Optimization Study on Gas Control of Coal Preparation Plant Bunker

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Abstract: According to Zhao Zhuang coal mine coal preparation plant of coal field, this paper adopt methods of theoretical analysis, monitoring and test research, studied the distribution of gas migration regularity and optimized the structure of coal preparation plant bunker. Adopt the natural ventilation system to replace the original coal power fan system, effectively controlled of the coal gas concentration below 0.5%, and obtained the good effect of gas control, and created the better economic and social benefits. This study is of great significance to the control of coal bunker gas in other mining areas.

1. Preword
Gas exists in free state and adsorbed state in the coal. Most of the gas in the coal escapes in underground mining, transportation and other links, but some of the coal produced still has adsorbed gas [1]. In the process of coal being transported into the bunker of the coal plant, secondary falling failure occurs, which causes part of adsorbed gas to be released into the bunker. With the increase of coal reserves and storage time in the bunker, the amount of gas escaping from the bunker keeps increasing, which brings potential safety hazards to the bunker operation [2]. According to the document of Shanxi Bureau of Coal Industry, "Regulations on Gas Management of Coal Enterprises' Affiliated Coal Washing (Preparation) Plants", when the gas concentration reaches 0.5% or above, all non-intrinsically safe power sources in the bunker environment shall be cut off, and corresponding treatment measures shall be taken [3]. Therefore, the analysis and study of the law and distribution of gas migration in the bunker, the optimization of the bunker ventilation structure and the effective control of the problem of gas accumulation in the bunker play an important role in ensuring the safe operation of coal preparation plant bunker.

2. Current Governance Situation of Coal Bunker Gas
At present, many coal preparation plants adopt the power fan drainage system to control the coal bunker gas. Although this method can effectively drain coal bunker gas, there are still some problems. It is difficult to grasp the time and law of gas emission in coal bunker, and there is an instantaneous gas emission [4]. As a result, the gas in the warehouse exceeds the limit, and it is easy for the gas probe alarm to occur in the warehouse and on the warehouse, leading to power cut and shutdown of fans, belt conveyors, etc., which brings potential safety hazards to the operation of coal warehouse [5]. Due to the strong agitation of the coal body, a large amount of gas is spilt out from the coal outlet of the coal feeder.
and the transfer points of the coal bunker, resulting in the high gas concentration in this area and the problem of gas exceeding limit. The continuous operation of the power fan is prone to failure and shutdown. Due to the coal bunker is high, the fan needs to be hoisted up and down for maintenance, and the operation is dangerous. What’s more, long running of the fan requires a lot of manpower and financial resources[6]. Therefore, it is of great significance to study the natural ventilation drainage system of coal bunker to replace the original dynamic fan drainage system for effectively controlling the gas in coal bunker and improving the economic benefit of mine.

3. Study on the Law of Gas Emission on Coal Bunker

3.1. Analysis of Influencing Factors of Gas Emission in Coal Bunker

The coal bunker in the coal preparation plant is a closed silo structure with poor ventilation[7]. The residual gas contained in the coal stored in the warehouse cannot be discharged effectively, which may easily cause the gas concentration in the warehouse to exceed the limit. The factors that affect the gas emission of coal bunker mainly include metamorphism degree of coal, destruction degree of coal, coal bunker reserves, storage time, etc.[8]. The higher the metamorphism of coal, the more developed the pores and the higher the gas content of coal. The less destructive the coal is, the less residual gas is released when the coal is transported from the working face to the bunker, and the more gas is released when the coal is destroyed again. The greater the amount of coal in coal storage and the longer the storage time, the greater the gas emission of coal bunker[9]. Therefore, in order to prevent the high concentration of gas in the bunker from posing a threat to mine safety production, a crusher should be used to crush the large coal before it enters the bunker[10]. The rate of coal transportation should be accelerated to avoid excessive coal reserves. The ventilation structure should be optimized, the local ventilation capacity should be enhanced, and the coal bunker gas should be pumped and discharged efficiently.

