pumping in the mining area, mainly reflected in:

a. The inserting depth and inserting width design is problematic, and the upper angle gas is not effectively intercepted, resulting in insufficient mixing flow for the whole discharge.

b. The construction of the closed wall is too simple, and its poor sealing results in a low pumping concentration.

c. Buried pipe diameter is small, coupled with a single buried pipe, resulting in a higher negative pressure of the pipe mouth, affecting the pumping effect.

d. The coal mining work surface leakage is serious.

e. The whole work surface inserting extraction process did not carry out basic investigation and design, more random, simple construction.

5. On-site technical inspection and improvement

5.1. Construction and perfection of gas drainage system in 21704 working face
During the normal production of the 21704 work surface of Dashe Coal Mine, the daily output of the work surface is 1000t. At the same time, according to the forecast results of the gas gushing out of the work surface, when the mine is in normal production, the gas gushing out of the coal seam is the main source of gas gushing out of the work surface. Therefore, according to the "Provisional Regulations on Coal Mine Gas Extraction Standards", the residual gas content of coal seams not only meets the requirement that the analytical gas content is less than 8m3/t, but also meets the requirement that the residual gas content is less than 8m3/t. In order to ensure the safety of mine production and strengthen the safety factor, the critical value of residual gas content of mine is determined to be 7m3/t. During the operation in the field, when the residual gas pressure or residual gas content of coal seams measured by all measuring points within the evaluation range is less than the expected anti-burst effect to meet the standard gas pressure or gas content, and the construction to determine drilling holes without spray holes, top drills or other power phenomena, it is judged to highlight the coal seam evaluation range of pre-pumped gas anti-burst effect to meet the standards; Otherwise, the supplementary measures must be re-executed if the determination exceeds the standard.

5.2. Improvements in the inserting process in the upper corners
(1) Pipe Insert depth value survey
Because the gas is lighter than the air, the gas concentration of the mixture gas is high in principle at the upper angle near the top plate. The concentration of mixed gas is low near the bottom plate. However, the gas flow field of the mining area is not a irregular gas flow field because it is affected by the leakage factor of the work surface. In order to truly grasp the distribution law of gas upper angle gas concentration in spatial height, Dashe coal mine in 21704 work in the upper angle mining area gas concentration and vertical height distribution relationship was examined and tested, the test results are seen in Table 2.

| Testing number | Height from the roof (m) | Gas concentration (%) |
|----------------|--------------------------|-----------------------|
| the first time | 0 ~ 0.3                  | 14 ~ 17               |
|                | 0.3 ~ 0.8                | 16 ~ 22               |
|                | 0.8 ~ 1.7                | 9 ~ 13                |
| the second time| 0 ~ 0.3                  | 13 ~ 18               |
|                | 0.3 ~ 0.8                | 19 ~ 25               |
|                | 0.8 ~ 1.7                | 7 ~ 15                |
|                | 0 ~ 0.3                  | 14 ~ 16               |
According to Table 2, the concentration of mixed gas is relatively high in the space range from the top plate to 0.3m in the upper angle mining area, the highest gas concentration in the height range from 0.3 to 0.8m from the top plate, and the smallest gas concentration in the height range near the base plate. Therefore, it is determined that the angle inserting on the working surface covers the height range from 0.9 to 1.4m from the base plate.

(2) Pipe insertion height value survey

According to the law of gas gushing out of the upper angle, the relationship between the insertion depth and the gas concentration in the pipeline is examined separately when the insertion pipe discharges different positions, and the specific results are found in Table 3.

| The distance between the pipe and the upper wall (m) | The maximum gas concentration (%) | The depth of the inserting at the maximum concentration (m) | Insert the maximum depth of the pipe (m) |
|------------------------------------------------------|----------------------------------|----------------------------------------------------------|----------------------------------------|
| 0.5                                                  | 7.7                              | 4.7                                                      | 6.3                                    |
| 1.0                                                  | 15.7                             | 6.4                                                      | 7.1                                    |
| 1.5                                                  | 11.9                             | 5.8                                                      | 7.4                                    |

According to Table 3, the inserting works best when 1m from the upper corner of the work wall and from the inserting depth to 6.4m. Therefore, it is determined that the insert position of the upper angle pipe is 1m from the upper wall and the inserting depth is 6.4m.

(3) The intercept width value is determined

According to the analysis of the gas gushing out of the upper angle and the size of the backwind lane section, the intercepting width of the buried tube was determined to be 0.5m. That is, the distance to the hollowing area on the state wall 1m line as the center, left and right intercept width of 0.25m. On-site construction can be inserted side-by-side 250×14.8mm pipe, insert at the distance of 30 to 50m into the pumping pipe, the improved inserting diagram see Figure 3.

![Figure 3](image)

Figure 3 The improved construction process diagram of the upper angle inserting

(4) Other points to note

In the inserting process, due to the influence of the parameters of the thickness of the coal seam, the inserting parameters are not a constant layer, the mine should dynamically investigate the relationship between gas concentration and position parameters, and adjust the inserting parameters according to the
results of the investigation. In addition, in order to reduce the gas gushing out of the mining area, in addition to strengthening the pre-pumping of coal seams, measures should be taken to prevent serious leakage of the work surface.

5.3. On-site application effect investigation
After the improvement of on-site technology, after a month of on-site research and inspection, the effect of gas management has been significantly improved, the site inspection situation is as follows:
(1) Gas pumping parameter value
Changes in the parameters of gas pumping following technological improvements can be found in Table 4.

| Parameter name                  | Mixing capacity (m³/min) | Gas concentration (%) | Gas drainage scalar (m³/min) |
|---------------------------------|--------------------------|-----------------------|------------------------------|
| prior technical improvement     | 2                        | 5 ~ 7                 | 1.05 ~ 1.47                  |
| after technical improvement     | 3                        | 14 ~ 18               | 4.62 ~ 5.94                  |
| variable quantity               | 12                       | 9 ~ 11                | 3.57 ~ 4.53                  |

From Table 4, it can be learned that after a series of inspection and optimization through the site, the mixing flow and gas pumping concentration of the upper angle inserting tube have been greatly improved. Among them, the mixed flow increased by 1.6 times, the concentration increased nearly three times, and the pure flow increased fourfold.

(2) Practical application in the field
After technical improvement, the gas concentration in the normal propulsion process of the angle on the work surface was between 1.1% and 1.5%. The concentration of return gas is normally between 0.5% and 0.8%. On-site inspection of the number of gas exceeded the limit only 1 time in a month, greatly reducing the number of work surface gas exceeding the limit, basically in line with the national industry management requirements.

6. Conclusion
Through the analysis and investigation of the reasons for gas exceeding the limit in the work surface of Dashe coal mine, we find out the problems such as the failure of extraction in the process of gas treatment in Dashe coal mine, and the imperfection of the inserting process in the upper angle. According to these problems, the mine and cooperative units carried out on-site parameter inspection in the new test work surface, and formulated targeted technical improvement measures according to the results of the inspection. By perfecting the on-site construction, the angle gas pumping on the work surface has obtained good results, reduced the number of over-limit gas on the work surface, ensured the safe production of the mine, and provided some experience for the gas treatment of the same type of mine.

Acknowledgments
This study was financially supported by the Natural Science Foundation of Chongqing, China under grant No. cstc2020jcyj-msxmX1013.

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