3.2. Calculation of Coal Bunker Gas Emission Intensity

In order to discharge the gas released in the bunker and make the gas concentration in each area of the bunker less than 0.5%, the required air volume of the bunker can be calculated and determined according to formula (1), where \( P_1 \) and \( P_2 \) values are measured by the laboratory use of coal samples.

\[
L = \frac{V K (P_1 - P_2) M}{100 T Z} \tag{1}
\]

In the equation: \( L \) - coal bunker exhaust air rate (m³/h); \( V \) - maximum coal bunker reserves (t); \( K \) - filling degree of coal storage (%); \( P_1 \) - gas release rate (%) during the whole duration from mining to coal warehouse transportation; \( P_2 \) - gas release rate (%) during the whole duration from mining to warehousing; \( M \) - maximum content of gas in coal; \( T \) - storage time of coal in the bunker (h); \( Z \) - the maximum allowable gas concentration per cubic meter in the bunker is 0.5%.

3.3. Distribution and Migration of Coal Bunker Gas

A gas sensor is installed in Zhaozhuang fine coal bunker and an independent sub-station is established. Through PLC control technology, the gas concentration value of each measuring point is monitored in real time, and the distribution and migration rule of gas in the bunker is studied by analyzing the gas concentration data of each measuring point. The sensor is installed at the top of the bunker, the middle of the bunker wall, the coal outlet of the coal feeder and the transfer point of the belt. The maximum variation of gas concentration at each measuring point every day within a week is shown in Table 1.

| Location                  | Time/d | The top of the bunker | The middle of the bunker wall | The coal outlet of the coal feeder | The transfer point of the belt |
|---------------------------|--------|-----------------------|-------------------------------|-----------------------------------|--------------------------------|
| The top of the bunker     | 1      | 0.42                  | 0.35                          | 0.42                              | 0.32                           |
| The middle of the bunker  | 2      | 0.38                  | 0.30                          | 0.45                              | 0.38                           |
Through the real-time monitoring of the gas concentration values in different areas of the coal bunker in the coal preparation plant, it can be concluded that the gas distribution and migration in the bunker are regular, and the distribution trend changes only in local areas due to the backflow or eddy phenomenon in the flow field. The gas concentration at the top and upper corner of the bunker is high because the gas released by coal in the natural accumulation area accumulates upward continuously. The gas concentration in the middle of the bunker wall is high because the falling coal flushes the gas from the middle area to the surrounding area. Due to the strong agitation of the coal body, a large amount of gas is split from the coal outlet of the coal feeder and the transfer points of the coal bunker, resulting in a relatively high gas concentration in the area. Moreover, there are many mechanical and electrical equipment in the area, and there are serious potential safety hazards. The gas concentration is high in the local area of the bunker, which is prone to gas exceeding limit. Therefore, in order to eliminate the safety hidden danger of coal bunker, it is necessary to strengthen the ventilation in local area of coal bunker, reduce the number of electrical equipment in coal bunker as far as possible, and adopt natural ventilation drainage system of coal bunker to replace the original power fan drainage system.

4. Optimization of Bunker Ventilation Structure

4.1. Structural Improvement of Coal Bunker
Zhaozhuang fine coal bunker is a cylinder bunker, mainly storing and transporting 0~13mm sieve coal and washing coal. The coal bunker has a diameter of 21m and a height of 35m, and the reserves can reach 10,000 tons. In this paper, the ventilation structure of the bunker was optimized and improved by analyzing the factors affecting the gas emission amount of the bunker and the gas distribution and migration rule of the bunker. The coal bunker natural ventilation drainage system is used to replace the original power fan drainage system, and good treatment effect is achieved. The specific improvement measures are shown as follows.

As shown in Figure 1, 24 air inlet holes are set on the top wall of the bunker, which are uniformly distributed at an angle of 15 degrees. Twelve air inlet holes were arranged in the truncated vertebral shell, uniformly distributed at an angle of 30 degrees. The inlet aperture is 30mm. The orifice adopts steel tube to draw under the roof of the warehouse. The opening position avoids the equipment and steel reinforcement, the orifice is strengthened, and the rain-proof and fall-proof device is set, so as to form the effective air inlet channel of the bunker and strengthen the convection ventilation.

As shown in Figure 2~3, six return air holes are cut on the top wall and the top truncated vertebral shell of the bunker to erect a natural ventilation pipe to the roof outside. A cyclone roof natural ventilator is installed at the top of the ventilation pipe. 7 embedded square gas collectors are installed from top to bottom in each natural ventilation pipe. The vertical interval is set at 2.5m. The collector is made of steel plates, and the internal space is reinforced with support plates. The collection port is provided with an anti-backflow bulkhead, which is sectionally fixed with a fixed bracket and anchor rod to the inner wall of the bunker to effectively collect the continuously volatile gas in the accumulated coal. Through the cooperation of each cyclone type natural ventilator and the gas collector in the bunker, the ventilation airflow is formed in the ventilation space by taking advantage of the air pressure difference between the roof of the bunker and the natural air inlet, and the gas in the bunker is effectively diluted and discharged.

Semi-closed airflow hood is used to collect volatile gas at the coal outlet and belt transfer point of coal warehouse feeder. It is connected with the cyclone type natural ventilator through the galvanized steel duct to the outdoor, and can effectively drain the gas inside the warehouse in this area. Flame-retardant materials are used to fill the corner of the bunker so as to eliminate the environment of gas accumulation and prevent the gas from exceeding the limit.
4.2. Optimization Effect Analysis

After the optimization and improvement of the ventilation structure of the fine coal bunker of the coal preparation plant, real-time monitoring of gas concentration is carried out at the top, middle of the bunker wall, the outlet of the coal feeder and the transfer point of the belt through the gas sensor installed in the bunker. Figure 4 shows the variation of the maximum gas concentration data at each measuring point every day within a week.

According to the broken line diagram of the change of gas concentration at each measuring point, the gas concentration at each measuring point decreased significantly after the ventilation structure of...
the fine coal bunker of the coal preparation plant is optimized. The maximum gas concentration was less than 0.15%, which is in line with "Regulations on Gas Management of Coal Enterprises' Affiliated Coal Washing (Preparation) Plants". Moreover, the optimized natural gas extraction and drainage system can not only maintain a stable discharge effect, but also effectively solve the problem of high gas concentration in coal bunker. It also greatly reduced the cost of gas treatment, increased production efficiency and improved the working environment, thus creating better economic and social benefits for Zhaozhuang coal industry.

5. Conclusion

Through theoretical analysis, field monitoring and experimental research, conclusions are drawn as follows:

1. Secondary falling failure occurs during coal transport to the bunker of the coal plant, and part of the adsorbed gas is released to the bunker. With the increase of coal reserves and storage time, the amount of gas escaping continuously increases, which brings potential safety hazard to coal bunker operation.

2. There are some problems that need to be solved in the governance of coal bunker gas with the power fan drainage system. There is the possibility that the gas exceeds the limit in an instant in the bunker, which leads to the power cut off of the fan and belt conveyor. The continuous operation of the power fan is prone to failure and shutdown, and the maintenance operation is dangerous. A fan needs a lot of manpower and money to run for a long time.

3. The factors affecting the gas emission of coal bunker mainly include metamorphism degree of coal, destruction degree of coal, coal bunker reserves and storage time, etc. Coal bunker gas tends to gather in the upper corner of the bunker top, coal feeder outlet, belt transfer point and so on, resulting in local area gas concentration value exceeding the limit.

4. By improving the original power fan drainage system into a natural ventilation drainage system, the gas concentration in the bunker is reduced to less than 0.15%, and the gas treatment effect is significant and the gas treatment cost is greatly reduced.

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